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Exploiting Knowledge Management: The Engineering and Construction Perspective

Patricia Carrillo¹ and Paul Chinowsky²

Abstract

Construction companies have always relied on their knowledge assets to provide services to clients. In recent years the terminology 'knowledge management' has been introduced. Knowledge management (KM) seeks to formalize the manner in which companies exploit their knowledge assets by harnessing organizational knowledge, promoting greater collaboration between groups with similar interests, capturing and using lessons learned on previous projects, etc. This paper investigates how major US engineering design and construction firms are implementing knowledge management initiatives in order to identify best practice. It adopts a case study methodology to investigate companies' Strategy and Implementation, People Aspects and Metrics for Performance. The study finds that there is a clear distinction between the knowledge management activities undertaken by large engineering design firms and those of construction firms. There is also a much greater emphasis on knowledge sharing, which is just one component of knowledge management. Moreover, some companies have specific KM initiatives whilst others have activities that are part of their normal business processes.

CE Database subject headings: construction companies, human factors, information technology, knowledge-based systems, management

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Introduction

Knowledge management has received much attention since the publication of Nonaka and Takeuchi's (1995) text *The Knowledge-Creating Company*. KM has been sold as a tool to improve performance with many academic and practitioners advocating the business benefits of KM including revenue growth, shorter design and production times, customer and staff satisfaction, market leadership, etc. (Mertins et al., 2001, O'Dell et al., 2000). These findings have also been supported by companies such as BP, Buckman Laboratories, Marconi, Texaco Chevron, World Bank, etc. It is these benefits that many construction organizations seek to mirror when they invest in knowledge management. Unfortunately, these efforts have been hampered by the wide range of opposing definitions of knowledge management and different approaches adopted by companies. This adds to confusion within companies with conflicting interpretations of knowledge management and a lack of distinction from information management systems.

Early literature on KM was pre-occupied with the distinctions between data, information, and knowledge. However, it is now recognized that companies need a fluid mix of all these and whilst it is important to distinguish between information management and knowledge management, the latter also needs information management. Webb (1998) defines knowledge management as '*the identification, optimization and active management of intellectual assets to create value, increase productivity and gain and sustain competitive advantage*'. Other similar definitions are provided by KPMG (1998), Scarbrough et al. (1999) and Davenport and Prusak (2000) and stress the proactive exploitation of knowledge to improve company performance.

Organizations have adopted two different strategies to implement knowledge management. The IT-centric strategy focuses on the use of IT tools to facilitate the capture, access and reuse of information and knowledge (Earl, 2001; O'Leary 2001). These use electronic databases such as project extranets and collaborative tools to facilitate knowledge sharing. The HRM-centric strategy focuses on the establishment of means to motivate and facilitate knowledge workers to develop, enhance and use their knowledge in order to achieve organizational goals (Beijerse, 1999; Harman and Brelade, 2000). It fosters a learning organization, creation of networks, identifies and disseminates lessons learned on previous projects, addresses organizational culture, etc.

The different strategies can be attributed to Nonaka and Takeuchi's (1995) distinction between tacit and explicit knowledge. Explicit knowledge is that which could be documented and therefore physically stored in either paper or electronic format. For the construction industry these include standard operating procedures, best practice guides, etc. Explicit knowledge thus lends itself to an IT-centric strategy (Zack, 1999; Tiwana, 2000). Tacit knowledge is that which is stored in people's heads and is acquired through experience. This is much more difficult to document. For construction this covers the know-how of experienced staff e.g. team leaders. Tacit knowledge is better shared using communication channels such as face-to-face contact, communities of practice, lessons learned, etc and lends itself to an HRM-centric strategy.

Jashapara (2004) demonstrated the multi-faceted dimension of knowledge management. Regardless of the strategy selected, a number of inter-disciplinary factors such as organizational culture, the approach to learning and the systems and technology available, impact upon knowledge management as shown in Figure 1.

