Theme:

Title: **The Emergence of Second Generation Knowledge Management in Engineering Consulting**

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Abstract: *Knowledge Management (KM) has matured in the sense that there is a widespread consensus that KM is much more than information systems. This contribution discusses how engineering consulting can transcend the first generation of relatively technical oriented support for knowledge management into integrating information systems and soft management tools such as organisation, training and office design. Utilising their respective strength in enabling knowledge production. Results from a study of an engineering consulting company, which has adopted a KM-strategy, are analysed. The first activities had a strong focus on IT. Later efforts however integrate the IT-component with a set of other tools. The experiences are discussed and two main conclusions drawn: First KM is enabled by a bundle of information systems as well as soft management tools. Second there is, in the bundled KM-strategies, still a relative overemphasis on "circumstantial" frames for knowledge production and too little focus on dynamics in knowledge producing processes, which in the engineering consulting company predominantly runs, in customer oriented projects, relatively decoupled from corporate management. The information system architecture might possibly need to continue to be bundled in a kind of forced best of breed strategy, since the construction industry operates with a strong element of temporary cooperation. Moreover it is characteristic that basic tools, such as spreadsheets, prove to be relatively powerful in supporting specific knowledge production. It is recom-mended to shape the second generation of knowledge management by focusing on communities of practices and their intersection in project pro-cesses. IT continues to play a balanced and synchronised role with other tools.*

Keywords: *Knowledge Management, Conculting Engineering, Community of Practice*

Introduction

Knowledge and the handling of knowledge are currently assigned a central role in future competitive strategies for the construction sector. At least in Denmark management of the knowledge component is interpreted as crucial for the sector's future, including consulting engineering firms. The main contention in this paper is that leading Danish consulting engineering firms by 2002 have established a fairly good first generation platform for knowledge management. It consists of a combination of strategic management, Information Technologies, organisational means, culture and office design. The challenge for consulting engineering is by now to develop this platform into a much stronger support for the knowledge production.

The paper is structured as follows. After the method section, mainstream and sociological approaches to Knowledge Management (KM) are discussed, presenting communities of practice as a central concept for second generation KM. Followed by a section pointing at central KM tools and a section aiming at identifying the specific characteristics of the construction sector and knowledge production in the sector and in engineering companies. Then the case section presents experiences from a consulting engineering company, which represents the first generation knowledge management and the paper ends with a conclusion, including recommendation for developing the second generation KM. The paper draws heavily on Koch (2001) with which it shares the conceptualisation of Knowledge Management and other features.

Method

The main conceptual approach in the paper is multidisciplinary drawing on interpretive sociology. management and innovation studies and anthropological contributions to the discussion on knowledge and on management of knowledge. The paper's empirical part draws on qualitative case material from a Danish consulting engineering company, building on several interactions with the company; one is an interview-based case study (Kvale 1996), the other an ethnographic study (Denzin & Lincoln 2000). The company is a medium size company, but is still among the major twenty players in consulting engineering in Denmark. The company has been visited several times by the author, but it is an investigation carried out by Rolf Simonsen, which is the backbone of the material, used here (Simonsen forthcoming).. Simonsen was employed for five months in a cooperation project between DTU and the company with the aim of studying and improving KM in the company. Simonsen participated in three building design projects, doing participant observation and carried out interviews and dialogues with members of the organisation. The author carried out two interviews with managers of the organisation and further informal dialogue. This was supplemented with written material from the company.

What is knowledge management?

Knowledge Management is –and will continue to be- a contested and emergent term. In academia and amongst consultants multiple definitions on knowledge, knowledge production and management flourish (see Pritchard et al 2000, Sverlinger 2001, Liebowitch 1999, Scarborough et al 1999). The definition used here draws on learning organisation approaches, that distinguish between the learning and the management of learning. In this case the distinction is between knowledge production and knowledge management. Knowledge Management is therefore defined as:

Management activities that frame and guide knowledge production in an organisation.

