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Managing knowledge: lessons from the oil and gas sector

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Knowledge management (KM) is of increasing interest to a number of leading UK construction organizations. Companies are keen to find out what other organizations are doing both within the construction and other industry sectors. There are important lessons to be learned from Canadian oil and gas organizations on how they manage their knowledge. A case study is used to explore the KM activities of eight leading organizations and investigate the opportunities for construction organizations to adopt some of their ideas. Three areas are covered: KM strategy and implementation, people aspects of KM and metrics for KM performance. There are several potential lessons for UK organizations: the need for KM to be driven by senior management if it is to have any notable success; the use of people-centred techniques for sharing tacit knowledge and IT tools for sharing explicit knowledge; the importance of selling solutions to project teams to obtain employee support for KM; peer recognition has a more sustainable impact than financial reward; and KM measurement should be considered as a way of improving its impact, rather than justifying expenditure.

Keywords: Knowledge management, construction, oil and gas sector

Introduction

Several authors refer to the existing knowledge economy and the need for organizations to develop their knowledge assets. The UK Government's Competitiveness White Paper, *Building the Knowledge Driven Economy*, defines the knowledge driven economy as 'one in which the generation and the exploitation of knowledge has come to play the predominant part of wealth creation' (Department of Trade and Industry (DTI), 1998). The paper refers to the more effective use and exploitation of all types of knowledge, particularly in the traditional engineering industries in order to give the UK a competitive edge.

Knowledge is at the heart of today's global economy but a comprehensive approach to managing knowledge in order to maximize returns is missing (Kluge *et al.*, 2001). Managing knowledge more effectively offers construction organizations a possible mechanism for improving their performance in times of greater competition and reduced profit margins. For example, using a skills database to rapidly source expertise in a

particular domain within a large, international organization can be an important factor in convincing a client that the company has expertise in that area. Similarly, knowledge gained on a particular project may be leveraged to improve bidding opportunity on another project and disseminating lessons learned from problem projects may be used to avoid similar mistakes being repeated.

A number of authors provide different definitions for KM based on their individual perspectives. These fall mainly into the IT perspective where authors focus on IT tools to deliver KM solutions (Ruggles, 1997; Bair and O'Connor, 1998; Jackson, 1998; Gottschalk, 2000; O'Leary, 2001; Tsui, 2002), the Human Resource (HR) perspective that relies on the people aspect to provide KM solutions (King, 1999; Harman and Brelade, 2000; Egbu *et al.*, 2001a) and the integrated perspective which acknowledges that both the IT and HR perspectives complement each other (Quintas *et al.*, 1997; KPMG, 1998; Scarbrough *et al.*, 1999; Tiwana, 2000). Webb's (1998) definition of knowledge management adopts an integrated perspective and defines it as 'the identification, optimization and active management of intellectual assets to create value,

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Table 1 Driving forces for KM

Classification	Driving forces
External	Globalization of business and internal competition Sophisticated customers Sophisticated competitors Sophisticated suppliers
Internal	Bottlenecks in enterprise effectiveness Increased technological capability Understanding of human cognitive functions
Ongoing developments	Economics of innovative ideas Information management and technology Cognitive science Shifts in bottlenecks Customization requirements for sophisticated customers Sophisticated competitors Globalization

(Source: Wiig, 2000).

increase productivity and gain and sustain competitive advantage'. It is this view that KM can develop new opportunity and create value that has attracted the attention of many organizations and has led to a global interest in KM. However, before KM gains support, senior managers are keen to investigate why it is important and the potential business benefits. Wiig (2000) classified the main driving forces behind KM as shown in Table 1.

Mertins *et al.* (2001) highlighted KM's ability to improve organizational goals and therefore its close connection to business processes. They considered KM:

- Provides an understanding of markets and customers;
- Develops visions and strategies;
- Develops products and services;
- Improves marketing and sales; and
- Improves the production and distribution of products and/or services.

In addition, they also identified the top ten improvements achieved through KM as shown in Table 2.

In recent years leading UK construction firms such as Amec, Arup, Bovis Lend Lease and Taylor Woodrow have employed knowledge managers. The number of seminars and studies on KM in construction has heightened the interest in KM and created the need to find out more about how knowledge can be managed better. This paper therefore aims to investigate how companies in another industry sector manage knowledge. It focuses on three key areas of KM strategy and implementation, people aspects of KM and the need for metrics for KM performance.