<Insert Figure 1>

KM in Construction

The construction industry is very competitive with low profit margins. It is this competitive environment that makes knowledge management appear particularly attractive. Specifically, although each project is unique, there are processes that require employees to find out 'who knows what' and to share 'lessons learned' in a timely fashion. Thus KM has created considerable interest in many large, geographically dispersed construction companies where there is a need to tap into the knowledge and expertise of employees, regardless of location. In the UK, many leading engineering design and construction firms have appointed Knowledge Managers to oversee their knowledge management activities. These include companies such as Amec, Arup, Balfour Beatty, Bovis Lend Lease, Cyril Sweett, Taylor Woodrow, Turner Townsend, Wates Construction, etc. In addition, there are a number of publicly funded projects investigating how knowledge management could be exploited in the construction sector. These include the Construction Industry Research and Information Association's (CIRIA) Benchmarking Knowledge Management Practice in Construction (CIRIA, 2004) and 'Building a Business Case for Knowledge Management, and the Partners In Innovation (PII) Knowledge Management for Sustainable Construction. In addition, there are numerous other research projects based at universities that include industry collaborators. Combined, these projects have provided an overview of the state of knowledge management within the UK sector and have highlighted the knowledge management activities in the industry, the benefits to be derived and the challenges encountered.

A survey of UK project-based organisations shows that about 50% of the respondents (majority were from the construction industry) noted that KM would result in new technologies and new processes that will benefit the organisation (Egbu, 2002). Robinson et al. (2001), in a survey of UK engineering and construction firms, was able to identify the main drivers for knowledge management in construction as:

- 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%).

Another survey of engineering design and construction organisations revealed that about 40% already have a KM strategy and another 41% plan to have a strategy within a year (Carrillo et al., 2004). Studies show that the most publicized knowledge management initiative is the post-project evaluation (Orange et al. 1999). Kamara et al. (2003) also describe the reliance of people to transfer project knowledge and the use contractual arrangement such as partnering to share knowledge.

The increasing interest in knowledge management has led to an eagerness to find out what others are doing and thus benchmark company efforts. In the UK a number of research projects allow this to be undertaken informally. In the US the APQC has a benchmarking forum but to date construction companies have not participated.

KM in the US construction sector

Like the UK, the US construction market is also facing confusion regarding the use of knowledge management terminology. In the US, the differences between best-practices, knowledge management, and learning organizations are currently a focus of interest in the research domain. However, as defined in the UK research, the US is similarly adopting an approach that knowledge management extends beyond information retrieval to an active focus on sharing tacit and explicit knowledge. As detailed by Messner (2003), the focus of knowledge management research in the US is now extending beyond the construction boundaries to include all facets of the construction life-cycle. This focus reflects the awareness that construction knowledge is often tied to issues such as constructability, material management, and design intent, each of which are closely related to the design input. Thus, knowledge managers are recognizing the need to incorporate a broader definition of knowledge in the construction context.

In a current effort to develop an understanding of knowledge management practices in the US construction industry, the Construction Industry Institute is funding a research team to explore Learning Organizations in Construction. As an extension to knowledge management, learning organizations emphasize the continuous acquisition of knowledge and the proactive use of that knowledge to change organizational behavior (Senge, 1990). In this context, the current research effort is exploring the emphasis by construction organizations on two critical elements. First, whether the concept of continuous learning and personal advancement is a fundamental operating concept within the organization at every level and throughout every project and business process, and second, if the tools to access knowledge and institutional experience are available to all personnel to transform the concept of organization learning into a physical reality. These two elements are being investigated through a combination of survey and case study methodologies.

The initial results from this study (based on the first 30 organizations studied) indicate that the US construction industry is fragmented in terms of KM and learning organization implementation. For example, although almost all of the organizations interviewed have a process for capturing lessons learned, 50% state that the process is “ad-hoc” and occurs only after a problem is found rather than scheduling a formal review process. Similarly, almost 50% do not yet employ communities of practice where individuals in similar technical areas can exchange ideas and request input on problem issues. This lack of focus on exchange extends to the implementation of knowledge management software where 37% of the organizations do not have a technical solution in place to support knowledge management. In a related issue, 67% of the companies focus on updating or changing practices reactively after a problem arises rather than proactively when new knowledge indicates a potential enhancement to existing behaviours. However, every company asserts that it does provide access to this knowledge to every employee as they need it for their job.

In summary, the US construction sector is in a similar state as the UK industry. Construction organizations are aware that knowledge management is relevant to their long-term enhancement, but are slow in identifying where to start or where the greatest benefit is going to be provided.

Misconceptions of Knowledge Management

The perception that lessons learned or using project extranets are a company’s knowledge management systems are two major misconceptions. Many construction organizations claim to undertake lessons learned sessions at project close-out. Whilst these contribute to knowledge sharing, lessons learned are only one specific mechanism to share knowledge. Lessons learned add to knowledge gained but frequently they are

not conducted in a systematic manner and have other shortcomings including the absence of all relevant stakeholders, incomplete recording of lessons learned and ad hoc dissemination of the findings, if at all (Orange et al. 1999). This means that lessons learned are not leveraged as well as they may be (Kamara et al., 2003).