Below these activities are discussed as different tools or enablers for KM. Knowledge production in itself can be understood as a combination of retrieval, combination, creation and erasing of knowledge. Some authors believe that a clear distinction can be made between data- information-knowledge and between different types of knowledge like tacit and explicit. These distinctions are tempting in their clarity, but less applicable in practice (Robertson et al 2001). The position adopted here thus refrains from such distinctions and leans towards understanding knowledge as contextual and cultural.

Perspectives on Knowledge Management

A rough characterisation of positions within KM could distinguish between cognitive, functionalistic, cultural and socio-political perspectives. Cognitive and functionalistic positions can be characterized as mainstream, since they tend to dominate the discourse, whereas cultural and socio-political perspectives are emerging as being the potential basis for the next generation of efforts. Mainstream approaches to Knowledge Management originates from positions as diverse as innovation economics, information systems science, strategic management and others(Scarborough et al 1999). Nonaka & Takeuchi (1995) as well as Davenport & Prusak (1998) have become central reference points. The essential elements of mainstream Knowledge Management can therefore be distilled from Nonaka & Takeuchi's (1995) contribution. Briefly Nonaka & Takeuchi articulates predominantly rationalistic and functionalistic views on knowledge and the possibilities for modelling it, capturing it and storing it. Nonaka et al's categorisation of types of knowledge and understanding of transformation between them (visualised as a spiral) seems to indicate that knowledge and the management of knowledge is a straightforward possibility. The distinction between tacit and explicit, between personal and codified appears very operational. Moreover the transformation of tacit, implicit knowledge into explicit and transportable knowledge is, in Nonaka et al's view, an important but also manageable task (Adler 1995). Some even describe it as "easy" to transport explicit knowledge (Hipp 1999). Nonaka et al predominantly describes and understands organisations as orderly, goal oriented and harmonic. Although some space is left for autonomy and what is called fluctuation, but could be read as politics, the main line is to see organisations in a systems theory oriented way. Nonaka's categories have been followed by other taxonomic approaches, which all signal neat ordering of knowledge production but appear to have little empirical

underpinning (Robertson et al 2001). Although the concepts of Nonaka et al do not directly mention IT, the approach clearly underpins the legitimacy of IT-solutions in managing knowledge.

Cultural and socio-political approaches

In contrast to mainstream KM literature a growing number of sociologically and anthropologically informed approaches are emerging. These are considerably more cautious in their approach to knowledge (Prichard et al 2000, Scarborough et al 1999). This group draws on approaches informed by different variants of interpretive sociology, sociology of scientific knowledge and anthropology refering to, but also criticising the concept of "communities of practice" (Wenger 1998). A central commonality of these emerging positions is the assertion that IT and mainstream KM misses the point in focusing on knowledge codified in distinct elements suitable for IT-storage and ordering. A central difference is however that the cultural approaches assumes a relative harmony in knowledge production in the "community of practice", where the participants share goals and aims, whereas the socio-political position has an eye for the negotiation of knowledge, potential conflict on knowledge claims and the like. According to the cultural position, knowledge is embedded in a culture consisting of shared systems of meaning, rituals, verbal and physical symbols (Alvesson 1995). Knowledge is related to and attached to a set of practices, and is actually potentially meaningless if disentangled from these practices. . The understanding is thus picturing knowledge as a heterogeneous assemblage of tangible and non tangible elements and as something strongly contextual.Studies of professional cultures and engineering cultures, point at the importance of *object worlds*, somewhat ordered abstractions that represent the technologies which the engineers work with (Bucciarelli 1994). Designing engineers interaction is marked by numerous and various tools, verbalisation and other means. Orr (1996) thus highlights the importance of *storytelling*. The boundary of the organisation is, in the cultural view, a less obvious limit to knowledge creating processes (at least in contrast to the economically oriented positions mentioned above, Nonaka et al 2000). Engineering cultures can be assumed to cross organisational boundaries and encompass informal networks enabling the maintaining and development of a professional object world..