Table 2 Improvements through knowledge management

Rank	Improvement
1	Cost/time reduction, increase in productivity
2	Process improvement
3	Improvement in the exchange of information
4	Customer orientation and satisfaction
5	Transparency of structures and processes
6	Facilitation of decisions and predictions
7	Quality improvement
8	Staff quality and satisfaction
9	Success, market leadership

(Source: Mertins *et al.*, 2001).

KM in construction

Construction organizations have always managed their knowledge in some form. They have always relied on the expertise of key members of staff. Thus, knowledge management is not entirely new to the industry. What is new is the terminology used and the increased awareness that knowledge should be managed in a more structured manner. This has been largely brought about by a number of factors such as the increased global competition, company size, geographical spread and employee turnover. The increasing size and the geographical spread of organizations have led to large, international organizations that makes it difficult to source expertise quickly or indeed know what expertise is available within the organization. In addition, the high turnover of employees means that there is a need to provide clients with confidence that the organization is competent in specific areas of work. The greater awareness of KM is also particularly timely given the newer types of procurement in the UK, such as the repetitive nature of some PFI projects.

Knowledge is a valuable yet frequently intangible asset. The work by Nonaka and Takeuchi (1995) divided knowledge into tacit (that which is stored in people's heads and is acquired through experience) and explicit knowledge (that which could be documented and therefore physically stored). Within construction, the type of knowledge varies enormously in companies and depends on the aspect of the project life cycle. For example, a consulting engineer's tacit knowledge may be about a specific domain such as the design of oil refineries developed from years of work in this field whereas explicit knowledge may be stored in the codes of practice used to design such refineries. A contractor's tacit knowledge may be the knowledge of which construction methods are most appropriate for a specific situation whereas explicit knowledge will be that contained in a health and safety manual specifying what procedures need to be followed and why.

There has been a lot of interest in knowledge management both from academia and industry. In academia, there have been a number of research papers published on KM relevant to construction. These include: the provision of a KM framework (Kamara *et al.*, 2002); knowledge transfers between organizations (Ferne *et al.*, 2001); the role of IT (Carrillo *et al.*, 2000; Patel *et al.*, 2000); the impact on construction innovation (Egbu *et al.*, 2001b); the impact on business processes and performance (Preece *et al.*, 2000; Robinson *et al.*, 2001); and case studies within specific construction companies (Moodley *et al.*, 2001). Robinson *et al.* (2001), in a study of the state of KM within the UK sector, discovered that over 70% organizations intended to have a knowledge management strategy in place by the end of 2002. The main reasons for this were as follows:

- The need to encourage continuous improvement (92.5%);
- To share valuable tacit knowledge (88.7%);
- To disseminate best practices (86.8%);
- To respond to customers quickly (84.9%);
- To reduce rework (77.4%); and
- To develop new products and services (58.5%).

Some of the larger construction organizations have therefore appointed Knowledge Managers to cope with this new challenge whilst others, such as Mowlem, Interserve plc, AWG plc, have the role consumed within the post of Business Improvement Manager.

Justification for research

A number of other sectors such as oil and gas, manufacturing, software companies, have been involved in KM for a much longer period than construction (Chase, 2003). It is because of the benefits identified by these organizations that a number of organizations are investigating KM. Kluge *et al.* (2001) highlighted the benefits of transferring knowledge between two different contexts to generate benefits such as airline/car racing, hotel/hospital, and cement manufacturer/pizza delivery. In the UK, both industry and research funding bodies have encouraged organizations to look outside their industry sector to identify best practice. The DTI (1998) also supports this by stating that businesses need to benchmark their performance to help identify world-class performance and best practice.

The oil and gas sector in Canada was chosen for lessons learned in managing knowledge for several reasons. Firstly, oil and gas companies such as BP and Shell have been at the forefront of KM research. These organizations have been featured as Global MAKE

(Most Admired Knowledge Enterprises) finalists in each of the five annual studies (Chase, 2003). The MAKE study is the de facto benchmark that identifies leaders in the new knowledge economy. Secondly, Mertins *et al.* (2001) observed that KM in North American firms was at a much more advanced level of development than Europe. Thirdly, Canada is one of the world's largest producer of natural gas and crude oil (World Petroleum Congress, 2000). Fourthly, like the construction sector, the knowledge managed by the upstream businesses (exploration and production) require both tacit and explicit knowledge to be shared amongst virtual project teams. The upstream teams include geologists, geophysicists, reservoir engineers, drilling engineers, marketing personnel, etc. Like construction, it brings together a multi-disciplinary team (who are geographically dispersed) for a limited period to deliver an end product for clients. In construction, the end product is a physical structure. In the case of the oil and gas sector, the end products are natural gas, bitumen, crude oil, etc., delivered to a refinery for processing.

