CAN SHARED KNOWLEDGE BASES SUPPORT KNOWLEDGE MANAGEMENT SYSTEMS IN CONSTRUCTION?

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ABSTRACT

Construction companies all over the world are increasingly being challenged by high cost pressure, shortened project cycles and increasing competition. Within a business environment, where the fast and reliable access to knowledge is a key success factor, an efficient handling of the organizational knowledge is crucial.
Knowledge management has appeared on the business scene and is capturing the attention of business. Knowledge management is the formal management of knowledge for facilitating creation, access, and reuse of knowledge, using advanced technology. Knowledge bases provide technology to organize, represent, capture and maintain the content of the knowledge management systems. Sound knowledge management systems employ a wide range of knowledge bases.
This paper identifies the main knowledge management processes and supporting technologies within a construction organization based on three case studies. It looks at the way knowledge bases interact to form effective knowledge management systems.

KEY WORDS

Construction, knowledge, management, processes.

INTRODUCTION

In today's knowledge-based economy, the competitiveness of enterprises is directly tied to the ability to effectively create and share knowledge both within and across organizations. Managing knowledge as a strategic business asset is crucial for achieving competitive edge in the construction markets. As a consequence, enabling sharing corporate knowledge and finding ways to make such knowledge useful to enhance efficiency and effectiveness of construction business is a key challenge (Obaide et Alshawi 2005; Bonifacio e *al*. 2002; Abecker et al 1998).

Knowledge Management (KM) is the formal management of knowledge for facilitating creation, access, and reuse of knowledge, using advanced technology. KM does not deal with structured information, but with "living" information and experience that circulates within the company everyday operations (Chaminade 2004). KM takes advantage of an organization's most valuable asset – the collective expertise of its employees and business partners.

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The real issue for construction companies is how to use knowledge created from everyday operations to beat competitors (Walker et *al.* 2005; Newcombe 1996).

Large construction companies know a lot of things, but they don't always know what they know (Burk 1999; Newcombe 1999). One of the challenges of KM is that of getting people to share their knowledge. Enabling every employee to know all that is worth knowing in an instant is not an easy task. Knowledge bases provide technology to organize, represent, capture and maintain the content of the KM systems. Sound KM systems employ a wide range of knowledge bases.

This paper identifies the main KM processes and supporting technologies within a construction organization based on three case studies. It looks at the way knowledge bases interact to form effective KM systems.

WHAT ARE KNOWLEDGE BASES

A knowledge base is a special kind of database for KM. It provides the means for computerized collection, organization, and retrieval and reuse of knowledge (Nordlander et al 2003). The idea of knowledge bases lies at the heart of symbolic, or "traditional," Artificial Intelligence (AI).

Knowledge bases are commonly used to capture explicit knowledge of an organization, including best practices, troubleshooting, articles, white papers, user manuals and others. The primary benefit of such a knowledge base is to provide a means to discover solutions to problems that have known solutions which can be re-applied by others, less experienced in the problem area.

The most important aspect of a knowledge base is the quality of knowledge and information it contains. The best knowledge bases have carefully written articles that are kept up to date, an excellent information retrieval system (search engine), and a carefully designed content format and classification structure. A well-organized knowledge base can save an enterprise's money by decreasing the amount of employee time spent trying to find information about - among myriad possibilities – best practices or company policies and procedures. As a customer relationship management (CRM) tool, a knowledge base can give customers easy access to information that would otherwise require contact with an organization's staff; as a rule, this capacity should make the interaction simpler for both the customer and the organization. A number of software applications are available that allow users to create their own knowledge bases, either separately (these are usually called *KM software*) or as part of another application, such as a CRM package.

A knowledge base is not a static collection of information, but a dynamic resource that may itself have the capacity to learn, as part of an artificial intelligence (AI) expert system, for example. According to the World Wide Web Consortium (W3C), in the future the Internet may become a vast and complex global knowledge base known as the Semantic Web. Enabling technologies for supporting the Semantic Web are rapidly becoming available.

A knowledge base uses ontologies to specify its structure (entity types and relationships) and its classification scheme. Ontologies are explicit specifications of conceptualizations (Fensel 2001). An ontology, together with a set of instances of its classes constitutes a knowledge base. The ontology lays' the ground rules for modeling a domain by defining the basic terms and relations that make up the vocabulary of areas covered by the knowledge base (Neches et al 1991). These knowledge-based specifications typically describe content theory of the domain on which the KM system is to work.

Ontologies are content theories about the sorts of objects, properties of objects, and relations between objects that are possible in a specified domain of knowledge (Chandrasekaran et *al.l* 1999). Their main contribution for a knowledge base is to identify specific classes of objects and relations that exist in some domain. Therefore, an ontology provides a shared memory of knowledge and lessons learned from company everyday operations in which a KM system can ground its activities such as knowledge creation, reuse and sharing.

Knowledge bases can not do much without the support a good content theory of the domain on which it is to work. Moreover, once a good content memory is available, may different mechanisms might be used equally well to implement software systems, all using essentially the same content. To support the sharing and reuse of formally represented knowledge among enterprise systems, it is useful to define the common vocabulary in which shared knowledge is represented.

