A WEB-BASED KNOWLEDGE MANAGEMENT SYSTEM FOR CONSTRUCTION PROJECTS

Serkan Kivrak and Gökhan Arslan

Anadolu University, Faculty of Engineering and Architecture, Civil Engineering Department, Eskisehir, Turkey

E-mail: serkankivrak@anadolu.edu.tr

Abstract: Knowledge has become an important competitive tool for almost every industry. Managing knowledge effectively is critical to the survival and advance of a company especially in project-based industries such as construction. Proper knowledge management can reduce project time and cost, improve quality and provide a vital competitive advantage for the construction organisations in today's knowledge-based economy. Knowledge consists of explicit and tacit knowledge. Tacit knowledge is based on the experience of individuals and is not easily visible or expressible. This type of knowledge usually is not captured during the construction phase. Capturing tacit knowledge and reusing in future projects can give construction companies a strong competitive advantage. Sharing and reusing knowledge can improve the business performance of the companies. In this study, a survey was carried out among eight leading Turkish construction contractors that are operating within the international construction market. The specific objectives of this survey were to find out how these organisations share and reuse knowledge, the opinions of senior engineers and experts on the capture and reuse of knowledge and experience in construction projects, and the main barriers for implementing knowledge management. Based on the survey, it was found that most of these firms do not manage knowledge effectively. A web-based knowledge management system is proposed in order to manage knowledge, both tacit and explicit, effectively in construction projects. This system enables companies to store, share and reuse knowledge, and save time and cost.

Keywords: Construction Projects, Knowledge Management in Construction, Knowledge Sharing, Reusing Knowledge, Web-Based Technology.

1. INTRODUCTION

According to Davenport et al., knowledge is defined as 'a fluid mix of framed experience, values, contextual information and expert insight' [1]. Knowledge is a broader, deeper and richer concept than information. It comes in two different types as explicit and tacit knowledge. Explicit knowledge can readily be codified in words and numbers, easily shared in manuals and is easy to distribute [2]. According to Polanyi's definition, tacit knowledge is highly personal and context-specific, therefore it is hard to formalize and communicate [3]. Tacit knowledge is stored in people's heads, so it is difficult to pass on to others. Tacit knowledge can give companies a strong advantage over their competitors since it is difficult to see and copy [2].

There is no universal definition for knowledge management (KM). According to the definition of Davenport et al., KM is the process of creating value from an organisation's intangible assets [1]. Another definition for KM is made by Laudon et al. as 'the process of systematically and actively managing and leveraging the stores of knowledge in an organisation' [4]. The management of knowledge is not a new

concept. Many organisations already manage their knowledge through some ways such as databases and social interaction between people.

The construction industry (CI) is a knowledge-based industry. The production and management of knowledge is therefore highly essential for businesses operating within this industry and for projects on which they work [5]. During the construction phase of projects, most know-how, know-what and experience exist in the minds of individuals. In order to improve the construction process and reduce the time and cost of solving problems, it is highly essential to capture knowledge of experts involved in projects and reuse in future projects [6].

In this study, a survey was conducted among eight leading Turkish construction contractors. A web-based prototype system is proposed in order to manage knowledge effectively in construction projects.

2. KNOWLEDGE MANAGEMENT IN CONSTRUCTION

The main drivers for KM in the CI are the need for innovation, improved business performance and client satisfaction [7]. Kamara et al. stated that innovation and efficiency are related to the delivery of projects since the industry is organised around projects [8].

An enormous volume of architecture, engineering and construction knowledge is generated during the phases of design, planning, construction and maintenance of a facility [9]. During these facilities, capturing tacit knowledge and making it available as explicit knowledge are very important to KM in the construction phase. Since most project-related problems, solutions, experiences and know-how are in the heads of individual engineers and experts during the construction phase, capturing them and reusing in future projects can create several advantages for a company [10].