KM is at an embryonic stage in UK construction (McConalogue, 1999; Robinson *et al.*, 2001). Based on research conducted since 1999 with leading UK construction companies regarding their KM practices, such companies are interested in KM and are eager to find out what others are doing. In particular, companies are interested in the strategies and techniques for managing knowledge, mechanisms for encouraging employees to participate in KM activities and how to identify benefits of KM. With this in mind, three key areas were devised for investigation. These were as follows:

- KM strategy and implementation;
- People aspects of KM; and
- Metrics for KM performance.

Research methodology

A case study research methodology was adopted because it facilitated access to staff who could explain the importance of KM to the organization and how they managed knowledge. The Canadian oil and gas companies are clustered in Calgary, in the province of Alberta thus making it easy to gain access to a number of organizations in a limited period. A research secondment to the University of Calgary, Canada provided key contacts within the oil and gas companies. Eleven Canadian oil and gas companies were interviewed. The staff interviewed had senior positions with responsibility for KM such as the Director

Table 3 Company background

Category	Organization	Position	Net earnings (\$M CDN)*	Number of employees
1	A	eBusiness Leader	7730	3400
	B	Manager, Technology Planning & Integration	3995	3300
	C	Manager, Business Information	3194	2800
	D	Vice President, Knowledge Exchange	6272	3700
	E	Director, Knowledge Exchange	2606	2000
2	F	Manager, Project Planning & Control	17 245	6740
	G	Project Manager	3200	3500
	H	Manager, Reservoir Engineering	8690	4500

*The exchange during the research period was \$2.2 CDN = £1.

of Technology Planning and Integration, Director of Knowledge Exchange, Manager of Project Planning & Control, Project Managers and Lessons Learned Co-ordinators. Interviews were generally conducted with one senior individual but in three cases, joint interviews were held with two individuals because the main interviewee felt that one of their employees could offer valuable input to the questions asked. Each interview lasted one to two hours and was supplemented by information available on the company websites, company publications, internal reports and copies of presentations made to the executive board.

Case study results

The case studies sought answers for a number of questions relevant to UK construction organizations about to embark on KM, as well as those already involved in KM. The main topics covered for the case study were as follows:

- Company background;
- KM strategy and implementation;
- People aspects of KM; and
- Metrics for KM Performance.

Company background was investigated in order to understand how the size of the Canadian companies compared to UK construction companies in terms of revenue and number of employees. KM strategy and implementation was investigated because UK construction companies, as relative newcomers to KM, are keen to investigate what their competitors and those in other sectors are doing. The people aspects was investigated because this is the area that is causing much interest in KM. Literature has shown that a multi-faceted approach of focusing both on people as well as IT is required for KM to be successful. The metrics for KM performance was highlighted because of the need to justify KM expenditure to the executive board.

Company background

In benchmarking KM activities, it is important to understand how the case study companies compare in terms of company size, i.e. number of employees and annual turnover. KM is an activity that mainly large organizations have invested in so far. It is also a problem mainly associated with large organizations (Davenport and Prusak, 1998). Thus, the largest eleven oil and gas companies in Canada were used as case studies. The case study organizations can be classified into three categories. Category 1 consists of organizations that have specific KM initiatives and dedicated staff implementing KM. Five companies belong to this category. Category 2 consists of organizations that do not use the term KM in their everyday vocabulary but practised specific aspects of KM, e.g. succession planning and lessons learned. Another three companies belong to this category. The remaining three organizations interviewed do not use the term KM and stated that they did not undertake any specific activities to pro-actively manage knowledge. Table 3 below shows the background of the companies interviewed

KM strategy and implementation

If senior management is not aware of the benefits of KM and if they are not seen to give it priority, then no one else will take it seriously (Kluge *et al.*, 2001). Skyrme (2000) stated that successful organizations are typically those that have a clear vision and leadership, and appreciate the contribution of knowledge to business performance. This section addressed four main areas as follows:

- (1) Level of awareness of KM – this investigates the level of awareness of KM amongst the senior management level;
- (2) KM strategy – this investigates specific strategies and initiatives used;
- (3) Main KM tools – this investigates the IT and non-IT tools being used; and

- (4) Main barriers to KM – this investigates specific barriers encountered in managing knowledge and whether they were similar to those encountered by UK construction companies.