Some organizations also misinterpret their intranet/extranet as *the* knowledge management system. Whilst these are vital for both communication and access to data, they are information systems, rather than knowledge management systems.

Challenges for Knowledge Management in Construction

Carrillo (2004) ranked the main challenges faced in implementing knowledge management in construction companies as:

1. Not enough time;
2. Organizational culture;
- 3.= Lack of standard work processes ; and
- 3.= Insufficient funding.

These challenges concur with those experienced by organizations in other sectors Kelleher and Levene (2001) and are thus not unique to construction. Not enough time remains a major challenge, particularly when companies expect employees to take on additional responsibility for knowledge management activities in addition to their everyday responsibilities. In such scenarios knowledge sharing may not appear as a top priority unless individual performance metrics incorporate them.

Organizational culture was ranked second in terms of challenges. Many authors have identified culture as a significant barrier to sharing knowledge (Ruggles, 1998; McDermott and O'Dell, 2001; Moore and Dainty, 2001; Holton, 2001). Dainty et al. (2004) also stated that a challenge for knowledge management is how to encourage

people to willingly share their knowledge. Organizational culture has been blamed for many problems in terms of vertical silos in organizations which lead to a lack of awareness of what others have done, a culture of internal competition which undermines effort to share knowledge, knowledge hoarding, etc.

Lack of standard work processes is a problem with large organizations where, in some cases, have grown rapidly and there are no longer standard procedures leading to different approaches being adopted. The low profit margins of construction organizations and their conservative nature have also led to a reluctance to invest in KM initiatives and the infrastructure support required.

What companies have now realized is that knowledge management cannot be solved by IT alone because it ignores the sharing of tacit knowledge (Tiwana, 2000), a vital component of all construction organizations' expertise. Also, many authors blame the overemphasis on technological solutions for managing knowledge within large organizations for the relatively high failure rate (Ambrosio, 2000; Carter and Scarbrough, 2001; McDermott and O'Dell, 2001).

Methodology

The current research investigated the knowledge management practices of US engineering design and construction firms. This is considered of interest to both US and UK firms as a benchmark of knowledge management activities. A case study methodology was adopted in order to gain a detailed insight into the companies' knowledge management activities. Two large design firms and two large contractors were selected to gain a perspective on the activities of large firms. In addition, one

medium- sized design firm and one medium-sized contractor were studied to understand the similarities and differences between their approaches to knowledge management. It was also envisaged that the study may highlight differences in approach between the design firms and the construction firms.

For each case study company, the person with overall responsibility for knowledge management was interviewed. Interviews were conducted between July to September 2004 and each lasted one to two hours. A total of 19 people were interviewed from 6 companies. The interviews were transcribed and returned to the company in order to ensure the accuracy of the transcript and also, in some cases, to gain additional information. Additional company information such internal reports and presentations were used for supplementary information.

One limitation of the study was the problem of interviewing the correct individual(s) who could answer a wide range of questions relating to knowledge management, including IT and HRM issues. Only one organization had a dedicated knowledge officer. In the remaining organizations, the personnel interviewed had their own perspectives, which may be biased towards their own job function. The case study companies details and the personnel interviewed are shown in Table 1.

<Insert Table 1>

In order to obtain a broader view, the following companies were contacted to enquire whether there was someone, such as a Knowledge Manager or Knowledge Officer to whom questions could be directed. The companies contacted and their responses are shown in Table 2.

<Insert Table 2>

Many staff given responsibility for knowledge management have a technical background and little formal knowledge management training. Thus this investigation is important in providing case studies of how companies addressed knowledge management both strategically and operationally. The interviewees were therefore questioned under three main themes as follows:

- KM Strategy and Implementation;
- People Aspects of KM; and
- KM Metrics for Performance.

KM Strategy and Implementation was investigated in order to understand the approach the companies had adopted and their knowledge management activities. It also provided an insight into the benefits of managing knowledge and the barriers to KM. The People Aspects of KM was investigated to understand how companies obtained employee buy-in for their knowledge management initiatives and their views on the controversial area of reward and incentives for sharing knowledge. KM Metrics for Performance were investigated to find out how companies knew that their initiatives were producing the expected results and how it helped them to improve on existing initiatives.