The Community of practice concept

The community of practice concept has been created and developed by Lave & Wenger , Wenger 1998,2001 Brown & Duguid 1991, 2000 and numerous commentators/adopters. Wenger 1998 is used below to describe the concept. Wenger argue that collective learning results in practices and vice versa. This reflects both the pursuit of an enterprise and the attendant social practices. These practices are thus the property of a kind of community created over time by the sustained pursuit of shared enterprise. Wenger points at three main elements in a community of practice (c-o-p): mutual engagement,joint enterprise and shared repertoire. Wenger describes practice as a source of coherence. Practice exists because people are engaged in actions whose meanings they negotiate with one another. The group thus sustains a dense relationship of *mutual engagement*. Such a mutuality does not mean that c-o-p is only characterised by harmony and consensus. Wenger actually argues that mutual relationships are complex mixtures of power and dependency, pleasure and pain, expertise and helplessness, success and failure (Wenger 1998 :77). A c-o-p is also characterised by diversity and partiality, some are more strongly included than others etc. The second feature is negotiation of a *joint enterprise*. This Wenger describes as not just a stated goal (p.78) but a collective process of negotiations, where the joint enterprise gets defined by participants in the process of pursuing it. The joint enterprise also embodies the members' position in a broader system and is the members' response to their conditions. It can be noted that both mutual engagement and joint enterprise has overlap with shared meaning which is a central concept in symbolic organisational culture understanding (Alvesson 1995). As a third main characteristic Wenger describes how a c-o-p *shares a repertoire*. The repertoire includes routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions or concepts. This should not be understood as mechanistic. The repertoire is inherently ambiguous and a shared practice does not in itself imply harmony or collaboration (s85). Nevertheless the repertoire is maybe one of the strongest direct manifestations of a community of practice and it also here shares elements with the organisational culture (Alvesson 1995)

Multiple communities of practice

Moving beyond the single c-o-p, Wenger (as well as Brown 2002) develops a discussion on relations and connections between different communities of practices (c-o-p-s). Two types of connections are

discussed: participation and reification. Participation covers brokers, boundary spanners between two or more distinct c-o-p-s. Reification covers boundary objects, such as common documents, prototypes or parts of a product. Moreover overlaps between c-o-p-s are discussed. Wenger demonstrates how two c-o-p-s can mutually strengthen each other in everyday practices (Wenger 1998 p) but downplays, on the one hand, the possibility of such a deep embedding of the overlap that ambiguity and tension are introduced and on the other hand disregards the possibility of two c-o-p-s that might be in conflict with each other, or even constitute themselves as a stereotypic image of "the others"(a phenomenon well described in organisational culture literature, Alvesson 1993). Another important issue is the relationship between boundaries and boundaries between c-o-p-s. Professional groups, for example, are a classical example of a bonded set of people, which broadly use the same repertoire of tools, share a mindset and to some extent also a joint enterprise and engagement. However the relationship between members in a professional group seems to be somewhat looser than the relationships in a professional group all working in the same department. Finally there is the issue of a managerially installed c-o-p. On a corporate level there might be a strong wish to develop an unitary organisational culture or c-o-p. This can be enforced by a set of means of economic, technical and social character. It will often be characterised by an emphasis on the joint enterprise and engagement of the company as such.