Level of awareness

Of the eight Category 1 and 2 organizations, the five Category 1 organizations were able to define KM and identify specific KM initiatives within their organizations. The KM definitions provided were: ‘a mechanism for accessing the expertise held by members of staff even after they have left the organization, the retention of intellectual capital, the ability of people in the organization to know what information is held by the organization and to be able to access it’; ‘managing the organization’s explicit and tacit knowledge to provide competitive advantage’; ‘getting knowledge to the right people at the right time so that they can make the best possible business decisions’; ‘a mechanism for encouraging a collaborative culture within the organization in order to foster innovation and a culture of exchanging knowledge’ and ‘getting the right knowledge to the right people so that they can add value’. Category 2 organizations did not have definitions of KM but some of their activities are certainly mechanisms for sharing knowledge.

There are different levels of awareness and support for KM amongst the companies. For example, companies B, C, D and E had KM driven from the senior executive level. Companies F, G and H had very strong support from senior management but focused on particular aspects of KM, namely Succession Planning and Lessons Learned. Company A had little support from senior management and this resulted in one individual championing KM.

The main drivers for KM were (1) the financial consequences and (2) the need to transfer knowledge to a young workforce. Plant shutdowns mean a loss of millions of dollars per day in revenue. Therefore, any mechanism for helping to minimize these shutdowns,

based on rapid access to knowledge, is considered valuable. Also, there is an ageing population employed by the oil and gas sector, and companies such as A, C and E recognize that they will lose a large proportion of their tacit knowledge within a few years. Therefore, any mechanism that transfers knowledge more rapidly is vital. Company B had its knowledge assets valued by a leading management consultant and became concerned about how they were managing this asset.

KM strategy

In order for KM not to be just another business solution sold by management consultants, organizations have to be clear as to why they are managing knowledge and what they expect from it. Thus planning what is to be done in terms of a KM strategy and devising an implementation plan is vital. Of the eight Category 1 and 2 organizations, four organizations (B, C, D, E) have a KM strategy that is linked to their business strategy. This concurs with a survey of leading organizations using KM where only 52% of the respondents had strategic goals that included KM explicitly (EFQM/APQC/KMN, 1997). The preferred mechanism of linking the KM and business strategies was to look at how the KM initiatives implemented related to the metrics used by the business units.

The focus has been mainly on sharing knowledge although some organizations are actively pursuing mechanisms for creating knowledge. The people-centred approach is more appropriate for sharing tacit knowledge since it puts people in touch with one another whereas the IT-centred approach is more appropriate for sharing explicit knowledge (Ruggles, 1997). Of the eight companies, 5 (D, E, F, G and H) adopted a people-centred approach to sharing tacit knowledge, two companies (B and C) adopted an IT-centred approach for sharing primarily explicit knowledge whilst the remaining organization (A) adopted an approach that combined both people and IT. Table 4 shows the approaches and techniques adopted by each company.

Table 4 Companies’ approach to KM

People-centred	People-centred & IT-centred	IT-centred
D (Expertise database*, communities of practice*, technical forum)	A (Expertise database, threaded discussion, Intranet, Electronic Document Management System)	B (Company web portal, data mining tools)
E (Expertise database and communities of practice)		C (Range of IT tools for sharing knowledge)
F (Succession planning and lessons learned)		
G (Succession planning, lessons learned, ‘cold eyes’ review, communities of practice)		
H (Tutoring and succession planning)		

*Note: Expertise database and communities of practice are considered as people-centred because they rely on getting people to contact each other although these techniques use IT as the media to store contact details.

The main techniques used for sharing tacit knowledge were communities of practice, expertise databases, succession planning, mentoring, tutoring, technical forum and lessons learned sessions. Communities of practice are groups of individuals with a common interest although they may work for different business units. Expertise databases (or skilled yellow pages) are used to source individuals in order to encourage communication. Succession Planning is a formal process designed to groom specific employees for a role once the incumbent leaves the company. This facilitates the transfer of mainly tacit knowledge between the successor and the incumbent. Some companies have found that mentoring does not work as well as it should because the mentors are too busy. Tutoring attempts to overcome the shortcomings of mentoring. Companies employ a third party, usually a retired employee or external consultant who has inside knowledge of how the company operates, to coach junior employees. Technical forums are sessions that last several days and are used to bring employees from different business units together in order to share knowledge. The topics and agenda of the technical forums are organized by discipline leaders within a particular business unit and the KM team. Lessons learned sessions are conducted close to or after project completion. It aims to understand the successes as well as the failures on the project in order to re-create successes and avoid future mistakes. It provides a forum to openly discuss problems in a no-blame environment. Linked to lessons learned was a technique used by Company G called the 'cold eyes' review. It involves a meeting of 9–12 experts (internal and external) of different backgrounds at the start of a project. They critique the project at various stages and provide feedback on how it could be improved.

