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Spiral of Knowledge, Network Theory and Communities of Practice in a Consulting Engineering Firm

Abbas Elmulaim
Innovative Construction Research Centre, School of Construction Management and Engineering
University of Reading, UK
a.a.elmualim@reading.ac.uk

Simon Howard
Innovative Construction Research Centre, School of Construction Management and Engineering
University of Reading, UK
s.howard@reading.ac.uk

Abstract

There has been a great interest in knowledge management theories within the construction sector to achieve competitive advantage. A case study was conducted in a consulting engineering firm to evaluate the application of various knowledge management theories and practices. A spiral of knowledge was identified amongst the firm's engineers while network theory explained the codification and sharing of knowledge among the practicing engineers. The firm further adopted the concept of communities of practice to strengthen its internal networks and harness knowledge sharing and management.

Keywords

Knowledge management, Spiral of knowledge, Communities of practice and consulting engineering firm

1. Introduction

The connectivity between the knowledge and firms' competitiveness in the knowledge-based economy is well emphasized (DTI, 1998). There is consensus for the need for non-cost competition particularly competition on the basis of knowledge and innovation (Porter, 1998, Prahalad and Hamel, 1990). For firms operating on the market niche of sustainability knowledge and innovation are the driving forces for their competitive advantage (Brown and Duguid, 2001, Wenger *et al.*, 2002). There is need for research into sustainable knowledge management in order to advance the discourse of environmental awareness and further help eradicate the environmental problems that humanity is facing in this planet, planet Earth.

This paper investigates and assesses the way knowledge is managed within a Consulting Engineering Firm. At present the practice battles with a superfluity of information and categorizing and making efficient use of it has become a significant challenge for the firm. To maintain its success the practice needs to continue to retain and create new knowledge, disseminate it widely throughout the organization, and quickly embody it in projects. In an economy where the only certainty is uncertainty, the source of lasting competitive advantage is knowledge (Gundonavicus and Savaneviciene, 2004).

The creation and harnessing of new knowledge comes from experience gained when undertaking jobs and through processing new information gained from a library or the internet. This development can be seen as more than data processing if focus is given to the less tangible, subjective, tacit understanding contained within people's experience.

Knowledge gained can then remain as tacit knowledge with the people who achieved it or can become codified and stored as information. Problems then arise if the information is difficult to access and use as knowledge once more.

In achieving its objectives, this paper looks at some knowledge management theory to try and understand current practice at this Consulting Engineering Firm, particularly Nonaka's "Spiral of Knowledge" (Nonaka, 1991) and Network Theory. It then looks at how the situation can be improved utilizing the concept of Communities of Practice using a case study methodology.

2. Knowledge Management Theory and CoP

2.1 The Spiral of Knowledge

The concepts of tacit and explicit knowledge is widely use in the knowledge management literature. Research in Knowledge Management literature (Collins, 2001; Ambrosini and Bowman, 2001; Herbig and Büssing, 2003; Fleck, 1996) defines the terms in different manners particularly the differentiation between explicit and tacit knowledge. Explicit knowledge refers to codified knowledge which is really information, this is tangible, usually written and can be utilized by any individual who possesses it (Busch *et al*., 2002). Tacit knowledge is used to describe anything within the practice which is known but not written down, which can only be accessed through personal contact with its possessor.

To express the interaction and development of explicit with implicit knowledge Nonaka proposes a "spiral of knowledge" as follows:

Tacit to tacit: one person teaching another is an effective transfer of knowledge but the information never become explicit and usable by the rest of the practice.

Explicit to explicit: the combination of two existing pieces of "hard" information from different sources to make one, a report or similar. But, this is not creating new knowledge.

Tacit to explicit: a useful exchange is when the implicit knowledge is documented for use by others. By writing a detailed report at the end of a project the engineer makes their experience of the job accessible for the practice to learn from.

Explicit to tacit: as the new "hard" knowledge is used by the practice it becomes part of individuals tacit knowledge and can be built upon to create further innovation.

Nonaka (1991) further suggested that making tacit knowledge available to others is complex and should be undertaken continually. Unlike hard, explicit knowledge which can be contained within a data base, tacit knowledge is hard to formalise. People often know more than they can tell, their tacit knowledge rooted in action and their commitment to their profession, (Nonaka, 1991).