The multiple configuration of communities of practice

Wenger's description of the multiple communities ends up being increasingly complex. He thus describes the multiple communities like this

"By weaving boundaries and peripheries, a landscape of practice forms a complex texture of distinction and association and impossibilities, opening and closing, limits and latitude, gates and entries, participation and non participation." (Wenger 1998: p 121)

It is striking that, when one combines this with subsequent attempts to apply the concepts to various contexts, then some of the attempted complexity has been left behind for the benefit of relatively simple differentiation.(Kauhaluoma 2000 and Hislop et al 2000 are just two examples). Scholars have attempted to distinguish c-o-p-s from each other forgetting the potential complex texture overlapping and ambiguous relationship to several c-o-p-s. It is with this background that we propose to adopt an analytical strategy from organisational culture studies. Since Martin& Meyrson 1987 a series of studies propose to tackle the research issue, one orseveral, distinct overlapping culture(s) by looking for elements of differentiation, integration and ambiguity to reach a mapping of a multiple configuration of communities of practice (Alvesson 1995). Applied to communities of practice this implies that it is an empirical question how the multiple configuration of c-o-p looks in a particular setting. One will have to look for how strong and with which scope the mutual engagement and joint enterprise reaches, when it will be necessary to distinguish between different sets of repertoires etc. Hislop et all (2000) for example discuss seven cases, which are characterised by differentiated communities of practice, on the basis of structure, geography, business units, products and occupation. Hislop et al argue that the strong differentiation is due to limited cooperation between units or others.

Juxtaposing these positions and drawing on their combined insights leads to an understanding of knowledge production as multi-facetted, with the implication that Knowledge Management cannot rely on one single, or a few, tools or enablers. Roughly first generation Knowledge Management came to rely predominantly on information technology and strategic management, whereas second generation could rely on a much richer understanding of the knowledge production in the projects, such as is offered by the community of practice approach.

Tools in Knowledge management

There is no consensus on which tools and activities characterise KM. But across the contributors one can point at a set of generic areas and with certain common activities (see also Sverlinger's dicussion on enablers for KM, Sverlinger 2000): Corporate and strategic management, Information Systems, Organisation, Human Resources, Office Design and Culture. Within *corporate and strategic management* one can point to the formulation, communication and clarity of a knowledge management strategy

(Sverlinger 2000). The appointment of a responsible top-level manager and or a knowledge officer is another central activity. Last but not least the effort to put evaluation tools in place, monitoring knowledge as an asset and calculating knowledge balances, have been central. *Information systems* were initially thought of as the central tool of KM (Ruggles 1998) and the KM literature still is dominated by this position (Robertson et al 2001). Systems include technologies such as intranets, groupware, list servers, knowledge repositories, database management, data warehousing, data mining and knowledge action networks (, Ruggles 1998). *Organisation* relates to Nonaka & Takeuchi's discussion on middle up down management and their orientation points; "organisational intention", "autonomy", "fluctuation and creative chaos", "redundancy", "requisite variety" (Nonaka & Takeuchi1995). *Human resources* relates to developing competency profiles, designing recruitment and training and to designing reward system (Davenport & Prusak 1998, Scarborough et al 1999, Sverlinger 2000). *Office design* relates to a shift from a traditional open office landscape and cells; where individuals either work in parallel on tasks that are assigned to them or in singular offices (Duffy 1997). This traditional form was an underpinning of a hierarchy, where managers and senior expert employees have their own offices, whereas clerks, junior employees and others work in open spaces. In the new office concept a direct support for different knowledge activities is sought (Duffy 1997). The office is supposed to support group interaction, intensive individual knowledge work (cells) and networks. The *culture* aspect has been addressed by the literature on knowledge intensive companies (Alvesson 1995) and on communities of practice (Wenger 1998, Brown & Duguid 2000). KM is here concerned with "installing" a knowledge sharing culture, which will often collide with existing organisational cultures, for example constituted by professional groups. This extensive, but not exhaustive, set of tools can, when turned into a strategy-design concern, be understood as a reflection that knowledge exists in diverse forms and is transformed and represented in many ways. Designing a set of KM activities in such a pragmatic perspective implies a choice between, and/or a combination of, these approaches, something that might be realised in an ad hoc searching way (bricolage, see Koch 2001). This is resonant with the empirical material discussed below, which implies that knowledge resides and exists in a number of forms in a knowledge intensive company.

