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Knowledge management perceptions in construction and design companies

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ABSTRACT

Knowledge management (KM) has been studied extensively in recent years. Some consider knowledge to be the most strategically important resource for any company, but the fragmented, project-based and task-oriented nature of construction work makes it more difficult to implement KM in this sector. This paper presents a survey of perceptions of KM implementation in the Spanish construction sector and compares the results obtained from design and construction firms. Data were collected from the leading civil engineering companies in Spain. The survey found that the Spanish construction industry is aware of the benefits of KM but that systematic KM is not generally implemented. The findings clearly demonstrate that changes in organizational culture are critical to successful KM. The survey also revealed some distinctions between the KM perception of design firms and that of construction firms.

Author keywords:

Knowledge management, Spain, civil engineering.

1. INTRODUCTION

Knowledge management (KM) is defined as “the identification, optimization, and active management of intellectual assets to create value, increase productivity and gain and sustain competitive advantage” [1].

Although the construction industry is a strong, knowledge-based industry that relies heavily on knowledge input by the different participants in a project team, its nature is not conducive to effective KM; it is complex and heterogeneous and notorious for the level of rivalry between companies and employee migration; it operates within a dynamic and changing environment; and clients are becoming more sophisticated and demand more units of construction for fewer units of expenditure [2]. The project-based

nature of the industry also hinders effective KM, since most work is carried out by one-off project teams, varies between projects and is subject to time constraints, so there are few incentives to appraise performance, pass learning on and improve overall delivery [3].

A variety of approaches and practices are required to manage knowledge in this heterogeneous assemblage, which is made up of many professions, occupations, materials, practices and so forth [4]. In fact, there is no such thing as a “one size fits all” theory when it comes to KM in the construction industry [4]. The KM challenges in large, complex projects are different from those encountered in small, simple ones. The same is true of long-term versus short-term projects, and innovative projects versus projects that use well-established approaches or technologies.

A number of studies have shown that knowledge is managed across projects by considering them to be part of wider institutional and organizational ecologies, rather than focusing on the individual project as the unit of analysis. Grabher [5] stated that the “processes of creating and sedimenting knowledge accrue at the interface between projects and the organizations, communities, and networks in and through which projects operate”. Davies and Brady [6] also considered that “learning is geared towards moving from ‘one-off’ to repeatable solutions”. Engwall [7] found that historical and organizational context influenced the processes of a project. Moreover, local and contingent practices in different domains of the heterogeneous construction industry demand different approaches [4].

At present, the construction sector in Spain is facing challenges that affect its future viability and that of the entire national economy. Many small and medium enterprises (SMEs) are disappearing, and larger companies have begun to specialize in civil engineering and have developed strong industry profiles for the quality of their work. Although KM strategies are important in the performance and the competitiveness of the companies, studies to analyze KM implementation in the construction sector have been mainly carried out in leading countries such as UK and USA. Given the importance of this sector to the Spanish economy, it seemed a fruitful area for research. This research aims to better understand the status of KM in civil engineering companies: the sector of the Spanish construction industry in which the biggest companies operate. This area was chosen because KM appears to be more important to larger organizations, where it is more difficult to determine “who knows what” [8]. The results of this study will serve as a starting point for the companies to improve their KM systems and for the government to develop standards to promote KM strategies.

As construction and engineering companies mobilize and employ different bodies of know-how, the study focused on determining whether there are different KM approaches in these two types of companies. Understanding the different orientation of KM activities that is currently underway in design and construction firms can help companies develop organisational strategies aimed at increasing knowledge sharing such as people-centred techniques, IT tools, intra-organizational support and KM training. Hence, the goal of this study is to test the following hypotheses.

H01: The Spanish construction industry is implementing KM strategies.

H02: There is a distinction between the KM perception of design firms and that of construction firms.

The study analyzes strategic, organizational and instrumental aspects of KM [9] and is structured into: (1) the importance of KM to the organization; (2) the KM strategies adopted; and (3) the resources used to implement a KM strategy.

The first area analyzes how widespread proactive KM is within the Spanish civil engineering sector and identifies obstacles to implementing KM activities. The second area identifies strategies and areas in which KM can be applied. The third area provides insight into the type of infrastructures used to support the KM strategy.

2. THE SPANISH CONSTRUCTION INDUSTRY

Over the last ten years, the Spanish construction industry has enjoyed unprecedented growth. The demand for housing increased significantly in the mid-1990s, leading to a rise in prices and increased activity in the construction sector. Several factors contributed to this growth in demand: low interest rates, availability of credit, population growth through migration and socio-demographic changes. In 2004, the construction industry accounted for 10% of GDP, with the housing sector representing 36% of construction output, civil engineering 24%, general building 15% and restoration 25% [10].