2.2 Network Theory

The worldwide web, biological cells and human society are all driven by similar organizing principles. Network theory gives a conceptual framework by which to understand many such complex systems (Barabasis, 2005). By connecting human with non human sources of knowledge, network theory is able to

incorporate technical, managerial and cultural aspects of its management. (McNamara *et al*., 2003). The knowledge network at Consulting Engineering Firm consists of a number of information hubs; electronic files, intranet sites, books, people and the internet. These are linked to other hubs to varying degrees. A person seeking information within this network can move between the hubs, provided a link exists, to find what they are looking for. By gaining a greater understanding of this it is hoped better use can be made of existing information.

2.3 Communities of Practice (CoP)

To bring together the knowledge contained within the consulting engineering firm. It is interesting to look at the theory of communities of practice. This provides a system for comprehension of the complex social basis of knowledge management and development (Wenger *et al*., 2002). The concept gives organisations the ability to utilise their people and knowledge base to their fullest extent achieving a persistent competitive advantage. (Pfeffer, 1998)

As previously stressed knowledge sharing is essential for the functioning of the consulting engineering firm and as such communities of practice provide an effective means of understanding and instigating this. (Anumba *et al*., 2005) The abundance of specialism within the company and its need for dispersion makes Communities of Practice particularly applicable. (Anumba *et al*., 2005)

Communities of practice can be described as "groups of people who share a concern or passion for something they do, and learn how to do it better as they interact regularly" (Wenger, 1998). In the past this would have referred individuals working together such as masons, potters and other crafts men. Now it is more likely that the community will exist within another, larger organisation (Elmualim and Govender, 2006). Within the practice this already exists as groups specialising in topics such as electronics and acoustics, but the potential to take it further should be examined.

Communities of practice are closely linked to situate learning, whereby learning is continuous and dependent on the environment in which it takes place. This theory looks to surpass previous thinking that learning is the end point of knowledge transmission (Lave and Wenger, 1991). This is of particular interest given the young nature of the practice and rapid pace at which people need to be brought up to speed.

Situated learning leads to the immersion of the learner in their subject which is known as "legitimate peripheral participation" (Wenger, 1999). Stemming from a traditional master/student view of apprenticeship this moves on to one of changing participation and identity within the communities of practice. As a new community member becomes acquainted with the manner in which the community operates and accumulates knowledge, they progress from the practice fringes to its centre. "Participation shapes not only what we do, but also who we are and how we interpret what we do" (Elmualim and Govender, 2006) so learning as a fundamentally social process must be integral with social participation (Peltonem and Lamsa, 2004).

The fundamental difference between communities of practice and the teams and task groups commonly found within the industry is that the group is linked via knowledge rather than the job at hand. So such communities are bound by the learning they have engaged in rather than their venture and it is the knowledge contained within the group that makes being part of it valuable (Wenger, 1998). The benefits of Communities of Practice within business are wide ranging, facilitating creation, accumulation and diffusion of knowledge. Work can be achieved quicker and with a higher degree of competence within a dynamic, evolving environment (Wenger, 1998).

The organic dynamism associated with Communities of Practice makes them difficult to manage or create artificially, in fact they function best when allowed to work without management, to innovate and adapt

(McDermott, 2003). However, research has shown that a top down managerial approach to communities of practice can be used, providing it doesn't prevent knowledge being the group's central binding force as apposed to task or objective (Thompson, 2005). Along side the very positive influence communities of practice can have, it should be noted that their intrinsic social structure can lead to conflict caused by an unequal distribution of power. New members entering the community have potential to upset dynamics due to a lack of consensual knowledge and divergent sense of identity (Hislop, 2005).

3. Consulting Engineering Firm: The Case Study

The case study was conducted over two years in a consulting engineering firm. The firm has 3 offices in the UK and employs more than 150 engineers. The firm utilizes five major systems to disseminate and hold knowledge. Knowledge of these systems has been gained through personal experience and through a series of interviews and questionnaires with senior engineers. The following outlines how these systems function and tries to place them within the knowledge management theories discussed.

3.1 Ask an Engineer – Knowledge Contained Tacitly in People

The regular and frequent use of electronic mail within the office environment allows the tacit knowledge of over 100 engineers to be accessed. The system acts as a direct link to the tacit knowledge of individuals who can provide immediate answers to questions posed. Alternatively an enquiry is linked to a potential information hub, an individual with tacit knowledge of information sources for the given topic. This allows a link to be made to information stored within or outside the practice. Thirdly, the individual or hub could link to a second hub which leads to the information required. In this manner access to a large volume of decentralized, apparently disordered information is gained rapidly though a network of communication.