Contextualising Knowledge Management: Construction and the role of the consulting engineering companies

The knowledge production within construction is closely related to projects realising "one of a kind" production (Gann 2000). The knowledge production is however also relying on the ability to re-use and mobilise existing knowledge of the different elements of the construction project. It is an often celebrated sectoral myth , that the inter-organisational cooperation is temporary and constantly, and even chaotically, reconfiguring partnerships. However, when focussing on the single project and institutional links, it will occur that the temporary character is relaxed. It appears rather to be a network of recurring partners in different constellations and with rather well defined and well exercised roles that is in play. This characteristic is of major importance when discussing management of knowledge in and between construction projects. Networks of construction players form communities of practice that share repertoire and knowledge embedded in practices (Wenger 1998). This form of knowledge management might, at a closer examination, be rather strong in linking knowledge from one project to the next. This is also an element in the strategic partnering-approach.

Knowledge Management in Consulting Engineering Companies- a Case.

Given these characteristics of the inter-organisational setting, we can now turn to the predominantly internal organisational issues of the consulting engineering companies. The company described below, actively works with knowledge management as part of the corporate strategy. The section is structured in two tempi. First the elements of knowledge management are dealt with:corporate and strategy management, information systems, organisation, training and personnel issues, office design and culture. Second the knowledge production in the project processes is discussed. The company employs around 500 members of staff. The organisation operates with matrix-like overall organisation in three dimensions. The focus horizontally is on customer groups and/or products, whereas the vertical focus is on major areas of competence. Finally the third dimension focus is on professions and best practices. The company has major competencies, albeit with different emphasis, within; Energy, environment, building,

construction management and industrial solutions.Within the building areas, which are in focus here, the companies operate with specific portfolios of competencies, such as building physics, thermal engineering, electrical engineering and the like.

Corporate Strategy and Management

The KM strategy for the company is directly linked to corporate competitive strategy and is organised with close links to top-level management. The company has ongoing activities to realise the KM-strategy. The strategy is made explicit and backed up with appointment of a responsible manager although he is not explicitly called a "knowledge officer". KM plays a role as part of the external branding of the company as well. The company have implemented means to evaluate the strategy, and to evaluate the knowledge component in the companies. Knowledge accounting is carried out, although not as a yearly intellectual capital report (in contrast to many other consulting engineering companies.

Information Systems

The company employ a host of IT-systems including an intranet with an enterprise portal, accounting/ERP, office/document handling, CAD and project management tools. All these systems play a role in managing knowledge and in storing and providing different forms of information. Several of the systems were implemented before the knowledge management strategy was made explicit, but a further and more integrated use has been a central element, and first step, of KM. Especially the intranet and an enterprise portal have been positioned as central to the first effort of KM. Moreover integration between systems has become a central preoccupation. Employees receive the effort with ambivalence and the KM-functions of various kinds are not used overwhelmingly. The intranet is used to store and support information on various knowledge areas. The capture of best practice and the facilitation of professional networks are central elements. Also more "mature" explicit information such as standards, guidelines, templates for formulas and other documents are part of the intranet-facilities, not to mention e-mail communication and corporate information. The aim is that codified knowledge is to be supported by intranet.The company has implemented two types of management information systems and partly integrated them with the other systems. These are an Enterprise Resource Planning (ERP) system and a document handling system. The aim is to integrate accounting, Human Resources (enforcing hours spent registration) engineering data and project management as well as building up an information database. The configuration of ERP constitutes a particular "engineering" version. It is thus time sheet functions which are most frequently used (by all employees) in both companies, secondly the financial modules for basic accounting and financial management, and to handle the economic side of projects. Finally the HR-functions are used. It should be noted that Knowledge Management modules offered as add ons are not in use. Compared with manufacturing configurations of ERP, material handling and production planning are not used at all. The companies use several different engineering information management systems (EIM). Drawing and handling of drawn information is central here. The KM element relates to the potential reuse of drawings on either component level (building elements) or higher levels (buildings). Several project management software packages are in use. Also different types of project webs are used. *Summarising* the company exercises a "forced" Best of breed –strategy. Single source is interpreted as impossible also given the temporary character of the project work. The IT has to be used in markedly different ways according to cooperation partners. Some contractors do not employ CAD-systems and merely ask for plain drawings and documents as representation of the design. Others ask for multi-layer intelligent drawings and demand that the cooperation is exerted through project webs.