However, as the economic situation changed, leading to higher unemployment and interest rates, the forecast rise in real estate prices that had sustained demand and encouraged new developments did not materialize. Real estate transactions fell to levels not seen since the previous downturn in the early 1990s, the number of housing permits dropped sharply and prices slumped. At present, the construction sector is facing challenges that affect its future viability and that of the entire national economy.

Many small and medium enterprises (SMEs) are disappearing, and larger companies have begun to specialize in civil engineering in response to the new national and regional development plans promoted by the Spanish government to reduce unemployment. In 2010 the housing sector decreased to 4% of total construction output, whereas civil engineering increased to 58%, general building increased slightly at 30% and restoration decreased slightly to 8% [11].

The biggest construction companies focus mainly on civil works, specialize in particular areas and have developed strong industry profiles for the quality of their work. However, they have also suffered serious problems due to the cyclical nature of the sector. KM strategies are particularly important in the construction sector, which is threatened by short-term uncertainties affecting the housing market and mid-term uncertainties affecting civil engineering [11].

3. KNOWLEDGE MANAGEMENT IN CONSTRUCTION AND ENGINEERING COMPANIES

Several studies have analyzed the perceptions and implementation of KM in the construction industry [13] [14] [8] [15] [18] [19] [20], most of which were conducted in the USA, the UK and Hong Kong. Table 1 summarizes the aims of these surveys and their findings. In general, KM is considered a fundamental organizational asset. However, organizational culture, business strategy and individual motivation to share knowledge must be taken into consideration for a successful implementation of KM. In relation to the use of IT for KM, the construction industry has the potential to greatly benefit from Information and Communication Technology (ICT) tools, although only a few firms (mainly the largest) are at the cutting edge of IT use [25] [26] [27]. Issa and Haddad [28] analyzed the implications of organizational culture and IT on KM in construction companies and concluded that IT is perceived as a tool for assisting KM but not for motivating people in sharing their knowledge and that not all types of knowledge can be shared using ITs. They proposed that a proper organizational culture, mutual trust between employees and organization, and the use of computer-supported collaborative work leads to more knowledge sharing.

Author	Focus groups	Aim of the analysis	Findings	Country
Carrillo and Chinowsky [13]	Design and construction firms	KM strategies	Clear distinction between design and construction firms.	USA UK
Carrillo et al. [14]	Construction industry	The use of KM	The majority of the companies actively used KM practices.	UK
Chen and Mohamed [20]	Construction organizations	Map KM activities	Tacit KM is very important in construction companies.	Hong Kong
Drejer and Vinding [19]	Construction industry	KM importance at the firm level	Knowledge-anchoring mechanisms and partnering may help reduce the shortcomings of project-based organizations.	Denmark
Esmi and Ennals [29]	Construction companies	Implementation of KM strategies	KM is considered a fundamental organizational asset even though few companies are currently implementing strategies comprehensively or consistently	UK
Fong and Kwok [18]	Contracting firms	Organizational Culture and KM Success	Cultivating the right organizational culture is a prerequisite for successful KM implementation in contracting organizations.	Hong Kong
Issa and Haddad [28]	Construction companies	Implications of organizational culture and IT on KM	Not all types of knowledge can be shared using ITs. A proper organizational culture, mutual trust between employees and organization, and the use of computer-supported collaborative work leads to more knowledge sharing.	
Zerjav et al. [24]	Engineering and construction	Knowledge sharing	A lack of attention to individual motivation to share knowledge is one of	USA

	organizations	motivators	the reasons of KM initiatives failures.	
Javernick-Will and Scott [12]	Engineering and construction organizations	Importance of knowledge	Developers, contractors and engineers had different opinions on the knowledge that is important for international firms due to the different type of firm's source of revenue and commitment time horizon.	USA
Robinson et al. [8]	Construction industry	The use of KM	The link between KM and business strategy must be taken into consideration for a successful implementation of KM.	UK
Sverlinger [15]	Technical consultancy firms	KM implementation	The project-based nature of design companies and the organization of tasks predominantly around projects rather than around departments explain why knowledge transfer in design companies is mainly from other companies participating in the same project organization.	Sweden

Table 1. Surveys on KM.

Regarding the differences between design and construction companies, the main barriers to implementing KM in design firms are concerns about sharing best practices and an unwillingness to share knowledge [15] [16]. In construction firms, the demands for mastering a multiplicity of processes and activities and the specific work situation of site construction managers mean that they have fewer opportunities for collaborating with peers and they find themselves with conflicting priorities and goals. Moreover, there is deference to the collective and general objective of the organization [16] and the main obstacles to implementing KM are workload stress, time pressure and long working hours [21], the organizational culture and the lack of standardized work processes [22] [17] and the application of technology and leadership [23].