2.1 Advantages of Knowledge Management for Construction Companies

The following are advantages to adopting formal KM procedures [5]:
- Increased efficiency in project implementation:
  Organisations that manage knowledge better, can easily find solutions to problems when they arise.
- Reduction in wasteful costs:
  Organisations that manage knowledge better, can reduce time and money in finding solutions to problems already solved by individuals / teams working on other projects. As a result, the same problems in the construction phase do not need to be solved again.
- Greater innovation:
  Organisations that manage knowledge better, can stumble upon new and innovative ways of working.
- Competitive advantage:
  Organisations that manage knowledge better, can discover something extra that separates them from their competitors.
- Greater success:

Organisations that manage knowledge better, can win more new and repeat business than their competitors.

3. THE SURVEY

The survey was conducted in Turkey among 8 leading Turkish construction contractors that are all members of the Turkish Contractors Association (TCA). The companies are large size contractors and operating within the international construction market. A total of 12 top-level managers including general managers, business development managers, bid proposal managers and IT managers from these companies were interviewed for this research. The twelve interviews took place over a five month period between February – June 2005. The survey questionnaire has been administered during face-to-face interviews. Some of the questions allowed the participants to give multiple responses to a question. The specific objectives of this survey were to find out how these organisations share and reuse knowledge, the opinions of senior engineers and experts on the capture and reuse of knowledge and experience in construction projects, and the main barriers for implementing knowledge management. The surveys referred were conducted in the UK [11, 12] and Finland [13].

4. SURVEY RESULTS

The survey results are classified in four categories as capturing knowledge, storing knowledge, reusing and sharing knowledge, and KM strategies.

4.1 Capturing Knowledge

All of the respondents stated that their firms have been successful at capturing knowledge from external sources.

Tacit knowledge is the key component in reusing knowledge. Half of the respondents considered their company knowledge to be 41-60 % as tacit nature. It can be stated that these firms do not capture their expert's knowledge successfully since more than half of the company knowledge exists in individual's heads. On the other hand, the companies that implemented a KM strategy within their organisations are more successful at capturing tacit knowledge since the participants of these firms considered their company knowledge to be only 0-20 % as tacit nature (Fig. 1).

The most important knowledge sources for the firms are determined as colleagues and company's experience (Fig. 2). The majority of the respondents stated that they rely on their colleagues as a knowledge source. This result correlates well with the research done in the UK, in which the most important knowledge source was also considered as the other individuals in the firms [12]. However, major Turkish contractors rely more on their company's experience and current project documentation as a knowledge source than UK firms.

Some knowledge sources were reported to be less significant than might be expected. For example, Internet was not considered of a major knowledge source. It has been

determined that the usage of Internet in these firms is limited with only some business activities such as exchanging and sharing documents via e-mail.
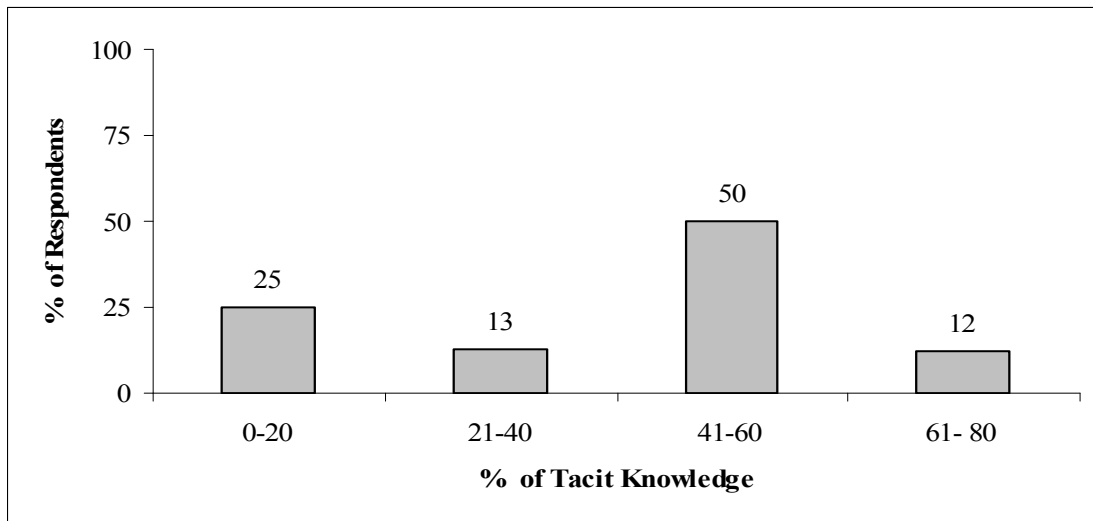