Organisation

The organisation is characterised by an emphasis on projects as the main value adder. Most projects have to be carried out in a multidisciplinary manner and across departmental borders and involving active intersections between the company's communities of practice. Moreover the employees interpret project work as essential for developing new knowledge. Nevertheless the company still has "left-overs" of an hierarchical organisation with several levels. And the KM strategy focuses more on frameworks for the projects. Management emphasises small organic departments and fewer hierarchical levels and actively avoids large departments. KM means focusing on and enhancing existing professional disciplines, this is predominantly done by organising professional networks. These professional networks have an appointed

manager and he/she acknowledges proposals for best practice, which are then registered on the company's intranet.

Training and Personnel

The company encompasses a strong element of Human Resource Management in their understanding of knowledge management. Recruiting and training are important ways of developing knowledge resources, but it should be noted that project-financed and in built training is favoured mostly by managers, but also by employees. Moreover an emphasis is adopted on making it attractive to stay with the company, making the employees loyal. The company management asserts that employee turn over could be improved, since the company experiences a fall in the (previously long) length of employment. The loyalty activities also relate to the understanding that an important part of the company's knowledge resides with the employee.

Office Design

The company has rearranged its office space as part of an effort to physically support sharing of knowledge. The introduction of new office ideas in the company has reduced the amount of paper and storage space per employee. It is characteristic that the company has a piece-meal implementation of new office ideas. Moreover the shared open spaces are organised according to the departmental structure in order to support exchange of knowledge within the same specialism. The projects typically cut across departmental structures and project members thus still have to meet formally. The co-local fashion of interaction amongst project members from different departments is less prevalent and emails and phones are used. There is an attempt to downplay hierarchy by letting the department manager work in the open space among the other employees. However corporate management has been strengthened at the same time. Part of the space dynamic in engineering relates to large projects with site management and local engineering and design, where groups of employees or single site managers are absent from the main building of the engineering company. Such absence implies that coordination and management with groups of employees has to be done in a virtual way for long periods of time.

Culture

The different departments seem to represent relatively distinct communities of practice. It is signified by the repertoire mobilised in establishing contacts to customers, the roles of the department manager, the types of tasks carried out by the employees etc. These distinct c-o-p are however overlapped by a common c-o-p and c-o-p-s related to carrying out projects. This multiple configuration of cultures/c-o-p-s is central for the handling of knowledge in project processes:

Project Processes- Knowledge production

The project processes are the central knowledge production. Below a process is described to illustrate the knowledge production activities. The project is the establishment of a fitness center, offices and storage facilities in a previous factory building. The budget was at 4,5 mil. £ and the fee of the civil engineering company was 350.000 £. The tasks were organised as sub contracting for a developer, which had the responsibility for the site management. The first phase of the project was focused on designing a retail facility. The investor behind this project withdrew however and it was halted after three months. Half a year later a new investor was found and the design of the fitness center in the same building commenced. The responsible project manager nevertheless interpreted the content of the project as "standard". The formation of the project group was therefore carried out by the project manager. He manned the project with seven engineers. The engineers stemmed from three internal departments and technical draughts(wo)men were attached to the project group. The major competencies were interpreted as being related to water and heating engineering, electricity, and building physics. The frequent change of demands from the builder underlined the need for updating basic information on the tasks in the projects especially between the project manager and the project members. Moreover the handling of information relating to overlaps between the engineering disciplines was crucial, such as the power need of pumps, which link water and heat-engineering tasks with electrical engineering tasks. While designing the water and heat functions in the fitness center both technical and organisational methods were used to share and develop knowledge. The design of bathing facilities (with showers) was carried out by several engineers. After initially having shared the tasks among them, there was later a need for an informal meeting where