Carrillo and Chinowsky [13] studied the KM strategies of major engineering design and construction firms in the US and the UK. They observed a clear distinction between the KM activities implemented by large engineering design firms and those carried out by construction firms. Their results showed that design firms had specific initiatives labeled and funded as distinct efforts to share and manage knowledge, while the KM activities conducted by construction firms were an extension of their normal business processes.

In fact, there are many KM strategies currently being adopted and used by organizations. However, there is no unique strategy that is likely to lead to successful outcomes in all organizations, but will depend on a host of factors, including organizational capabilities [30]. For example, regarding the knowledge that is important for international firms, developers, contractors and engineers had different opinions due to each type of firm's source of revenue and commitment time horizon [12].

Bearing in mind that design and construction firms are significantly different in terms of tasks organization, sources of power and influence, control and coordination, formality, people issues and nature of tasks [16], it's normal they adopt different KM strategies.

4. METHODOLOGY

4.1. Questionnaire survey

The questionnaire was based on questions devised by Uit Beijerse [9] to assess KM implementation in organizations, taking into account both organizational and social aspects of companies. Uit Beijerse [9] focused the survey on four main areas and defined the questions to be asked in each one. The areas were the strategy of the organization, organizational matters, the instruments used in KM, and the output of the entire process.

The questionnaire was designed for managing directors, who were asked to choose from a list of options, rank a series of options, and add further options with explanations. It was divided into the following sections (see Appendix A):

Section A: Respondent's Details (name, activity, etc.) and Company Background (number of employees, annual turnover, etc).

Section B: KM awareness and commitment (understanding of KM, drivers for KM, details of KM strategy, obstacles to KM, etc).

Section C: KM strategies (status of KM implementation, areas in which KM is implemented, etc).

Section D: Tools used for KM (focuses on IT and non-IT tools for capturing, storing and sharing knowledge).

4.2. Sample characteristics

To study and compare perceptions of KM implementation in the Spanish construction industry, a survey of the civil engineering sector, which contains most of the large design and construction companies in Spain was conducted. The literature review revealed that KM is a particularly challenging task for larger organizations because their size and geographical distribution make it difficult to establish “what the organization knows” [13] [8].

The survey was addressed to the managing directors of 70 design and construction companies based in Spain with a turnover in excess of seven million Euros and a total workforce of more than 50 employees (large and very large companies), particularly those specializing in civil engineering activities. The sample was obtained from an analysis of the construction sector to identify companies involved in civil engineering. The results were based on the KM awareness of the managing directors. The results

may have differed if the survey had been answered by employees at the operational level or IT managers, for instance.

Patel et al. [31] argued that large construction firms recognize the potential importance of KM and organizational learning but have done little to introduce it formally. This guided our choice of survey respondents, since most of the companies involved in civil engineering activities in Spain are large or very large. Details of the respondents and the respective company backgrounds were obtained in Section A of the survey. 58% of the companies were design companies and 42% were construction firms involved in civil engineering works.

A pilot survey was carried out, in which the questionnaire was sent to two construction companies and two engineering companies. The aim was to test the suitability and comprehensibility of the questionnaire. First, the companies were contacted by telephone and explained the aims of the study. If they gave their consent, the questionnaire was e-mailed to them. The respondents were asked to complete the questionnaire and to review the design and structure of the survey. All of the comments that were received were positive. As a result, no changes were made to the questionnaire for the main survey. The response rate for the pilot survey was 100%. In the main survey, 66 questionnaires were e-mailed to the rest of the companies. E-mail was used to ensure that no interviewer bias was introduced, and because it is the fastest method. The responses to the pilot survey were added to the sample, bringing the total to 70. Fifty-eight valid questionnaires were returned, giving a response rate of 83%, which is acceptable for this type of research.

4.3. Statistical analysis

To determine whether the answers to the questionnaire varied between construction and design companies, a statistical analysis was carried out when possible.

The data collected were analyzed using the Statistical Package for the Social Sciences (SPSS) for Windows (version 19.00) to identify where any differences between types of companies (construction and design) might lie by means of a chi-square test and a t-test. A chi-square test was used for those qualitative results (questions 1, 3, 4, 5, 6, 8, 9 and 12). The fact that the Pearson chi-square value is less than 0.05 indicates that both samples are independent. For those quantitative results (questions 2, 10 and 11) an Andersen Darling test was performed to determine the distribution type of the results. The p-value of this test for a normal distribution must be less than 0.05. For those normal distributions a t-test was performed while for those non-normal distributions the Mann Whitney non-parametric test was performed. For both tests, the fact that the significance index is less than 0.05 indicates that both samples are independent. The mean and standard deviation was also computed.

5. RESULTS

The survey results are divided into three sections: Section B examines the importance of KM to the organization, Section C investigates the resources allocated for implementing KM strategies, and Section D identifies the tools used for KM.