Case Study Findings

The following section describes the case study findings grouped according to engineering design firms and construction firms respectively.

Engineering Design Firms

Company Background

Three engineering design firms were used as case study companies, two large international firms (CH2M Hill and MWH) and one medium sized national firm (Merrick & Company). Of the three companies interviewed only MWH had a position with sole responsibility for knowledge management; the Chief People and Knowledge Officer. For both CH2M Hill and Merrick, knowledge management activities were added-on tasks for certain employees. MWH has undertaken specific KM activities since 1997 and although CH2M Hill did not have dedicated staff, they have had specific knowledge management initiatives since 2002. The term 'knowledge management' was new to Merrick & Company.

KM Strategy and Implementation

MWH was the only design firm with a KM Strategy. This focused mainly on a people-centric facility involving 'knowledge communities' and 'knowledge bases'. However, major investments were made to their IT infrastructure to support the knowledge communities. Their knowledge management efforts won the Linkage International 2001 Award for their change management and the DM (Data Management) Award 2004 for its KNet portal. They were also the only construction sector company to be featured in the APQC's Virtual Collaboration benchmarking study (a part of their larger KM strategy). CH2M Hill's knowledge management efforts focused on the use of communities of practice.

The main knowledge management activities undertaken by the design firms are shown in Table 3. The primary activities denote those activities that are receiving a strategic focus. The secondary activities are those that occur as background activities

and whilst they fall under the knowledge management portfolio, they are not labeled as such within the companies. Table 3 shows a bias towards design firms using networks (communities of practice) to put employees in touch with each other to exchange tacit knowledge. This is supplemented with other mechanisms such as lessons learned and personnel development schemes to enhance employee knowledge.

<Insert Table 3>

Barriers to Knowledge Management

The case study companies were asked to identify the top three barriers for knowledge management within the organization. The results were disparate. Lack of time was the only factor selected by more than one company. Other barriers highlighted were:

- Lack of management support
- Employee resistance to sharing
- Poor IT infrastructure
- 'Stove-piping'
- Accessing knowledge
- 'Not invented' here syndrome
- Lack of a real-time integrated database

People Aspects of KM

For knowledge management to be a success, companies need to gain employee buy-in for their initiatives so that these are not seen as yet another management idea forced upon the workforce. CH2M Hill's Transportation Business Group's current focus is deploying communities of practice throughout the US. The Communities have teams consisting of representatives from all four US geographical regions. The teams develop, launch and market the communities of practice. Each team member undertakes a tour of offices in their region to sell the benefits of joining the community. The main encouragement offered is the access to a much wider network of expertise that will have

direct benefits in improving an individual's workload. MWH surveyed their employees who were members of the three strategic knowledge centers in order to gain an understanding of employee needs. Four areas of benefit to the workforce were identified as:

- The ability to get in touch with the 'smart' people and to learn from them;
- The value they could bring to the clients and the visibility from the technology and company knowledge;
- Networking improved leading to jobs getting done more effectively with access to knowledgeable people; and
- KM awards won in 2001 and 2004.

Merrick & Company was unique because of its smaller size and employee ownership. They reported no specific challenges or incentives for getting employees to participate in knowledge sharing.

Metrics for Performance

The CH2M Hill Transportation Business Group had not yet decided upon how they were going to measure the success of their communities of practice. The intention was to consult with other CH2M Hill communities to identify the metrics in use. Some of those communities have run annual surveys to gauge the impact of the community on employees' everyday tasks. Possible suggestions were to investigate the number of hits for each community website and measuring the readership of news articles that are posted.

MWH considered it important to measure the quantitative benefits of knowledge but as yet had not found any definitive measures. Two of the knowledge centers have issued questionnaire surveys to measure the value of membership of the community and

how employees used the knowledge shared through the community. These have received very positive responses and will be used to steer the direction of the knowledge centers.

Construction Firms

Company Background

Three construction firms were used as case study companies - two large national firms (PCL Construction Enterprises and J.E. Dunn Construction) and one medium-sized regional firm (Haselden Construction). Of these three companies, only J.E. Dunn used the term 'knowledge management' and none had a position with sole responsibility for knowledge management. Although PCL did not use the term, the company strategically endorses learning and knowledge sharing. Haselden did not use the term but recognized that a number of their corporate activities constituted knowledge sharing.