the importance of the factor of coinciding use of the bathing facilities was discussed. An experienced design engineer described a set of rules of thumb for the design and underlined the role of "coincidental use" through telling an anecdote of 400 Japanese guests on a hotel using the bath at 8 o'clock in the morning. Such informal meetings and dialogues strengthened the single engineering profession (in this case water and heating) in their design. More spreadsheets and design programs for heating systems were used by most of the engineers. The spreadsheets were often designed to a specific tasks, but some are also informally distributed among the design engineers. None of those are however formally distributed (to everyone). The design was carried out under time pressure. The developer wanted to rent the offices and the fitness center as quickly as possible. This resulted in the abandoning of the quality review, which is usually carried out as one of the last activities in the design. The building did actually encounter failures, which can be ascribed to the incomplete communication between the contractors and the designers.

Conclusion

Two main conclusions can be drawn from the case: First KM is enabled by a configuration of several information systems as well as soft management tools. Second there is, in the bundled KM-strategies, still a relative overemphasis on "circumstantial" frames for knowledge production and too little focus on dynamics in knowledge producing processes, which in the engineering consulting company, run in customer oriented projects relatively decoupled from corporate management. The information system architecture might possibly need to continue to be a combination of several systems in a kind of forced best of breed strategy, since the construction industry operates with a strong element of temporary cooperation forms. Moreover it is characteristic that basic tools, such as spreadsheets, prove to be relatively powerful in supporting specific knowledge production. It is recommended to shape the second generation of knowledge management by focussing on communities of practices and their intersection. In the case it seems evident that a more in-depth analysis of the communities of practice, than the one loosely drawn up here, would underline the different performance of the communities and their intersection. An enhanced focus on communities as central in knowledge production does not mean that the second generation of knowledge management should avoid IT. On the contrary IT continues to play a role as a tool for organising data and information needed for the knowledge production. The support for a community of practice favours flexible and relatively simple tools such as office packages and document handling systems. In other words IT has a balanced and synchronized role with other tools in second generation knowledge management.

References

Davenport T. & Prusak L.(1997): Information Ecology- Mastering the information and Knowledge Management. Oxford University Press. Oxford.
Davenport T. & Prusak L. (1998): Working Knowledge. Harvard Business Press. Boston.
Egbu C & Sturges J.(2001): Knowledge Management in Small and Medium Enterprises in the Construction industry: Challenges and Opportunities. Paper presented at Managing Knowledge – Conversations and Critiques. University of Leicester.UK
Gann D (2000): Building Innovation. Complex constructs in a changing world. Thomas Thelford
Hislop D., Newell S., Scarbrough H. and Swan J.(2000) Communities of practice and the Appropriation of Innovation. Paper presented at EGOS 2000, Helsinki.
Koch C.(2001) Can Bricolage be squared? Integrating Information Systems and Soft Management Tools in Engineering Knowledge Production. Proceedings The Fifth World Multi-Conference on Systemics, Cybernetics and Informatics, SCI 2001, Orlando Florida.
Ruggles, R.(1998): The State of Notion: Knowledge Management in Practice, *California Management Review. Vol.40. no.3.*
Prichard, C., Hull, R., Chumer, M., Willmott, H. (Eds.)(2000) *Managing Knowledge: Critical Investigations of Work and Learning*. London: MacMillan.
Scarbrough, H., Swan, J., Preston, J. (1999), Knowledge Management: A review of the literature, London: Institute of Personnel and Development.
Sverlinger P.O. M. (2000): Managing Knowledge in Professional Service Organisations: Technical Consultants Serving the Construction Industry. Doktorsafhandlinger Chalmers Universitet. Nr 1644.
Wenger E. (1998): *Communities of practice*. Cambridge, Cambridge University.