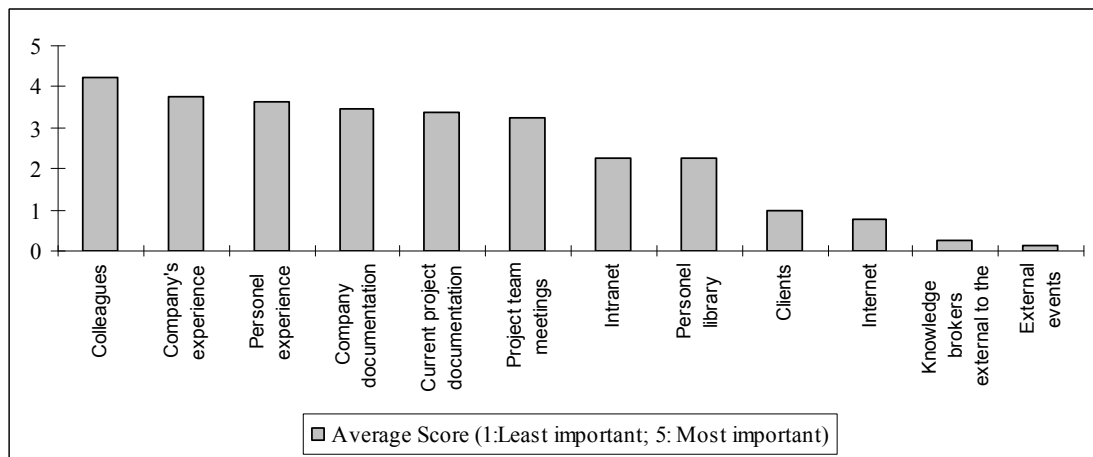**Figure 1:** The percentage of company knowledge as tacit nature

Figure 2: Knowledge sources

4.2 Storing Knowledge

The respondents were asked the availability of a database in their company related to past projects. Most of the respondents indicated that post-project appraisals have been used for learning from past projects and are available only in paper format. Only few companies have stored these documents in digital format. This results show that companies mostly use post-project appraisals for learning from past projects. In addition, most of the firms store the problems and solutions during the construction phase. However, the participants also stated that there has been difficulties to find the necessary documents since they were not systematically stored.

Reports are indicated as the most used tool to accumulate and store knowledge gained in the projects (Fig. 3). The folder, computer files and personal archives are determined as the following important tools.
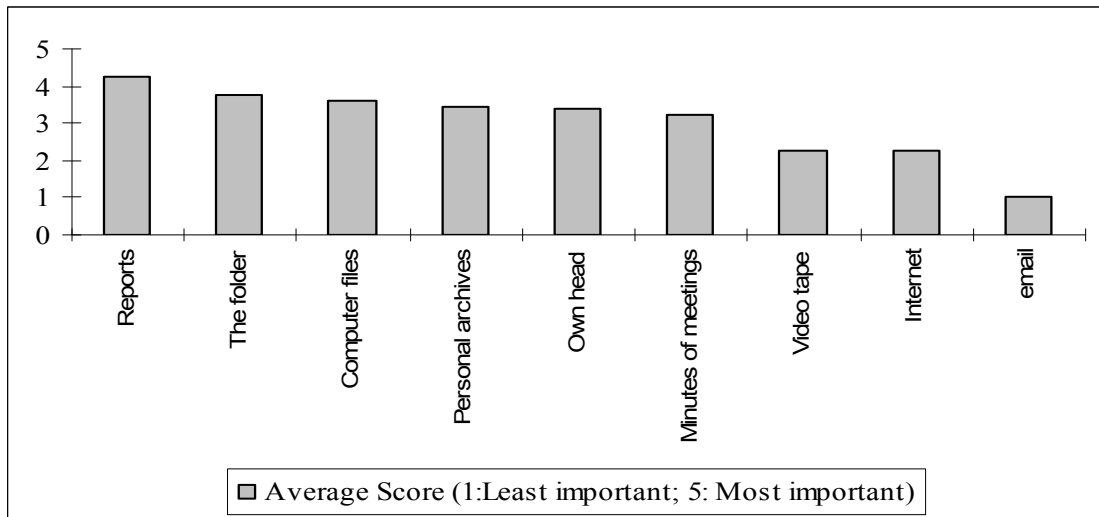
Figure 3: Tools used to accumulate and store knowledge