5.1. Section B: Knowledge management awareness and commitment

5.1.1. Understanding of the knowledge management concept

Construction and design companies understand the knowledge management concept differently (question 1; $p=0.019<0.05$).

These results might be attributed to problems with labeling KM, which is made up of quite diverse and heterogeneous practices, processes, and technologies. Some of these aspects only apply to KM, whereas others represent more general organizational features that could equally be included under different initiatives and different labels. In addition, companies may undertake knowledge and learning initiatives that they do not specifically label as KM, as they are not likely to use this particular terminology.

5.1.2. Awareness of KM benefits

From the questionnaire (question 2) it can be concluded that all of the respondents were aware of the benefits of KM but they identified different business areas that would benefit from the implementation of a KM strategy.

Each parameter had non-normal distributions. Therefore a Mann Whitney non-parametric test was performed. Table 2 shows the perceived effectiveness in different aspects that KM can offer to the company. The data show the results of the Mann Whitney test and the average rating for each factor on a scale from (1) least important to (5) most important.

Construction and design companies have different perceptions of the effectiveness of the following aspects: efficiency improvement (Table 2; $\text{sig}=0.000$), group work improvement (Table 2; $\text{sig}=0.021$), delivery time reduction (Table 2; $\text{sig}=0.035$), time reduction (Table 2; $\text{sig}=0.032$) and employees' experiences exchange (Table 2; $\text{sig}=0.000$).

Design companies identified improvements in group work as the second most important benefit of KM, whereas construction companies believed that this aspect was less important.

Design and construction companies also disagreed on the efficiency improvement, time reduction and employees' experiences exchange that KM could provide.

Aspects	Mann Whitney test (Sig.)	Design companies (Mean)	Construction companies (Mean)
Decision-making improvement		3.71	3.59
Efficiency improvement	0.000*	3.17	3.65
Group work improvement	0.021*	3.42	3.71
Product/service improvement		3.42	3.41
Costs cuts		3.29	3.09
Flexibility improvement		3.04	3.29
Delivery time reduction	0.035*	2.67	3.08
Time reduction	0.032*	2.92	3.24
Customers and suppliers relations improvement		3.29	3.00
Quality improvement		3.46	3.53
Employees' experiences exchange	0.000*	3.42	3.94

* sig.<0.05

Table 2. Level of awareness of KM benefits.

5.1.3. Recognition of KM as a strategic asset

The results of questions 3, 4, 6 and 8 had a normal distribution. Therefore, a Pearson test was performed. Table 3 shows the Pearson chi square value for these questions.

Regarding the recognition of KM as a strategic asset, construction and design companies have different points of view (Table 3; question 3; $p=0.014<0.05$). All design companies recognize KM as a strategic asset, whereas only 70% of the construction companies express this view. All respondents indicated that there are critical business processes in which it would be beneficial for more employees to have the knowledge that is currently only available to one or two.

Design and construction companies are equally aware of situations in their organizations in which costly errors have been made because of insufficient knowledge (Table 2; question 4; $p=0.808>0.05$). In both types of companies, these errors mainly occurred when knowledge was not available when and where it was needed and because employees did not know how to interpret or use the information available to them. These results are mainly due to the project-based nature of the construction industry and the fact that knowledge is embedded in social relations.

Construction and design companies are equally conscious that they might be missing out on business opportunities by failing to successfully exploit available knowledge (Table 3; question 6; $p=0.76 >0.05$).

Question	Pearson chi-square (p)	Design companies (%)		Construction companies (%)	
		Yes	No	Yes	No
3. Does your company recognize knowledge as a strategic asset?	0.014	100%	0%	70%	30%
4. Are you personally aware of any situation in your organization in which costly errors or mistakes were made because of insufficient knowledge?	0.808	79%	21%	80%	20%
6. Do you believe you may be currently missing out on business opportunities by failing to successfully exploit available knowledge?	0.76	86%	14%	78%	22%
8. Is there any kind of knowledge management system available in your organization?	0.853	43%	57%	30%	70%

Table 3. Recognition of KM as a strategic asset. Pearson chi-square.

5.1.4. Obstacles to implementing a KM strategy

Design and construction companies identified the same obstacles to implement KM strategies.

Those obstacles were the change of mentality needed to introduce KM systems (20%), the involvement of employees (12%), and the emphasis on individual rather than team work (13%).

5.2. Section C: Knowledge management strategies

5.2.1. Development of a KM business strategy

Construction and design companies have equally implemented some kind of KM system in their organizations (Table 3; question 8; $p=0.853>0.05$).

Most of the respondents indicated that their company already has a KM strategy, is working on its implementation or is planning to develop a strategy in the short term.

5.2.2. Areas benefitting from a KM strategy

Of the companies with an operational KM business strategy, 35% are implementing it in R&D (question 9). Some companies also apply their KM strategy to areas such as logistics, outsourcing, execution and processes, and marketing. No differences were found between construction and design companies ($p=0.084>0.05$).