The main techniques for managing explicit knowledge focused on the use of IT tools such as document management systems. These are supported by a number of industry specific tools such as well as generic tools such as databases and collaborative tools.

Main KM tools used

Companies were asked to identify the IT and non-IT tools used for KM within the organization. It is interesting that some organizations had to be prompted to identify non-IT tools because many interpreted IT as *the* tools for KM. Table 5 shows the tools identified by the case study companies. These are divided into tools for creating and sharing knowledge. Companies believed the IT tools provide sufficient functionality but the main problem lies in getting busy employees to find time to learn to use the tools.

Main barriers to KM

Kelleher and Levene (2001) identified a number of barriers ranging from an over-emphasis on technology to the cultural shifts required. The case study companies were asked to identify their main barriers to KM. The results highlighted time constraints and cultural problems but disagreed with the over-emphasis on technology. The ranking obtained was as follows:

- (1) Not enough time – the need to prioritize tasks means that KM activity is seen as desirable but not essential;
- (2) Organizational culture – regarded as a problem because business units operate as vertical silos. Also, in terms of the organizational structure adopted, particularly if there is a top-down structure;
- (3=) Lack of standard work processes – this highlighted the different work practices throughout an organization resulting in a number of ways of conducting similar tasks; and
- (3=) Insufficient funding – the cost of the enterprise-wide systems desired by some organizations is prohibitively expensive. In addition, there is a perception that the organization is not yet ready for such systems and perhaps the use of more locally controlled systems are more appropriate.

Other barriers stated were (1) employee resistance where the organizations are trying to adopt enterprise-wide systems that encourage staff to change their work processes; (2) employees not understanding the benefits of KM; (3) lack of incentives to encourage knowledge sharing; (4) the reluctance to admit ignorance with employees believing that they are paid to solve problems, if they are not able to solve their problems they feel vulnerable and are unlikely to seek advice; (5) not knowing how to frame the question or who to ask because they do not have a network; and (6) organizational structure in terms of the asset-based operations and the competition between managers to achieve performance targets. Interestingly, poor IT infrastructure was not considered a problem because IT resources were considered to be readily available.

People aspects of knowledge management

Managers cannot neglect the softer, opaque, more difficult side of KM; this is the area for greatest potential (Kluge *et al.*, 2001). Ruggles (1997) has also highlighted that providing KM solutions involves both the hard technological aspects and the softer human resources (HR) aspects. The early focus on KM resulted in technological solutions with a bias towards the use of

Table 5 KM tools used

Create knowledge	Share knowledge
<p>Non-IT tools</p> <ul style="list-style-type: none"> • Conferences • CONRAD¹ • Customized training programmes • Technology planning process² • Tours to reputable universities and companies • University-based research projects • War room³ <p>IT Tools</p> <ul style="list-style-type: none"> • Discussion boards • Margin model (data warehousing software) • Patent search engines (for data mining) • Subscriptions to various corporate intelligence sources on the internet 	<p>Non-IT tools</p> <ul style="list-style-type: none"> • Career dialogues • ‘Cold eyes’ review • Communities of practice • Expertise database (skills yellow pages) • Lessons learned • Mentoring • Networks/decision teams • Performance diamond⁴ • Project management systems⁵ • Succession planning • Technical forum • Technical peer assist⁶ • Tutoring <p>IT Tools</p> <ul style="list-style-type: none"> • Autonomy • FileNet (document management system) • Game Changer⁷ • IMACS⁸ • LiveLink⁹ • Lotus Notes⁹ • NewsEdge¹⁰ • PEARL¹¹ • The Source¹² • Web portals

¹Canadian OilSands Research and Development is a research alliance between industry and other research partners including government and academia.

²In-house system to pro-actively look for technology to benefit the business in the future.

³Process aimed at capturing tacit knowledge.

⁴An in-house system to create work plans for staff development.

⁵In-house IT systems used for Upstream processes (used at a strategic level) and resources (used at a tactical level).

⁶In-house system for sharing and learning between teams.

⁷A web-based process for submitting and evaluating ideas for step changes.

⁸customer relationship management systems with other functions bolted on.

⁹A collaboration tool.

¹⁰A news alert service.

¹¹A mechanism for suggesting incremental process improvements.

¹²An in-house dissemination service to the most senior staff.