Determining what type of knowledge is captured, and where that knowledge resides in a knowledge base is something that is determined by the processes that support the system. A robust process structure is the backbone of any successful knowledge base. Above all, a knowledge base aims to reduce duplication of effort. Knowledge bases can help construction companies make the best of bad situations, offering a chance to retain knowledge that would otherwise disappear in times of severe pressure and contraction.

KM PROCESSES

In most construction organizations, knowledge tends to flow along organizational lines, from the top down. But that pattern seldom results in making knowledge available in a timely fashion and where it's needed the most (Cicmil 2005; Kululanga 1998). In organizations with managed knowledge, information can flow across organizational lines, reaching the people who can use it in ways that best promote the organization's goals and that enhance service to the customer at the same time.

How this happens can be understood by examining the four basic processes of the KM cycle: find/create, organize, share, and use/reuse. Under *find/create*, especially as it operates in a construction company, knowledge is gained through a variety of means, including publications, conferences and meetings, project experiences, research, and industry expertise. In the next step in the cycle, *organize/represent*, the knowledge is filtered, catalogued and represented. Then the knowledge is *connected*/*shared* for wide availability, making use of high-tech computer tools such as the Internet and other techniques such as conferences,

journal articles, and the natural communication channels created in a collaborative work environment.

To help carry out the "*organize*" and "*share*" processes in a specific community of people having a common interest, many experts recommend a knowledge manager. This person has the task of soliciting good practices, indexing and cataloguing new information as it comes in, and serving as an information broker by assisting people to obtain the information they need. The knowledge manager can also serve as an advocate for knowledge-sharing practices within and beyond his or her specific community of practice.

The final stage of the KM cycle, *use/reuse*, involves both informal contacts and access to reports, good practices, success stories, and other forms of communication, including exhibits, demonstrations, and training sessions. Much of this knowledge can be made available to a wide audience through the Internet. This is the step in which knowledge is applied and reapplied to solve real-world issues, such as building better bridges, operating roadways more efficiently, and improving highway safety. Of course, these results are then captured as part of the lessons learned for use as the knowledge cycle begins again.

Construction knowledge along the KM cycle is both explicit (drawings, specifications, engineering principles, methodologies, best practices etc.), and tacit (knowledge of cultural, organizational and people) (Mohamed and Anumba 2005; Whetherill *et al.*, 2002; Robinson *et al.*, 2001; and UMIST-Klicon, 1999). Explicit knowledge includes knowledge that can be articulated. Tacit knowledge includes knowledge that cannot be articulated.

Knowledge bases can play a key role in the KM cycle. An integral component of KM systems, a knowledge base is used to optimize information collection, organization, and retrieval for an organization, or for the general public.

CASE STUDIES INSIGTHS

Introduction

The main objective of these case studies was to identify the knowledge sources that occur on the construction projects. Furthermore, it investigates KM processes within project management practices.

Three construction organizations were involved in this study. They were:

- Organization A: Architectural and Engineering company
- Organization B: Building company
- Organization C: Consultant company

The three construction organizations that participated in this study were each requested to nominate their best project from the perspective of KM. This study was based principally on semi-structured interviews with one project-based project personnel of the companies. The project personnel involved were as follows:

(a) Organization A – Design Manager of commercial mall,
(b) Organization B – Site Manager of subway station site,
(c) C – Supervisor Manager of housing project.

Case 1: Commercial Mall project

Organization A is a major Architectural and Engineering company based in Lisbon. It is the main contractor for the development of the full design of a commercial mall.

The design manager observed that 80% of knowledge is embedded in the minds of the architects involved in the project, 15% of the knowledge is stored in an AutoCad system repository and 5% is from design methodologies, best practices, specifications and catalogs. This was simply based on his personal understanding rather than an empirical survey. The Design Manager holds regular meetings with major project participants to solve specific problems and share the lessons learnt in each design phase. In addition, project participants are encouraged to hold seminars on the specific areas of the design. These seminars are aimed at to share knowledge created during the design process. The outcomes of the seminars are stored in proceeding for future reuse.

Furthermore, the Design Manager has put in place a design process protocol that facilitates knowledge capture and storage in written documents. In the view of the Design Manager, the process protocol lay down well-designed steps of procedures that insure that the design activities can be repeated with same results.

Case 2: Subway station project

Organization B is the main contractor for the construction of a subway station of Lisbon underground network. It has implement, through its intranet, a central repository of corporate knowledge which can be shared by its site managers. The Site Manager observed that this central repository contains mostly explicitly knowledge in the form of organizational routines, methodologies, practices and norms. He also mentioned that it is not always easy to find the right knowledge when it is most needed.

There were several management tools used on this construction site. These are as follows: (a) “E-Controi” – and Internet system, (b) an email system (c) an ISO 9000 quality management system which includes a quality management manual, (d) On-line project management system - Primavera. The main role of the intranet system was for reuse and sharing the organization’s central repository.