3.2 J3000 – Selected Explicit Information

Electronic information gathered through the execution of a job is stored in one place under that jobs name. This file contains basic information, specific calculations, drawings, legislative changes, reports, presentations and images. The information is available to everyone in the practice but realistically, access is precluded by the volume of information stored. The location of information is known only by the individuals involved in its creation so access needs to be achieved through personal communication. This exists through the communication network discussed previously but if this system fails, if the required connections are not made, the information remains lost. Connections are missed for a number of reasons, when an email is sent it may miss the individual, the hub, it requires, or the fallibility of the human mind may have rendered the tacit knowledge inaccessible at its source.

Within the filing system there exists a location used for storage of any information deemed to be of particular use to the practice as a whole. During a job notable sources of information may be stored here under a relevant heading. This is a relatively organic process, files can be created and destroyed and the system is essentially unmanaged. This facilitates rapid deposition of information but hampers rapid retrieval. Attempts have been made to catalogue the information deposited within the file but this relies on the diligence of people involved.

A proportion of the information deposited in the file has been obtained from the internet. It is presumed that its storage within the practice system will increase the speed at which it can be accessed, which is of course true for those who know of its location. However, the organic nature of the file often makes access by an individual lacking the tacit knowledge laborious. Furthermore, if the information sought evolves

rapidly, specifically economic data, it may be more expedient to access the information from the internet directly.

3.3 Discussion Group – Selected Explicit Information

Personal insight and progress needs to be made available for experimentation and implementation by the practice as a whole. To persistently create knowledge, ideals must be focused on as much as ideas, recreating the world according to the practices vision (Nonaka, 1991). As such the practice and everyone in it should be undergoing constant renewal with everyone continuously creating and disseminating new knowledge. Knowledge creation occurs as a job develops. This may lead to individuals undertaking research into a particular topic through reading or attending seminars. This knowledge is fed into the practice via electronic mail in a similar manner as discussed previously, the process differs however in that it must be categorized before it is posted. This categorization allows it to be accessed more rapidly and is a process which could be applied to the other storage mediums.

This process often exhibits the useful transformation of knowledge from tacit to explicit. As the knowledge becomes categorized information it becomes more easily available to those who need it. Furthermore the post may act as a communication hub, connecting individuals to the tacit knowledge of specialist engineers or to explicit documents of relevance previously hidden in job files.

3.4 Helplines – Intranet Site for Basic Explicit Information and Link to Further Knowledge

Lotus notes supports an Intranet site providing introductory information to topics of use to engineers. Its structure is easy and clear to navigate and it acts as a hub to some information stored in job files, the library or the internet. However the construction of the sites is usually undertaken by one individual so tends to provide only their own tacit knowledge of the information available. The dynamic nature of the construction industry, particularly the sustainability sector requires constant attention, information sources need regular renewal. As such the Intranet sites can become outdated and less useful relatively quickly.

3.5 Job Database – Link to Electronic Filing System

To allow better access to the information stored within job files a data base of job characteristics is being formed. Using a detailed questionnaire, data for each job was gathered. This focused particularly on interesting features of the job, points that make the job file worth searching for the information required. This then provides a starting point for the exploration of the vast amount of data contained within the practice.

4. Discussion

4.1 What can be Learnt from the Spiral of Knowledge?

Nonaka (1991) spiral of knowledge provide the practice with a mode of understanding the different knowledge flows that exist. By recognizing the merits and limitations of tacit to explicit knowledge transfer the process can be supported and facilitated. Capturing expertise as general principles using a system such as lotus notes should continue to allow non-experts to benefit from an expert even in their absence. Busch *et al*., (2002) note that if tacit knowledge can be expressed all that limits its codifying is economic cost. As such it would be useful to codify all the tacit engineering knowledge held by the company, but given the economic restriction limits need to be drawn.

The discussion group provides a hub to job files and good tacit to explicit conversion of knowledge. This is a more efficient use of engineering time than the Helplines as it makes explicit only what is needed. Furthermore the exchange is interactive allowing large amounts of information to be gained rapidly.