IT. However, many of these were not successful because they ignored the people required to make them work. More recent work has focused on the importance of HR in knowledge management but these have yet to be developed in terms of concepts and frameworks (Hislop, 2003). This section focuses on investigating how the case study organizations encouraged employees to both contribute to and use their KM systems. It also investigated whether there was a need for financial incentives. The questions asked were:

- How was employees’ support for KM obtained;
- The need for incentives and rewards; and
- How the incentives were managed.

Employees’ support for KM was investigated because of the increasing awareness of the need for employee buy-in for successful KM initiatives (Storey and

Barnett, 2000). The needs for incentives and rewards are controversial. Some authors argue that employees must be encouraged and rewarded for sharing knowledge whilst others are firmly against this. The remaining questions sought to investigate the views on incentives and how they are managed.

Employees’ support

Companies A and C believe in selling solutions to teams. They considered it important to answer ‘what’s in it for me’ if employees were to support KM projects. Company B focuses on providing an IT solution and planned to make their new web portal indispensable to encourage use. Company D focuses on encouraging middle management to realize that they need to release their staff to attend the technical forums organized. Company E uses the benefits gained by other

companies, including oil and gas companies, to sell KM. Company F was well known throughout the industry for their adherence to processes. These processes have evolved over time and non-compliance is seriously frowned upon with potential adverse effects on career progression. Company G uses communities of practice, being part of the community was considered important. Company H requires leadership within a team (including sharing of knowledge) to be promoted to the upper levels of management.

The need for incentives and rewards

The question of incentives and rewards for encouraging employees to share knowledge provokes debate. Even those that support reward dispute whether these should be financial or non-financial. Incentives must encourage teamwork as well as individual performances and disincentives to discourage knowledge hoarding or any aversion to 'not invented here' (Harman and Brelade, 2000; Kluge *et al.*, 2001). Dixon (2000) adds that although incentives work to some extent, none of them deliver the hoped-for results. Murray (2000) believes that reward structures need to be visibly in place, not necessarily financial rewards; formal peer recognition is often a high motivator for experts. Limited research has been done in this area with respect to the construction sector but Sheehan (2000) believes that peer recognition is more highly valued in the construction sector and financial rewards promote division amongst employees.

Company A believes peer recognition is the main incentive with financial reward secondary. They use their in house PEARL system (a system that allows individual to submit suggestions for improvement) to propose financial reward in conjunction with personnel appraisals. Company B agrees that incentives are important, in the form peer recognition, not financial reward. The company has a culture of sharing and those not willing to share are ostracized by their peers. There are plans to create an award (non-financial) for recognizing people by their contribution to the portal. Company C has a number of performance-based rewards. They have a 'high performance work system' (HPWS) for all employees and an 'incentive compensation' for their leaders. The HPWS allows employees to get up to 6–12% of their salary as a bonus. This is to be considered for their KM system in terms of providing bonus for contribution to the KM system. The company also has an 'Applause' programme whereby any employee can give another up to a maximum of \$250CDN or a letter of thanks. However, a letter from the Chief Executive Officer is considered much more valuable. The Applause can also be up to six months salary after going through the HPWS process. Company D has performance-based incentives, but

these do not take into account sharing knowledge and is heavily biased towards individual performance. Senior management believes that the existing incentives are working and there are no immediate plans to provide separate incentives for knowledge sharing. Company E strongly supports incentives and rewards (financial and non-financial) to encourage knowledge sharing. However, these have not yet been finalized but were expected to be modelled on an existing innovation award. Company H's incentive for sharing is promotion to senior levels of management. To do this, employees must demonstrate leadership, of which one element is their ability to share knowledge. There are also cash and/or stock options for performance based on length of service. However, peer recognition is considered more important than financial rewards.

Metrics for KM performance

One of the main issues faced by those tasked with managing knowledge is how to justify expenditure on KM given the competition for funding. The commercial environment dictates that the benefits of managing knowledge should exceed the costs invested. The UK construction industry has become very focused on performance measurement and UK knowledge managers are seeking ways to justify KM expenditure. The problem lies in the selection of appropriate metrics. Skyrme (2000) warns that focusing too much on metrics can lead to measurement myopia. A number of authors have proposed metrics for KM performance but historically these have focused on financial indicators such as return on investment, market capitalization method, direct intellectual capital, etc. (Stewart, 1997). However, as Siemieniuch and Sinclair (1999) point out, these measures are a poor interpretation of the benefits of KM. In more recent years there has been a shift towards more holistic metrics such as the Balanced Scorecard (Kaplan and Norton, 1996) and the Excellence Model (EFQM, 2003) that take into account both financial and non-financial benefits, and leading and lagging measures (de Gooijer, 2000; Kelleher and Levene, 2001). Whatever the metrics, these should be linked to business goals. The challenge is whether and how the influence of other business improvement measures should be considered (Kluge *et al.*, 2001). Tiwana (2000) found that whilst several companies had been successful in implementing KM, as yet, none had a strong measurement programme in place.