The Site Manager observed that, in general, project knowledge is stored in the Project Management Data Base and in form of written documents (explicit knowledge) and in personnel’s experience (tacit knowledge). This site has there ways to reuse and share knowledge: “E-Constroi”, an email system and On-line project management system.

Case 3: Housing project

Organization C is the consultant contractor for the contract management of a seven storey building for a client in Lisbon. This organization did not have any systematic methods or processes for managing knowledge.

Principally, this organization relies on the contract specifications, drawings, norms and regulations. There were several management tools used on this project. The main management tools area as follows: (a) Microsoft Project, (b) an email system, (c) a document management system, and (d) Lotus Notes.

The Supervisor Manger observed that most contract management knowledge such as inspection and testing procedures, construction planning, cost management and best practices are within worker's experience. There are no systematic and formal methods for capturing, organizing and reuse this knowledge.

ANALYSIS

The cases studies show that KM on the companies covered by this study has primarily focused on *knowledge find and reuse*. This model is based upon managerial focus on seeking consensus and compliance to minimize variance so that pre-specified business performance outcomes are achieved. In this model of KM, conformance to pre-specified and pre-determined business logic is expected to ensure pre-specified and pre-determined business performance outcomes are achieved. Therefore, the goal of KM systems based on this model is often characterized as "getting the right information to the right person at the right time". Table 1 shows the relationship between construction processes, relevant KM process and knowledge sources found in the three organizations.

Table 1: Construction processes, KM processes and knowledge sources

Organization	Construction Process	KM processes	Knowledge Sources
A	Design process	Find/create; reuse; share	AutoCad repository; specifications; norms and regulations, expert's experience
B	Construction planning, cost management, quality and safety management, billing	Find, reuse	Project management Data Base; organization's central repository; quality management manual; contract documentation
C	Inspection and testing, cost management, financial management, contract management	Find	

The case studies show that the model used by construction organizations does not lead knowledge creation. Furthermore, the three organizations did not have any systematic or processes to build knowledge bases from experts and senior workers.

KNOWLEDGE BASES AS COMPONENTS OF KM SYSTEMS

Effective KM systems require a hybrid solution, one that involves people and technology (Abeker 1998). As shown in cases studies and literatures review KM in construction is about managing organization's knowledge assets to fulfill its organizational objectives. Thus, KM should enhance individual, group and organizational learning; improve information circulation; and even support innovation. Therefore, a KM system in construction is seen as a means of identifying and exploiting corporate individual knowledge assets: individual experiences, lessons learned, and best practices (Mohamed and Anumba 2005).

In building KM systems, we attempt to assimilates knowledge assets available within the organization and disseminate it to people connected to the organization. Malhotra (2004) highlighted seven challenges (enablers and constraints) that need to be met for successful KM systems:

- business and technology;
- information sharing culture;
- knowledge representation;
- organization structure;
- managerial command and control;
- economic returns.

These seven KM systems challenges are related to the recent evolution in thinking about effective business performance.

Knowledge bases provide technology to meet some of these enablers of KM systems including information sharing culture; knowledge representation; organization structure. They together with ontology frameworks provide techniques to facilitate the representation, capture, sharing, reuse, and creation of organization's knowledge assets (Simon et *al.* 2000).

Knowledge bases contain the content of the KM system. It aims at capture and represents an organization's knowledge assets to facilitate KM processes. Knowledge bases usually depend on the specific construction business domain in which the company is engaged. Not only do knowledge bases differ in their content, but also in their development complexity – or difficulty of developing the knowledge base, relative to other knowledge bases (O´Leary, 1998). Therefore, a KM system my contain numerous knowledge bases for both human and machine consumption.

Table 2 shows the relation of the Knowledge Engineering (KE) tasks required to build knowledge bases and tasks that can be performed by a subject matter expert.

Table 2: KE tasks required to build knowledge bases and tasks that can be performed by a subject matter expert.

KE tasks	Define domain model	Create ontology	Define rules, facts, and queries	Verify and update rules, facts and queries	Create formal sentences	Create formal explanations
Expert tasks	Refine domain model	Refine ontology	Define examples	Critique examples	Understand sentences	Create informal hints

Arranged around one or more knowledge bass, a KM system actively provides the user working on a knowledge-intensive operational task with all knowledge necessary and useful for fulfilling this task.

CONCLUSIONS

KM in a construction organization will benefit considerably from knowledge base technology, provided that such technology is integrated in the organization to support KM activities. For construction organizations in particular, to meet KM enablers is very import for business development.

An analysis of the major KM processes in construction has been presented in this paper. This paper highlights the main KM processes and sources in three construction organizations. They show that KM focus is on knowledge find and reuse and there is no systematic methods and processes to build knowledge bases.

The role of knowledge bases as components of KM systems has been discussed in this paper. It refers to the potentialities of these tools for improving organization's knowledge creation and sharing across the network. Within the limits of this study, we show how to take full advantage of knowledge base technologies for enabling KM in construction. Their adoption it is easy, and if they are used in structured manner great benefits can be expected from them.

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