4.3 Reusing and Sharing Knowledge

Most of the respondents stated that their firms have been successful in effective knowledge sharing. In addition, most of them indicated that the company culture supports knowledge sharing within their firms.

The respondents were asked how often they reuse knowledge gained from other projects. The results show that knowledge gained in past projects has not been used very often in company's current projects. Clearly, this will lead to inefficiencies in companies' activities since the problems should have to re-solve again in their ongoing projects. The respondents stated that they rely mostly on the experience of individuals in problem solving.

4.4 Knowledge Management Strategies

The respondents were asked the availability of an intranet within their firms. It was found that all the firms involved in this study use an intranet. The intranet is seen by the firms as a key aspect of the IT infrastructure. The results correlate well with the research done in the UK by Carrillo et al. carried out among 170 UK construction firms [11]. In the UK, 90.5 % of the large organisations use an intranet to support the KM process.

In this study, it was found that 25 % of the companies already have a KM strategy, while another 25 % plan to have a strategy in the future. It has been observed that the ones that have a KM strategy are more successful in their projects and their business volume is higher than the others. This result shows that KM could be one of the major factors for the companies in their business success.

The respondents were asked the drivers for KM. Only the respondents of the firms that have a KM strategy were asked the drivers for KM. All of them addressed the main driver as reducing rework (Fig. 4). Responding to the customers quickly is determined as the following important driver. The results obtained in this study are quite different

from the survey done in the UK in which the most important driver for KM was determined as sharing tacit knowledge [11].
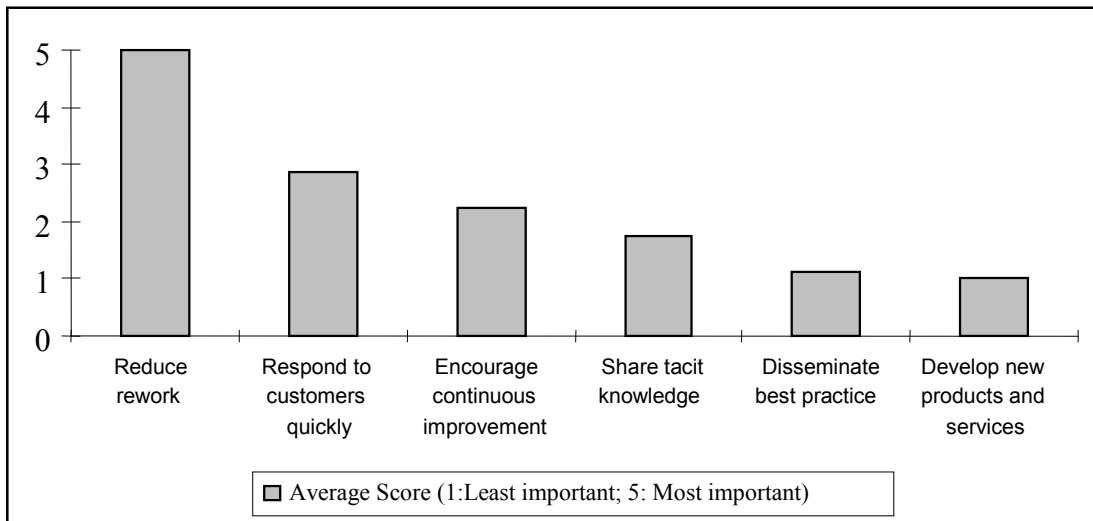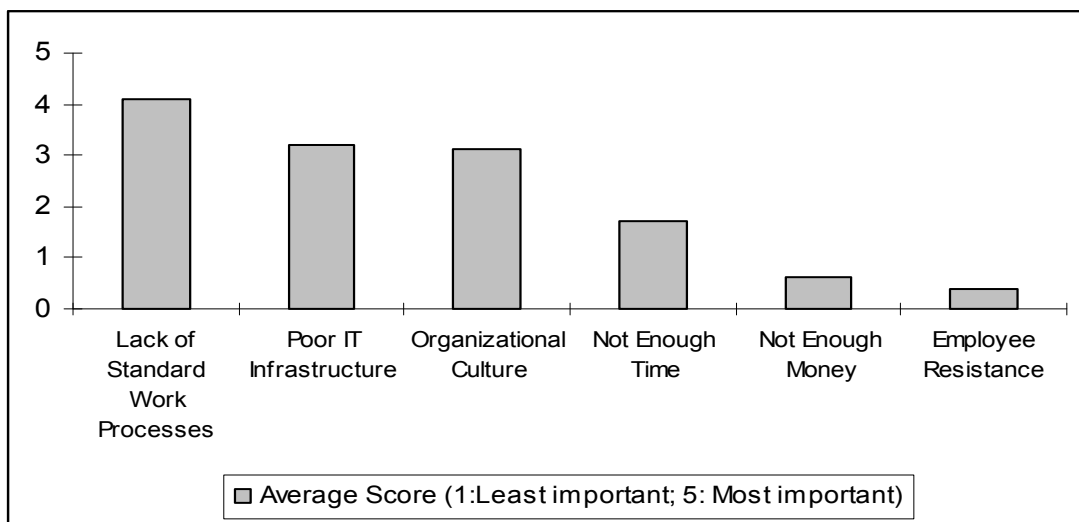