5.2.3. Importance of people, processes and technology in a KM strategy

The results of question 10 had a normal distribution. Therefore, a t-test was performed.

All respondents considered employees, processes and technology to be important for implementing a KM strategy and no difference was found between construction and design companies (technology (sig=0.51>0.05), people (sig=0.861>0.05), and processes (sig=0.227>0.05) areas). However, employees are considered to be the most important element. In fact, social relations are considered to be one of the key aspects of KM.

5.3. Section D: KM tools

5.3.1. Effectiveness of different tools for improving KM

The results of the survey show that there are some differences in the perceptions of different tools for improving KM between construction and design companies.

The results of question 11 had a normal distribution. Therefore, a t-test was performed. Table 4 shows the effectiveness of KM tools considered by construction and design companies and the results of the t-test. Construction and design firms have different perceptions of the effectiveness of the following tools for improving KM: video-conferencing (Table 4; sig=0.000<0.05), databases (Table 4; sig=0.001<0.05), consultancy (Table 4; sig=0.029<0.05) and monitoring of projects/services by client (Table 4; sig=0.000<0.05).

Tools	t-student test (Sig.)	Design companies (Mean)	Construction companies (Mean)
E-mail	.948	3.85	3.84
Intranet	.306	3.92	3.84
Internet	.948	3.85	3.84
Communities of practice	.152	2.69	2.40
Video-conferencing	.000*	3.46	2.68
Databases	.001*	3.69	3.20
Decision-making tools	.243	2.85	2.64
Brainstorming sessions	.171	3.46	3.20
Small group meetings (2-4 people)	.120	3.85	3.68
Training and education plans	.170	3.69	3.52
Consultancy	.029*	3.23	2.80
Monitoring of projects/services by clients	.000*	3.46	2.76

* sig.<0.05

Table 4. Effectiveness of KM tools.

5.3.2. Appointment of a knowledge manager

From the analysis of the results (question 12) it can be concluded that construction and design companies behave similarly on the appointment of a knowledge manager ($p=0.702>0.05$). The survey shows that 57% of the companies have already established a point of responsibility by appointing the head of the KM department or another management figure (33%) to implement their KM strategy.

6. DISCUSSION

6.1. Section B: Knowledge management awareness and commitment

6.1.1. Understanding of the knowledge management concept

There are several dimensions of organizational knowledge: individual and group knowledge, internal and external knowledge, and tacit and explicit knowledge [32]. However, many practitioners confuse KM with ICT systems as it can be concluded from the survey results. The majority of the design firms (79%) and half of the construction firms (50%) understand KM as an ICT system.

6.1.2. Awareness of KM benefits

The general awareness of the benefits of KM is fuelled by the need for innovation, improved business performance and client satisfaction. The fragmented nature of the industry reduces the efficiency of project delivery, which results in dissatisfied clients and low profitability [33]. In addition to the many initiatives that are being introduced to address these issues, the effective management of project knowledge is now seen as vital in enhancing continuous improvement from lessons learned [34].

However, knowledge is a social accomplishment that is embedded in heterogeneous assemblages constituted of practices, routines, ideologies, materials, blueprints and sketches, as well as other resources that are mobilized and brought into action [4]. Therefore, awareness of KM benefits varies depending on the context in which knowledge is applied and the way in which professionals collaborate on projects in their day-to-day work. In fact, there are differences between construction and design firms. Design companies identified improvements in group work as the second most important benefit of KM, whereas construction companies believed that this aspect was less important. In engineering companies, the importance of KM-related improvements in group work might be due to the kind of tasks carried out by these companies. Engineering companies are mainly focused on the design phase, in which the main objective is to combine practical, material, aesthetic and financial aspects with teamwork. Engineering companies need to be able to organize many design teams (installations, structural, civil and architectural, among others). This might explain why they are really committed to improvements in group work.

Design and construction companies also disagreed on the efficiency improvement, time reduction and employees' experiences exchange that KM could provide. These

differences are mainly due to the different activities, know-how, professionals' routines, skill and experience of design and construction companies.

6.1.3. Recognition of KM as a strategic asset

The fact that nearly all the respondents recognize KM as a strategic asset and that they all believe that they might be missing out on business opportunities by failing to successfully exploit available knowledge, indicates that KM plays an important role for competitive advantage and is an integral part of continuous performance improvement [31] [33] [35].

Companies are aware of situations in their organizations in which costly errors have been made because knowledge was not available when and where it was needed and because employees did not know how to interpret or use the information available to them. These results are mainly due to the project-based nature of the construction industry and the fact that knowledge is embedded in social relations. However, for those big companies who might be carrying out international projects strategies to mobilize knowledge are critically important [24].