The information contained within J3000 is of use, but only if it can be found. So where the information is stored needs to be logically and rigidly organized, for ease of both depositing and retrieving. It would be helpful if the information could be searchable through its contents as well as its title and if possible every subject file linked to its corresponding Helplines page. Achieve ridged categorization could be achieved through the utilization of a filing document, or by utilizing just one person as a filer. Ideally this drive should become a source of all the most useful explicit information held within the practice, it would be helpful if this could be extended to calculations and drawings as well as documents people consider to be of use. This system could be complemented and possibly superseded by an effective desk top search engine.

4.2 What can be Learnt from Network Theory?

The experience of the internet shows that if a site has more links it will receive more internet traffic. It has also been shown that networks use logarithmic distribution, that highly linked hubs grow faster and that all networks undergo phase transition. The top web sites on the internet have 100 times more links than the next set, which in turn have 100 times more links than the next. The relevance of this is that the third best site has only 1/1000 the links of the best so will receive only 1/1000 the traffic. The scale of the knowledge management network at consulting engineering firm is much smaller but it may be possible to draw lessons from this understanding of logarithmic distribution. If more links can be made to an information source or hub such as J3000, it will receive more traffic. The enthusiasm to do this must be tempered by the need for relevant links, to avoid important information being lost once more.

The internet has also taught us that new links will stem from the biggest hubs as these are the easiest to reach. In this manner "the rich get richer", the bigger hubs get more links. This leads to a network "phase transition" where the smaller hubs are lost as the biggest evolve. As such it may be possible to analyze which way this shift might naturally go, pre-empt and facilitate it to expedite the Consulting Engineering Firm networks evolution. It is possible that this could be J3000 and the Helplines, but further investigation should be undertaken. The decentralized nature of networks makes them stable. Destruction of 10% of hubs is not massively destructive as 80% of hubs tend to be of low value. However removing just a few very large hubs could have a large impact forcing a regressive "phase transition" to an earlier stage. The implications for Consulting Engineering Firm are that one person becoming a significant hub should be avoided, as their loss could seriously hamper knowledge distribution. The use of Communities of Practice could help to do this, by decentralizing specialty everyone in the group becomes an important hub.

The only links to the job files are human which makes finding information sporadic. Windows explorer can be used to locate documents but is slow and may produce too many documents to be sensibly useful. This could be improved with a desk top search engine which could sort information more efficiently. As discussed previously the merit of codifying all explicit knowledge held by the practice to an intranet site is questionable. However the site may provide a useful hub, linking to internet sites, J3000 and the rest of the j drive possibly through jobs questionnaire. This allows information to remain dynamic and evolving as most internet sites are regularly updated by their own dedicated staff. In this manner the search process may be expedited and the information current.

4.3 What can be Learnt from Communities of Practice?

Communities of practice have the potential to improve the tacit to tacit knowledge transfer within the company. The reuse of existing knowledge could be improved and hence reducing time wasted

"reinventing the wheel". Personal communication is interactive, which again saves time and gives amore efficient transfer. Communities of practice help decentralize knowledge, preventing one person becoming too significant a hub within the practice knowledge network. Without this system the removal of one very significant person could lead to the collapse of the network.

The theory of situated learning questions the conviction that there is intrinsic worth in capturing all tacit knowledge, making it explicit and distributing it to all. Within a Communities of Practice tacit to tacit transfer occurs when and where it is needed. Indeed, it has been argued in a number of papers (Collins, 2001; Ambrosini and Bowman, 2001; Herbig and Büssing, 2003), that tacit knowledge can not be expressed in a written form. By its definition knowledge is personal and context based, its use by another individual requires human interaction within a suitable environment such as a Communities of Practice (Ambrosini and Bowman, 2001). So focus needs to be given to which pieces of knowledge need to be made explicit.

5. Conclusions

Knowledge Management is considered to be one of the main aspects of advancing the competitive advantage of organization. It is no surprise that many organizations with the construction sector are keen to adopt various knowledge management theory and practice to achieve a competitive edge over their competitors.

A case study was conducted over two years to evaluate the application of various knowledge theories in a consulting engineering firm. The case study showed that knowledge within this consulting engineering firm exists in large quantities and in many forms. This paper has identified that access is gained to the information through a simple knowledge network. By streamlining this network, it is hoped more efficient access to information could be achieved. The major hubs appear to be the Helplines intranet site, which links to the internet, large computing database system (J3000) and specific engineers with expertise; and the engineers themselves who provide a link to the job files, J3000 and the internet. By utilizing Communities of Practice this network can be strengthened and tacit to tacit knowledge exchange improved.

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