Figure 4: Drivers for KM

Figure 5: Barriers to KM Implementation

Based on the responses, lack of standard work processes is identified as the main key barrier to KM implementation (Fig. 5). This result correlates well with the research done in the UK in which lack of standard work processes was also considered as the most important barrier to KM implementation [11]. The number of different processes in performing different activities and lack of systematic procedures for undertaking and documenting lessons learned is addressed as major shortcomings in accessing and sharing knowledge as like in the UK organizations [11].

Poor IT infrastructure and the organizational culture are seen as the other major barriers to KM implementation. Although the participants stated that there exists mutual trust and collaboration between employees, this result shows that the companies should put much more effort to promote knowledge sharing within their organizations.

Finally, the respondents were asked their opinions for a system by which knowledge, especially tacit knowledge, could be captured during the construction phase of a project, stored and reused in other projects. The majority of the respondents (63 %) indicated that such a system could be beneficial to their companies. However, 37 % of the respondents considered this proposed system as unusable due to the difficulties in capturing tacit knowledge and stated that the ongoing procedures were enough to manage knowledge effectively.

According to the survey results, it has been determined that the firms do not manage knowledge effectively. Half of the firms do not even have a KM strategy. Since knowledge has not been re-used often, the advantage of reducing rework by implementing KM activities is still not fully achieved by these firms.

The firms surveyed have not been successful at capturing and reusing tacit knowledge which could be a strong advantage for them in their future projects. Know-how and experience are still remaining mostly in individual's heads.