The questions asked in this section included: the need to measure the benefits of KM, and how to measure the benefits. These questions were asked because UK construction companies with KM initiatives can benefit

from understanding how other organizations justify their KM expenditure and the types of metrics used.

The need to measure the benefits of KM

Linking KM initiatives to profitability was acknowledged as a difficult problem and some interviewees recognized how fortunate they were to work for organizations that were prepared to invest in KM without expecting hard measures of success. Company A believes measurement is hugely important and the corporate view is that anecdotal and quantitative measurement is important. Company B launched a web portal thus they considered it important to measure the performance of the portal in order to improve its performance. However, they acknowledge that it is difficult to link their efforts with profitability. Company C recognizes the importance of measuring success. Its library acts as a focal point for the exchange of knowledge by both putting people in touch with the right person and by sourcing relevant material. The library is run as a business unit and its benefits are tracked in terms of staff time and cost savings. Company D has not been called upon to justify its KM initiatives because senior management understands there is a need for KM initiatives to foster greater communication between the business units. Company E considers measuring benefits important for obtaining support, providing value to members of the communities and as a mechanism for improvement. Company F compared their KM projects to that of the safety systems whereby the investment is the highest return possible, rather than face the consequences of losing competitive advantage due to a lack of investment in the KM. Companies G and H do not believe that there is a need to measure benefits since KM should form part of the normal business process.

How to measure the benefits

To date none of the organizations have any metrics specific to KM. Company A relies on anecdotal evidence of how KM helped individuals and teams and is extremely wary of attempting to put a cost to the benefits derived. Company B plans to use qualitative feedback from users of their web portal. They cannot see how their KM efforts can be distinguished from other business improvement methods. Company C uses different metrics depending on the phase of work. For example, their *Source* IT solution was evaluated based on how often it was accessed, how many staff were populating it, number of problems experienced accessing it, etc. However, they acknowledged that it would be difficult to have KM metrics for each project. Company D uses social network analyses and collects usage rates of its collaborative tools in order to understand what interventions are required.

Social network analysis is a technique used to identify communication bottlenecks or unexploited communication channels. Company E is in the process of linking their KM efforts with metrics for individual business units. Company G does not have any KM metrics and Company H benchmarks their overall performance in the industry to determine whether their KM efforts are being directed correctly. They make no attempt to separate KM efforts from other business performance efforts.

Discussion

The upstream oil and gas business has similarities to the construction sector in terms of its temporary and often virtual project teams. In addition, oil and gas companies have been at the forefront of KM and thus there may be an opportunity for the UK construction sector to learn from these case studies. The discussion examines the key learning points arising. The disadvantages of using a case study methodology is recognized in terms of rigour, generalization and validity (Yin, 1984). However, the paper is meant to provide an insight of KM activities for UK construction companies rather than rules for managing knowledge.

Lessons learned: KM strategy and implementation

There are numerous lessons arising in this area. Firstly, gain senior management support. The companies who were most proud of their KM achievements and had a clear idea of their goals had senior managers who were supportive of KM. Examples of these were companies B, C, D, E and F. In fact, Company E had KM author Larry Prusak speak to their executive board and review their KM strategy. These companies see KM as vital for corporate survival and allocate funding for KM initiatives. Company A was one example where one individual was championing KM without senior management support. This meant that he had insufficient resources to undertake the types of activities he thought necessary. For many UK construction organizations, because of 'initiative overload' KM may not appear on the radar screen of many senior executives. Thus, the onus is on KM enthusiasts to bring this issue to the fore. One way of doing this is for KM champions to develop a business case for KM within the organization. This business case should highlight why KM is important, the potential benefits of KM, and the types of KM initiatives that can be undertaken. Schilling *et al.* (2002) provides some guidelines on creating a business case to secure funding.

Secondly, identify separate tools for sharing tacit and explicit knowledge. IT tools are more suitable for

sharing explicit knowledge and facilitating collaboration. Different tools are needed for sharing tacit knowledge. These may include techniques such as succession planning, tutoring, technical forums and lessons learned. Succession planning is a long-term activity and requires commitment from senior management and the HR department to identify potential successors. Tutoring recognizes the shortcomings of mentoring and is a possible solution for the design office environment where tacit knowledge of more experienced personnel are able to coach junior members of staff. Technical forums and lessons learned facilitate the sharing of tacit knowledge and learning, both good and bad, to avoid repeating costly mistakes on future projects. They are mechanisms that UK companies consider of benefit but seldom manage to execute. Lessons learned requires a cultural shift to force them to happen. A suggestion is to make it part of the quality procedures to make sure it gets done.