KM Strategy & Implementation

Whilst none of the firms had a knowledge management strategy, they were able to identify a number of ongoing activities that contributed to knowledge creation and knowledge sharing. PCL had a dedicated 'INQUESTigator', an experienced project manager whose role was to identify good ideas and to disseminate these throughout the company. At J.E. Dunn, knowledge management is one component of their 'Cosential' system (an AEC application service provider) that facilitates collaboration between employees. Haselden's main knowledge sharing activities revolved around their lessons learned processes, their project databases and networking. The details of the main knowledge management activities highlighted are shown in Table 4. This shows a wide

range of knowledge management activities with a bias towards lessons learned. Only one firm indicated that communities of practice were used, but not to the extent as used by the design firms.

<Insert Table 4>

Barriers to Knowledge Management

Barriers identified were limited due to the lack of dedicated knowledge management activities. However those highlighted were as follows:

- Not enough time;
- Cautious approach to new 'management' idea;
- Not enough money;
- 'Not invented here' culture;
- 'Knowledge is Power' culture; and
- Use of Cosential was not mandatory.

People Aspects

PCL is employee owned and this is considered to be the main motivator for sharing knowledge, as it affects each employee directly. PCL employees abhor the idea of being separately rewarded for sharing knowledge. At J.E. Dunn, Cosential started as a marketing tool, its use is encouraged but is not mandatory leading to inconsistency in its use throughout the organization. At Hasleden knowledge sharing is encouraged by always ensuring that either the project manager or the project superintendent is very experienced.

Metrics for Performance

None of the companies in the study used metrics to assess their knowledge sharing activity. PCL considered metrics too bureaucratic and time consuming. The proof of their performance was judged by financial dividends and the percentage of employees buying their share allocation. J.E. Dunn regarded the time saved using Cosential as a valuable replacement for searching and maintaining data in several disparate databases. Haselden's lessons learned had led to process changes to improve performance on other projects.

Discussion

Comparison between Design and Construction Firms

The large design firms (CH2M Hill and MWH) had specific initiatives that were labeled and funded as distinct efforts to share and manage knowledge respectively. The activities conducted by the other firms were more of an extension of their normal business processes. For example, PCL Quest Bulletins share good ideas, J.E. Dunn's Cosential stores data on project extranets and Haselden's lessons learned encourages process improvements. Crucially, the willingness of the large design firms to invest in knowledge management without dictating performance criteria shows their commitment to KM. In the case of MWH, this included an initial multi-million dollar investment for IT infrastructure and substantial annual budgets for each knowledge center to cover staff and travel costs. For CH2M Hill the investment of key members of staff, the size and diversity of the community of practice teams and the support provided by the IT department highlighted the seriousness of their approach. For the construction firms,

many of their efforts to share knowledge are part of their business development, rather than specific KM initiatives with separate funding streams.

Comparison between company size

Knowledge management is a particular challenge for large, geographically dispersed organizations (Davenport and Prusak, 2000). This was clearly evident in the different approaches adopted by the large firms compared to the smaller firms. The large firms, both design and construction, had specific activities that could be labeled as knowledge sharing activities. This included MWH's Knowledge Centers supported by KNet, CH2M Hill's Communities of Practice, PCL's Connects to store its Quest Bulletins and J.E. Dunn's web portal to store project data. By virtue of their size, Merrick and Haselden relied on less formal mechanisms to share knowledge. This included Merrick's dependence on their team leaders' experience and memory and project data stored on their DelTek system. For Haselden, the company size meant that they relied on informal knowledge sharing between employees, project debriefing and project management tools. This meant the smaller firms had a much heavier reliance on personal contact and 'gurus' rather than wider networks. This also leaves them vulnerable to knowledge loss if these key individuals leave the organization (Kamara et al., 2003).

KM Strategy and Implementation

Companies adopt different strategies for managing knowledge based on a number of factors such as level of management support, available resources, organizational culture, etc. (Hansen et al., 1999). It is therefore important to understand why the case study companies have opted for certain strategies. This section categorizes the case

study findings in three main themes (1) Type of strategy adopted, (2) Implementation Efforts, and (3) Barriers to KM.