6.1.4. Obstacles to implementing a KM strategy

The findings of this study are consistent with the problems experienced by organizations in other sectors and are therefore not unique to construction [14].

The change of mentality is a recurring problem in the construction industry that has been studied by several researchers [36] [17] [37]. Most companies are divided into departments and business units that operate independently and have little contact with one another. Organizational culture cannot be modified overnight because of a new business initiative. McDermott and O'Dell [37] recommend that companies adapt their approach to KM to fit their mentality, that is, to complement the way in which their employees work, rather than forcing change. However, in many cases organizational change is necessary to break down knowledge silos and to seek expertise outside the immediate network.

There is growing evidence that organizations are restructuring their processes before implementing KM initiatives. However, these cases are limited to large organizations actively involved in R&D projects [38]. In addition, the changes in the sector over the past decade have transformed many organizations, forcing them to adopt new processes and creating a higher degree of diversity between the activities performed by each company. This makes it particularly difficult to access and share knowledge because of the number of ways and the lack of systematic procedures for documenting and implementing lessons learned.

Low employee involvement due to a lack of time, the emphasis on individual effort rather than teamwork and people's fear of sharing what they know are other obstacles that the companies consider to be very important. Carrillo and Chinowsky [13] found

that the main obstacle to implementing KM in both design and construction companies was the lack of time.

In construction organizations time is often associated with the need to deliver projects according to schedule. Many construction organizations believe that their organizational structure is too lean to exploit knowledge. Employees may be willing to share knowledge, but the pressure to deliver under tight project schedules and the need to take on additional responsibility for KM activities alongside everyday responsibilities rarely facilitate the successful development of a knowledge-sharing culture [39] [40]. Internal rivalry between employees is another important obstacle to knowledge sharing. Therefore, Dent and Montague [41] suggested that incentives and rewards might be necessary to encourage knowledge sharing. There are opposing views on incentives and reward schemes. Hall and Williams [42] identified them as a critical success factor for KM. However, reward systems are difficult to operate in the construction industry, even if there is a performance appraisal scheme in place; they are considered to be divisive because much depends on teamwork, and it is difficult to distinguish between the contributions to shared knowledge made by individual team members. Moreover, some construction professionals believe that financial incentives for sharing knowledge offer little chance of success and that peer recognition is more important [43].

6.2. Section C: Knowledge management strategies

6.2.1. Development of a KM business strategy

Most of the respondents indicated that their company already has a KM strategy, is working on its implementation or is planning to develop a strategy in the short term. As Demarest [44] noted firms without KM systems will effectively be unable to achieve the re-use levels required by the business model implicit in the markets they enter, and will lose market share to those firms that do practice KM.

Taking into account that most of the consulted organizations are large companies, this finding correlates well with previous studies indicating that KM is more important to large organizations [39]. In addition, larger and more widely distributed organizations benefit most from rapid access to knowledge held in other parts of the organization to provide quick and reliable solutions to clients.

6.3. Section D: KM tools

6.3.1. Effectiveness of different tools for improving KM

Many companies recognize that KM needs to be implemented through a number of complementary tools. Carrillo et al. [33] argued that any true KM system must support the full KM life cycle—from knowledge generation through transfer and eventual retirement—and not just a subset of the activities therein. Different types of tools have been identified for supporting the different phases of the KM life cycle, from creation to use. However, it should be noted that not all of these are ICT tools. Moreover, it could

be argued that companies should first identify specific KM problems and then determine the most appropriate tool, rather than identifying a tool and then finding a problem to solve.

The results of the survey show that there are some differences in the perceptions of different tools for improving KM between construction and design companies.

Regarding the priority of the different tools, small group meetings are considered the most effective tool for knowledge transfer both in construction and design firms, followed by e-mail, Internet and intranets. Training and education plans are also considered to be effective. The need to share tacit knowledge and disseminate best practices reflects the importance of leveraging the knowledge acquired by key employees to make it an organizational asset, rather than allowing this knowledge to be retained by each employee as an individual asset, which can be lost if employees leave the company. Face-to-face meetings are preferred to other systems for codifying knowledge, probably because tacit knowledge is considered to be more important than explicit knowledge.

Both construction and design companies identify the extranet and intranet as the main ICT tools for supporting the implementation of their KM strategy. There are several reasons for these results. Firstly, large organizations tend to have large amounts of knowledge to manage [39] and the intranet is a useful tool for managing explicit knowledge. Secondly, some types of knowledge require a high degree of security and the intranet provides a firewall to prevent unauthorized access [45]. Thirdly, the intranet facilitates communication [46] as organizations grow and become more diverse and geographically dispersed. Finally, large organizations are also likely to have the financial resources to implement and maintain an intranet. Although intranets are very useful tools, particularly for managing explicit knowledge, they do not adequately address the difficulties often associated with managing tacit knowledge [29]. Consequently, small group meetings are considered very important for sharing tacit knowledge.