Although an observation, rather than a lesson learned, it was interesting to note that the Canadian organizations experienced the same types of problems as those identified by UK organizations (Robinson *et al.*, 2001) in terms of lack of time, organizational culture, lack of standard work processes and insufficient funding. The main difference was that they did not consider IT support as a barrier.

Lessons learned: people aspects of KM

The key lessons to be learned concerned the approach adopted and the types of incentives awarded. Firstly, sell solutions to real problems experienced by project teams. Some of the case study companies undertook a root-cause analysis of problems (pain points) and proposed solutions are not labelled as 'KM' solutions. The benefit of this approach is that: (1) companies have found that teams are willing to discuss problem areas; (2) teams are then more willing to accept help and to help develop solutions; and (3) using a small KM team means that the project team has ownership of the solution and does not feel threatened by a large KM department imposing a solution.

Secondly, recognize contributions by highlighting employees' input and use of KM systems but avoid financial reward. The award of financial rewards for sharing knowledge is not part of the UK construction culture and whilst it may create a temporary interest in KM, it is not sustainable. It would be difficult to manage a performance related pay scheme specifically for KM given the given the emphasis on teamwork.

Lessons learned: metrics for KM performance

The key lessons learned are (1) measurement should only be used as a means of improving the impact of KM

initiatives, and (2) any metrics used should link directly to existing business metrics in order to show the added value of KM. The case study companies considered KM as an integral part of other business processes to improve performance with long-term rather than short-term results. None saw a need to segregate their KM efforts from other efforts to improve performance. Thus the view of measuring KM performance to justify expenditure on KM was not well received. UK construction companies should therefore recognize that KM is only one of the tools that contributes to business improvement. Measurement to justify KM expenditure may force companies to focus on the unrealistic quantitative measures rather than recognizing some of the qualitative benefits. In terms of metrics, three of the organizations were considering ways of developing metrics and these were all to be linked with existing performance metrics. Understanding the link between KM initiatives and how it impacts on existing business metrics is a key element in ensuring KM produces real added value.

Conclusions

Case studies of eight leading Canadian oil and gas companies' approach to managing knowledge have been carried out. Three areas were investigated: KM strategy and implementation, aspects of KM and metrics for KM performance. Several lessons were learned that can be considered by UK construction organizations:

- Lesson 1: KM should be driven by senior management if it is to have any notable success. The case study companies who were most proud of their KM achievements had the full support of the senior managers. Companies that do not have this support find that limited resources restrict their KM activity. One way of obtaining such senior level support is to produce a business case highlighting why KM is important, the potential benefits, the types of KM initiatives that need to be undertaken and an estimate of the costs involved.
- Lesson 2: use people-centred techniques for sharing tacit knowledge and IT tools for sharing explicit knowledge. Many companies focus on IT tools for knowledge sharing. However, whilst these are good at sharing explicit knowledge, there is a need to focus on techniques that support the sharing of tacit knowledge that is so vital to construction organizations. Possible techniques include succession planning, tutoring, technical forums and lessons learned sessions.
- Lesson 3: selling solutions to project teams helps gain employee support for KM. This relies on

providing solutions to real problems rather than an abstract desire to share knowledge throughout the organization. It involves exploring knowledge-related problems and providing solutions for these problems.

- Lesson 4: peer recognition has a more sustainable impact than financial reward. Acknowledging the contributions of both individuals and teams is not as prevalent in UK as it is in North America. In recent years the public recognition of individuals such as Building Manager of the Year Award, Consulting Engineer of the Year Award, etc., go some way to acknowledging employees' contributions. Some of these ideas can be scaled down to suit individual companies.
- Lesson 5: KM measurement should be considered as a way of improving its impact, rather than justifying expenditure. Performance measurement is now prolific amongst construction companies in an effort to show continuous improvement. One way of demonstrating impact is to tie KM initiatives to existing metrics to ensure that it adds value to the business.

KM is evolving rapidly but construction organizations are at the embryonic level and there is a lot of work to do. Organizations are keen to find out what works well in other organizations. This paper goes some way in suggesting how KM can be implemented. However, given KM's importance and an increasing amount of literature on the subject, there will be additional lessons to learn as the field matures.

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