Type of Strategy Adopted

Five of the case study companies opted for a people-centric strategy. In the case of MWH, the previous IT-centric strategy had not reached expectations and, based on employee feedback, there was a need to build networks and improve communications between employees. CH2M Hill also adopted a people-centric strategy to leverage the tacit knowledge of employees based in the four regions through the US. Only J.E. Dunn adopted an IT-centric strategy centering on its use of the Cosential web portal. Companies of different sizes and business have different needs. There is no one strategy to fit all. For example, MWH's knowledge management strategy aims to leverage its knowledge assets on a global basis and thus they have provided the infrastructure to facilitate this. However, smaller companies find it more cost effective to rely on local, accessible pools of knowledge and thus do not need the sort of IT and HR infrastructure required by the larger firms. It is also not necessary to have a corporate effort if the organizational structure provides autonomous business units. It is better to have individual efforts at sharing knowledge within a business unit rather than none at all. Individual business units can determine their own knowledge management activities based on need and resources. However, it is recommended to investigate where similar efforts have been expended and to learn from these experiences.

Implementation Efforts

A number of authors describe the different stages in knowledge management to include knowledge creation, capture, sharing, use, etc. (Davenport and Prusak, 1998; O'Dell et al., 2000; Soliman and Spooner, 2000; Kululanga and McCaffer, 2001; Bhatt, 2001;

Tiwana, 2000; Mertins et al., 2001; and Rollett, 2003). Five of the case study companies focused on the narrow aspect of knowledge sharing and indeed only MWH used the terminology 'knowledge management' as opposed to 'knowledge sharing'. This may be because companies regard sharing what they already know as higher priority than creating knowledge. Another reason is that companies do not consider their 'knowledge creation' activities such as research and development, training, attending conferences and seminars, etc. as part of knowledge management. This can be attributed to the problems regarding an acceptable taxonomy for knowledge management (Kakabadse et al., 2003) and the lack of awareness that knowledge management incorporates both IT and HRM issues as highlighted by Jashapara (2004).

Barriers to Knowledge Management

The case study organizations have highlighted that the barriers for the construction sector are by no means unique. The main problems lie in the lack of time available for knowledge management activities. This is particularly problematic when the individual benefits to employees are not properly communicated or understood. If employees understood how knowledge management initiatives directly impacted on the day to day tasks, they may be more willing to play an active role. The other barriers received little correlation between types or size of firms. What this means is that organizations have individual problems that affect their knowledge management efforts. In many cases these are organizational issues e.g. fostering a sharing culture, 'stove-piping' of business units, etc. Dainty et al (2004) therefore recommend that organizations use a variety of HRM mechanisms and techniques to encourage a knowledge sharing culture. These include reciprocity, a shared vision, trust and teamwork.

People Aspects of KM

Employee support for knowledge management initiatives is vital if they are to succeed and not be dismissed as yet another management fad (Storey and Barnet, 2001; Carlsson, 2001). MWH and CH2M Hill provided good examples of encouraging employee support for their initiatives. MWH's Director of People and Knowledge Management invested heavily in traveling to gain feedback from frontline employees about their problems and how the organization could help. The follow up surveys helped to obtain employee feedback on how it could be improved and thus made employees feel that their input was valuable. At CH2M Hill a similar approach using questionnaire surveys help collect feedback from community members and assess its impact. Also, the fact that the community of practices team leaders are deliberately selected to represent the different geographical regions is an asset since they are able to encourage local support. One observation is that companies that are employee-owned also expressed strong views that no additional rewards or incentives were required to share knowledge because the employees are affected directly.

KM Metrics

Active management of knowledge resources does not come cheaply. It requires senior management support and resources. Measurement therefore plays a role in ensuring that knowledge management initiatives provide value to the employees and the organization. Many have addressed this subject but the problem lies in the reliance on financial measures only, rather than other less tangible benefits. One possible option would be the APQC's (2003) *Measuring the Impact of Knowledge Management* which benchmarks five major companies and proposes a measurement framework.

Only the two large design firms saw the need to measure the effectiveness of their knowledge sharing efforts. For them, measurement was used to gauge effectiveness and also to address improvements. This may be because the cost of knowledge management efforts were substantial for these organizations. However, there was a challenge of adopting easy-to-use and meaningful measures. MWH attributed its success in winning projects and their six-fold increase in their Design-Build portfolio to their knowledge centers and knowledge bases. However, it remains difficult to assess the direct influence of communities. The challenge therefore is how to determine that participation in a knowledge community quantitatively impacts on winning work. The survey of community members is indeed a positive action. The next stage would be to develop a cause-effect mechanism for highlighting how the work within these communities has quantitatively impacted on business metrics.