According to the results obtained from this study, it can be stated that the leading Turkish construction contractors have not been successful at capturing tacit knowledge. A framework is proposed in order to capture tacit knowledge during construction projects and reuse in future projects (Fig. 6).
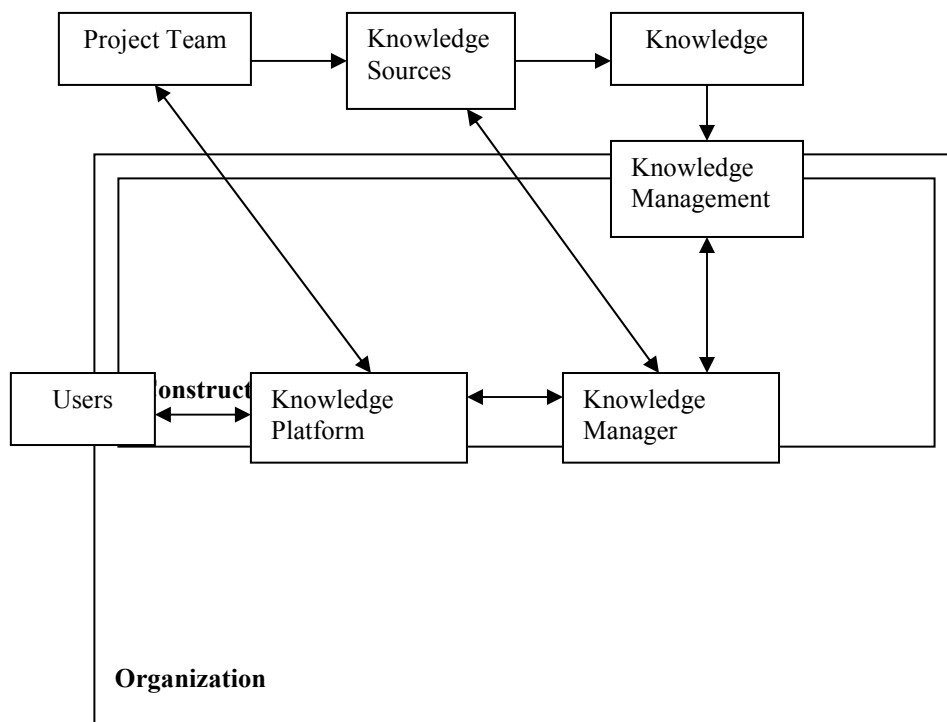

Figure 6: A framework for capturing and reusing knowledge

In this framework, the project team consists of the technical staff involved in a construction project. Knowledge sources include the organizational knowledge, internal and external knowledge sources. Knowledge consists of both tacit and explicit knowledge. The role of the knowledge manager is to collect, store and approve

knowledge so that it could be re-used by accessing into the system called knowledge platform which will be described in the next section.