Regarding the differences between construction and design firms, ICT tools such as video-conferencing and databases are better considered by design companies to improve KM rather than construction companies. This fact emphasizes the previous results that showed that for design companies KM has its roots in ICTs and the management of explicit knowledge by capturing and codifying information and storing it in databases. However, tacit knowledge is gradually gaining recognition as an important element in KM because the services the design companies offer are highly tacit, knowledge-intensive activities in which a wide range of professionals work in multi-disciplinary teams [8]. Therefore, other aspects such as consultancy and monitoring of projects/services by clients are other parameters that design firms perceive to be more effective for KM than construction firms.

6.3.2. Appointment of a knowledge manager

If KM is to achieve organizational goals, a knowledge manager or champion should be appointed to oversee delivery of the KM objectives [47]. Coordination and communication are more complex tasks in large companies such as the ones consulted in our survey, so it is important to assign a knowledge manager to oversee the implementation of the KM strategy. However, the functions of the knowledge manager and the management strategy should be based on the governance model of the company [24].

7. CONCLUSIONS

There is a growing awareness of the need for KM across a wide range of industry sectors. However, no study has been made of current implementation of KM in construction companies in Spain. The analysis of the survey sent to the 70 largest design and construction companies provides a fairly broad perspective, particularly in view of the high response rate.

This paper provides an overview of the status of KM activities in the leading Spanish construction companies, the resources used to implement KM initiatives and the perceived obstacles to implement a KM strategy.

Regarding H01 (The Spanish construction industry is implementing KM strategies), the findings highlight that although the leading companies of the Spanish construction industry are aware of the benefits of KM, systematic KM is not generally implemented. The research identifies critical findings that companies should take into consideration before establishing a KM system.

The findings clearly demonstrate that changes in organizational culture are critical to successful KM (the main obstacles to implementing a KM strategy are considered to be the change of mentality needed to introduce a KM system [20%], the involvement of employees [12%] and the emphasis on individual rather than team work [13%]). The necessary change of mentality would increase knowledge sharing between employees. The fact that most respondents indicated the need for a person or group to oversee KM activities reinforces the lack of a knowledge culture. Companies should invest in their employees by promoting them, offering them incentives and organizing meetings that help them to get to know one another better and to work in groups.

The results of this study appear to support the model of KM as people management. People should be effectively integrated into the processes they use and the technology they employ in their tasks. KM is a way to facilitate this integration. The construction industry realizes that strong integration of people in the processes they work with and the technology they use is important to ensure optimum utilization of the knowledge available in the organization. However, the research highlights the non-technology-centric view of KM in the construction industry. Although a range of ICT tools are available for knowledge sharing, KM is carried out predominantly through more conventional methods such as small group meetings. Of the ICT tools available for KM, the extranet and intranet are considered to be the most well-known and the easiest to

use. In contrast, communities of practice are considered to be ineffective probably because companies do not have a critical mass of people with a common interest.

On the other hand, regarding H02 (There is a distinction between the KM perception of design firms and that of construction firms) this analysis concludes that there are some distinctions among firms although they are similarly aware of the KM benefits, have equally implemented some kind of KM system and identify the same obstacles to implement a KM strategy.

Construction and design companies understand the knowledge management concept differently. Design firms are more ICT oriented and recognise KM as an ICT system for the management of intellectual assets while construction companies also understand KM as a methodology for the identification, optimization and active management of intellectual assets.

In the same line, although all companies recognize that KM needs to be implemented through a number of complementary tools and all of them state that they need to share tacit knowledge, ICT tools such as video-conferencing and databases are better considered by design companies to improve KM rather than construction companies. This fact emphasizes the previous results that showed that for design companies KM has its roots in ICTs and the management of explicit knowledge by capturing and codifying information and storing it in databases.

These differences are mainly attributed to the context in which knowledge is applied and the way in which professionals collaborate on projects in their day-to-day work. Understanding the different perceptions of KM effectiveness of different tools to improve KM can help companies develop organizational strategies aimed at increasing knowledge sharing.

For construction companies, these strategies can be oriented to improve ICT tools such as video-conferencing using mobile applications for the communication between on-site managers and office staff, development or improve of databases to capture and codify knowledge, potentiate small group meetings for knowledge transfer and implement training and educational plans.

For design companies, the organizational strategies to increase knowledge sharing can be oriented to promote face-to-face communication between designers and improve ICT tools such as communities of practices or Building and Information Modeling (BIM) to share visual information among all design partners.