Identification of Best Practice

This paper aimed to study the knowledge management activities of US engineering design and construction firms to highlight best practice within these organizations in terms of Strategy and Implementation, People Aspects and Knowledge Management Metrics. Knowledge management is a challenge for mainly large organizations where because of their size and geographically spread it is difficult to know 'what the organization knows'. Smaller organizations find this easier because of their accessibility to staff. They have different problems such as retaining project memory through documentation. Thus the following best practice are proposed mainly for large organizations, with the understanding that smaller organizations can customize some of these for their own needs:

- Identify the organization's most important knowledge assets. These may be its staff expertise on projects (tacit knowledge), it may be the firm's collection of best practices (explicit knowledge), it may be both. This will entail a knowledge mapping exercise that will highlight the areas where the firms needs to concentrate its knowledge management efforts.
- Identify what strategy best suits the organization. There is no one-size-fits-all strategy. Companies have different needs and resources available. Broadly, companies can follow a people-centric strategy to share tacit knowledge or an IT-centric strategy to share explicit knowledge. However, construction organizations are a combination of staff's tacit knowledge supported by access to explicit knowledge in the form of standard operating procedures, etc. Thus a people-centric strategy will require some IT investment and vice versa, an IT-centric strategy will require tools to tap into employees' tacit knowledge.
- Learn from others, both internally and externally. Some organizational structures inhibit sharing across business units but this can lead to reinvention and duplication of effort. Finding out who else in the organization has done similar tasks is important. Externally, there is now a substantial body of advice available for companies on practical aspects of implementing knowledge management.
- Identify the firm's unique barriers to knowledge management and understand how this will affect employees. The case study companies show that these relate to mainly lack of time and organizational issues. In terms of time, companies need to understand how best to sell knowledge management to their employees in order to gain employee-buy-in. This may entail appointing knowledge management champion(s) who can dedicate the time required to plan and execute knowledge management initiatives.

- Identify medium and long-term metrics. Senior management will not continue to support knowledge management efforts unless they are convinced that it adds value to the business. Companies therefore need to decide how best they should demonstrate the value-added. Recommended practice is that it is better to start with reviewing and celebrating successes and graduate to linking tangible metrics with funding if knowledge management is to maintain visibility (Dent and Montague, 2004).

Conclusions

This paper investigated the knowledge management initiatives of major US engineering design and construction organizations in order to identify best practice. Three engineering design firms and three construction firms were used as case studies. The study found that although knowledge management is gaining ground in the US AEC sector, it still has some way to go. There is quite a mixed awareness of the terminology 'knowledge management' and what constitutes 'knowledge'. Indeed, none of the medium-sized firms were aware of the terminology.

The research highlighted a number of differences in the approach both between design firms and the construction firms and also between the large firms and the medium-sized firms. The two large design firms had invested substantially in knowledge management and specific knowledge sharing activities could be identified. Both companies focused on tapping into a wider pool of employee knowledge, supported by customized web portals. The construction companies provided good examples of

knowledge sharing but these were part of their existing business development processes, rather than specific knowledge management activities.

There is growing recognition of the benefits of knowledge management to construction firms. One firm was able to demonstrate how its knowledge management initiatives had clearly impacted on winning new projects and business growth. Thus the benefits are there to be reaped for firms of all sizes. There is also a growing body of best practice from industry-led bodies such as the APQC and the CII if companies want to take the opportunity. Companies therefore need to be more proactive in exploiting their knowledge assets in order to reap the business benefits.

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Table 1: Case Study Company Details

Company	2004 ENR Ranking	Annual Revenue (\$ M)	Number Employees	Person(s) Interviewed
<i>Design Firms</i>				
CH2M Hill	7	1398.5	11000	Design-Build Community of Practice Leaders
MWH	12	720.5	6100	Chief People and Knowledge Manager
Merrick & Company	173	48.8	380	Manager of Procurement, Senior VP, Contracts manager, database operator
<i>Contractors</i>				
PCL Construction	15	2032.0	1900	Director Corporate Development, VP Professional Development
J.E. Dunn Group	25	1495.9	2900	Director, Business Development
Haselden Construction	247	170.0	275	VP Business Development