5. THE SYSTEM

In this part of the study, a proposed prototype system for capturing knowledge during the construction phase of a project and reusing in future projects is described briefly. The flowchart of this system is given in Fig. 7.
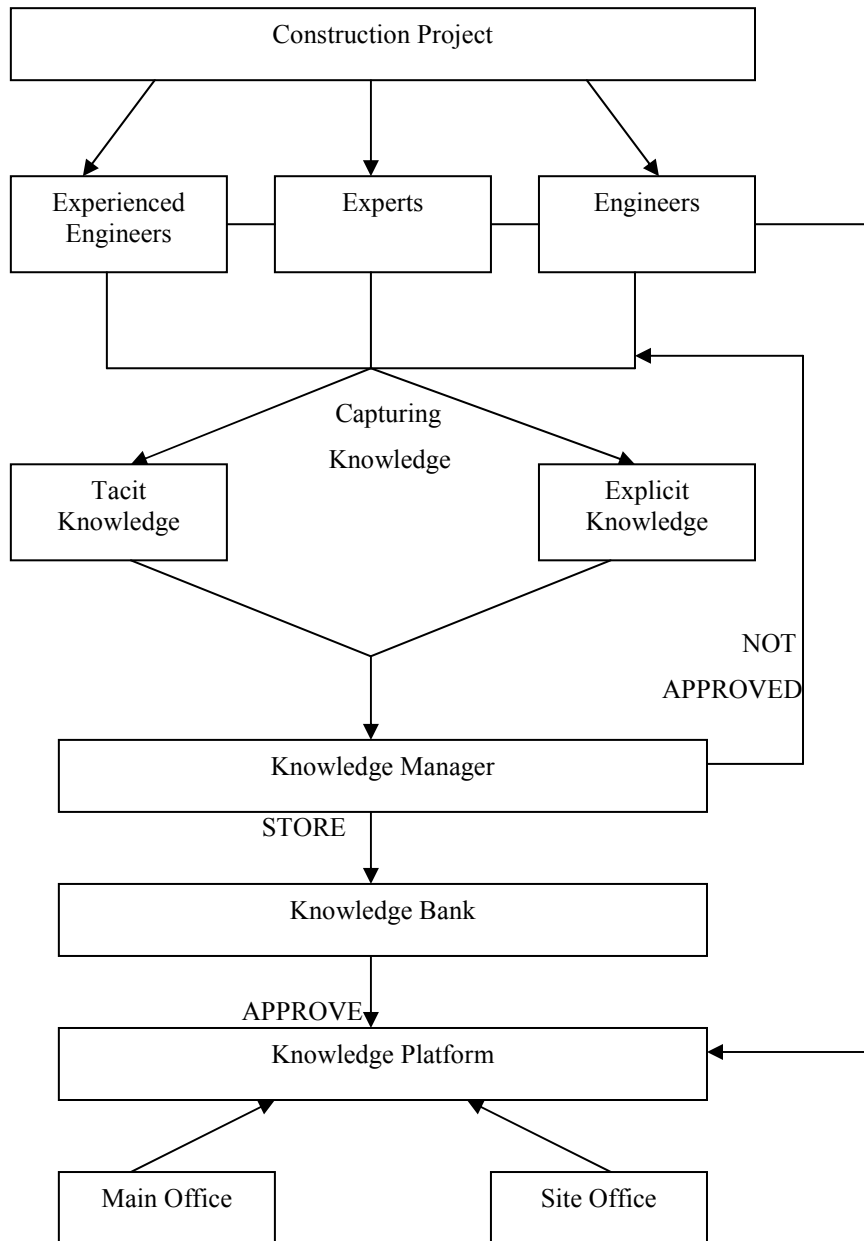
```
                    ┌──────────────────────────────┐
                    │     Construction Project     │
                    └──────────────────────────────┘

   ┌──────────────┐      ┌──────────────┐      ┌──────────────┐
   │ Experienced  │      │   Experts    │      │  Engineers   │
   │  Engineers   │      │              │      │              │
   └──────────────┘      └──────────────┘      └──────────────┘

                    Capturing
                    Knowledge

   ┌──────────────┐                      ┌──────────────┐
   │    Tacit     │                      │   Explicit   │
   │  Knowledge   │                      │  Knowledge   │
   └──────────────┘                      └──────────────┘

                                          NOT
                                          APPROVED

          ┌────────────────────────────────────┐
          │          Knowledge Manager         │
          └────────────────────────────────────┘
                    STORE

          ┌────────────────────────────────────┐
          │           Knowledge Bank           │
          └────────────────────────────────────┘

                    APPROVE
          ┌────────────────────────────────────┐
          │         Knowledge Platform         │
          └────────────────────────────────────┘

   ┌──────────────┐                      ┌──────────────┐
   │ Main Office  │                      │ Site Office  │
   └──────────────┘                      └──────────────┘
```

Figure 7: Flowchart of the knowledge platform

Technical staff can access into this system by having a password authorized by the company. The knowledge manager has the responsibility to collect knowledge and store it into the knowledge bank. Having approved the knowledge by the knowledge

manager, it will be then available in the knowledge platform. The knowledge platform includes tacit knowledge such as know-how, expert suggestions, innovations and also explicit knowledge such as reports and contract documents. Construction companies have not been successful at capturing tacit knowledge during the construction phase. The system is mostly based on accumulating and reusing tacit knowledge to overcome this problem.

The main page of the system contains the projects option where information about ongoing and finished projects of the company is available; the knowledge type option where users can access to tacit knowledge such as know-how, innovations, problems / solutions and explicit knowledge such as specifications, contracts and reports; and the add new knowledge option which is used only by the knowledge manager to add new knowledge into the system. The knowledge platform should also be updated by the knowledge manager. The users can find the relevant knowledge in this system by using the following search options; knowledge type search, author search and project search. On each web page the submitted date and approved date of the knowledge are given and the description of the knowledge is presented.