Table 2: Additional Companies Contacted

Design Firms	Construction Firms
URS (ranked #1) – responded, no such position within the company	Bechtel (ranked #1) – no response
Jacobs Engineering (ranked #3) – responded, no such position within the company	Centex (ranked #2) – no response
AECOM (ranked #4) – no response	KBR (ranked #3) – no response

Table 3: Design Firms KM Activity

Design Firm	Primary KM Activities	Secondary KM Activity
CH2M Hill	<ul style="list-style-type: none"> The Transportation Business Group focuses on the creation of Communities of Practice (CoP). The first CoP was set up in 2002. At the moment there are six CoPs (Computer Aided Engineering, Public Involvement, Ports and Marine, Sustainable Development, Traffic Modeling and Transportation NEPA (National Environmental Policy Act)). Another four CoPs will be launched in Fall 2004 (Design-Build, Transportation Structures, Transportation Planning and LEED – Leadership in Energy and Environmental Design). 	<ul style="list-style-type: none"> Senior Management Project Reviews - facilitates sharing project knowledge because the participants attend a number of different project reviews Skills Yellow Pages – allows employees to source expertise. Each business group has its own expert directory Technology Career Paths – planned personal development sessions offering promotion opportunities Mentoring and Coaching – to assist less experienced employees Lessons Learned sessions – captured at project close out Monthly Training sessions of Project Managers – covers 'hot' topics
MWH	<ul style="list-style-type: none"> The people focus has been a key addition to MWH's KM efforts since 1999. They currently have three strategic 'knowledge-centers' in Design-Build, Water and Wastewater There are 120 voluntary 'knowledge bases' in areas such as major clients, marketing, etc. Currently deploying a Global Competency Framework to provide global knowledge maps of company expertise 	
Merrick & Company	<ul style="list-style-type: none"> No primary KM activity provided because KM terminology unknown 	<ul style="list-style-type: none"> Deltek software provides a searchable resumés and project data sheets Some lessons learned sessions at project close-out Email enquiries to groups of staff Merrick Learning Institute – to provide HR training External Professional Memberships – networks that allows informal benchmarking of activities Succession Planning – undertaken at Board level only

Table 4: Contractor Firms KM Activity

Contractor Firm	Primary KM Activity	Secondary KM Activity
PCL Construction Enterprises	<ul style="list-style-type: none"> • 15 User Groups in areas such as Estimating, Project Management, Procurement, etc. The first was set up in 1995. • Communities of Practice • Excellence in Construction – an effort to improve technical skills by pairing members of staff with different skills and tasking them to research and present specific topics in a six-month period • Quest Bulletins – a means of disseminating good ideas 	<ul style="list-style-type: none"> • PCL All users email enquiry • PCL Connects – company intranet • College of Construction - a mechanism for enhancing profession development through self-directed material as well as specific courses • Annual Operations Conference • Quest Action Teams – teams brought together to solve specific problems • Lessons Learned • Mentoring scheme
J.E. Dunn Construction	<ul style="list-style-type: none"> • Cosential portal to store project documentation as well as employee and customer data. The KM section acts as a focal point for communities of practice. It also provides templates for structuring new project proposals rather than re-inventing these. 	<ul style="list-style-type: none"> • Lessons learned conducted as part of their Standard Operating Procedure
Haselden Construction	<ul style="list-style-type: none"> • Lessons learned for all projects over \$2M US at project close out 	<ul style="list-style-type: none"> • Primavera Expedition used to record and archive project data • Monthly events held to discuss pre-selected topics.

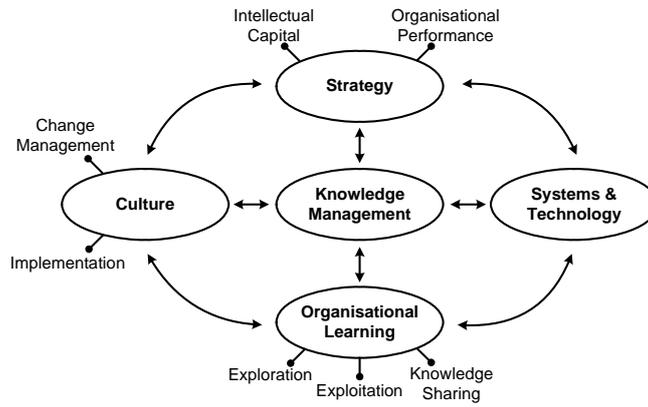


Figure 1: Dimensions of Knowledge Management (Jashapara, 2004, pp:12, with permission from Pearson Education publishers)