Using this system can provide time and cost savings for the companies. Time and cost savings are difficult to calculate. The following example is given to explain how the firms can save time and cost by using this system. An engineer working in an office or a site spends approximately 10 minutes to find a relevant knowledge without using this system. The duration (10 min.) includes; asking information to the person about the knowledge (1 min.), going to the person's office (1 min), finding knowledge from computer or files (2 min.), printing and saving knowledge (2 min.), reloading the knowledge into the computer and executing (4 min). Obviously the time duration is approximate and can vary. If an engineer is supposed to find 5-10 relevant knowledge during a day, he might spend approximately 50-100 minutes only for finding knowledge. This is equivalent to approximately 1000-2000 minutes in a month (assume 20 working days). Assuming that the engineer is working 40 hrs in a month (9600 min.), then the ratio of finding knowledge hrs / total working hrs in a month will be (1000-2000) / 9600 = 10-20 %. This result shows that an engineer will spend approximately 10-20 % of his total working hours in a month only for finding knowledge. Assuming the salary of this engineer as $ 2000, the cost of finding knowledge would be approximately $ 200-400 / month and $ 2400-4800 / year. This simple example shows that even for an individual engineer, finding knowledge is time consuming and expensive. Immediate access to the relevant knowledge can be provided by using this system. Therefore, it can reduce the time consumption and cost of finding knowledge. Besides finding the relevant knowledge, the company can also save time and cost by reducing rework.

6. CONCLUSIONS

Construction companies have to manage their knowledge better if they want to survive in the competitive business world. Construction firms have been successful at collecting and storing explicit knowledge, but they are poor at knowledge retrieval and exchange [9].

In this study, the survey carried out among eight leading Turkish construction firms has been examined. It was found that the firms do not capture tacit knowledge from experts' minds effectively. A framework is proposed in order to capture, store and reuse knowledge in projects. Finally, a prototype system that enables companies to capture knowledge during the construction phase of a project and reuse in future projects is described. The system could be a very helpful tool for the companies in saving time and cost by reusing knowledge.

6. REFERENCES

[1]   Davenport,TH., Prusak,L. (1998), Working Knowledge. Harvard Business School Press, Boston.
[2]   Henley Management College. (2004), Introduction to Knowledge Management in Construction, Henley Knowledge Management Forum.
[3]   Polanyi,M. (1967), The Tacit Dimension. Doubleday, New York.
[4]   Laudon,KC., Laudon,PL. (1998), Management Information Systems, 4th Edition, Prentice-Hall, New Jersey.
[5]   Glasgow Caledonian University. Your First Steps Into Knowledge Management, BNE Report 24 / 2004, www.constructingexcellence.org.uk (February, 2005).
[6]   Tserng,HP., Lin,YC. ''Developing an activity-based knowledge management system for contractors'', (2004), Automation in Construction, 13, 781-802.
[7]   Kamara,JM., Augenbroe,G., Anumba,CJ., Carrillo,PM. ''Knowledge Management in the architecture, engineering and construction industry'' (2002), Construction Innovation, 2, 53-67.
[8]   Kamara,JM., Anumba,CJ., Carrillo,PM. ''Cross-Project Knowledge Management'', (2005), 103-120, Knowledge Management in Construction (Ed. Anumba,CJ., Egbu,C., Carrillo,PM.), Blackwell Publishing.
[9]   Woo,JH., Clayton,MJ., Johnson,RE., Flores,BE., Ellis,C. ''Dynamic Knowledge Map: reusing experts' tacit knowledge in the AEC industry'' (2004), Automation in Construction, 13, 203-207.
[10]   Tserng,HP., Lin,YC. ''A Knowledge Management Portal System for Construction Projects Using Knowledge Map'', (2005), 299-322, Knowledge Management in the Construction Industry: A Socio-Technical Perspective (Ed. Kazi,AS.), Idea Group Publishing.
[11]   Carrillo,P., Robinson,H., Al-Ghassani,A., Anumba,C. ''Knowledge Management in UK Construction: Strategies, Resources and Barriers'' (2004), Project Management Journal, 46-56.
[12]   Egbu,C., Quintas,P., Anumba,C., Kurul,E., Hutchinson,V., Ruikar,K. Knowledge Production, Sources and Capabilities in the Construction Industry. Work Package 1 – Final Report (2003). www.knowledgemanagement.uk.net (January, 2005).
[13]   Kasvi JJJ., Vartiainen M., Hailikari M. ''Managing knowledge and knowledge competences in projects and project organisations'' (2003), International Journal of Project Management, 21, 571-582.