These results can also be used as a starting point for the government to develop standards to promote KM. Currently, the Spanish tendering process for public projects takes into account parameters such as whether the company has a quality management system. However, the government is analyzing the possibility to include document and knowledge management parameters to force companies to implement KM systems and, consequently, improve the quality of the projects. Based on the results of this study, these parameters should be based on a well-balanced integration between people, processes and technology.

The results of this study cannot be extrapolated to SMEs, which have a different structure and interests from large companies. However, the findings documented herein should provide SMEs with insight into the KM activities that are currently underway in the larger companies that are taking a lead.

This study was limited to managing directors from the civil engineering in a specific geographical region (Spain). To increase the generalizability of results, future research would benefit from greater sample diversity in terms of the size and type of companies, the cultural context and the different levels of employee. Further qualitative studies, such as in-depth case studies, are required to examine the interactions between different types of KM activities in detail.

APPENDIX A: KNOWLEDGE MANAGEMENT SURVEY

Section A: Respondent's details

Company	_____	Activity:	_____
Role:	_____	Date:	_____
Tel.:	_____	E-mail:	_____
N° of employees:	_____	Turnover:	_____

Section B: Knowledge management awareness and commitment

- What does knowledge management (KM) mean to you?
 - An ICT system for the management of intellectual assets.
 - A methodology for the identification, optimization and active management of intellectual assets.

- Qualify the effectiveness that KM can offer your company in the following aspects:

	Extremely beneficial	Very beneficial	Quite beneficial	Not very beneficial	Not at all beneficial
Decision-making improvement	<input type="checkbox"/>				
Efficiency improvement	<input type="checkbox"/>				
Group work improvement	<input type="checkbox"/>				
Product/service improvement	<input type="checkbox"/>				
Costs cuts	<input type="checkbox"/>				
Flexibility improvement	<input type="checkbox"/>				
Delivery time reduction	<input type="checkbox"/>				
Time reduction	<input type="checkbox"/>				

Customers and suppliers relations improvement	<input type="checkbox"/>				
Quality improvement	<input type="checkbox"/>				
Employees' experiences exchange	<input type="checkbox"/>				

3. Does your company recognize knowledge as a strategic asset?

- Yes
 No

4. Are you personally aware of any situation in your organization in which costly errors or mistakes were made because of insufficient knowledge?

- Yes
 No

If you have answered Yes, were they caused by the following reasons?

- | | | |
|---|---|-----------------------------|
| Insufficient technological knowledge | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| Loss of knowledge of vital importance | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| Insufficient knowledge about competitors | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Insufficient knowledge about customers | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| Insufficient knowledge about processes | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| Employees cannot interpret or use available information | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| Knowledge unavailable when needed | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| Repetition of previous errors | <input type="checkbox"/> Yes | <input type="checkbox"/> No |

5. Are there situations in which the knowledge acquired by only one or two employees would be useful for a higher number of employees?

- Yes
 No

6. Do you believe you may be currently missing out on business opportunities by failing to successfully exploit available knowledge?

- Yes
 No

7. What are the obstacles to developing a KM system?

- Change of mentality needed to use these systems.
 Time needed and high cost of implementing a KM system.
 Lack of proved methods for carrying out projects in KM.
 Low involvement of top management.
 Low involvement of employees.
 Emphasis on an individual level rather than a team level and people's fear of sharing what they know.
 Lack of an incentive system.
 Layout of work spaces.

- Lack of the technological infrastructure needed for its implementation.
- Lack of training.
- Information systems dispersed in different technological media (need for integration).
- The concept is unknown.

Section C: Knowledge management strategies

8. Is there any kind of knowledge management system available in your organization?
- Yes. there is a KM system available.
 - There is no KM system available at the moment. but we are working on one.
 - No. but we are considering the possibility.
 - We have no KM system and are not planning to have one.
9. If your organization is developing a KM business strategy. in what business area is it being implemented?
- Research & development
 - Business strategy
 - Other. Please state:
10. How important are people, processes and technology within your organization in their contribution to a KM system?

Area	Extremely important	Very important	Quite important	Not very important	Not at all important
People	<input type="checkbox"/>				
Technology	<input type="checkbox"/>				
Processes	<input type="checkbox"/>				

Section D: Tools used for knowledge management

11. How effective are these tools within your organization?

	Very effective	Effective	Not very effective	Ineffective	Not used
E-mail	<input type="checkbox"/>				
Intranet	<input type="checkbox"/>				
Internet	<input type="checkbox"/>				
Communities of practice	<input type="checkbox"/>				
Video-conferencing	<input type="checkbox"/>				
Databases	<input type="checkbox"/>				
Decision-making tools	<input type="checkbox"/>				

Brainstorming sessions	<input type="checkbox"/>				
Small group meetings (2-4	<input type="checkbox"/>				
Training and education	<input type="checkbox"/>				
Consultancy	<input type="checkbox"/>				
Monitoring of projects/services by clients	<input type="checkbox"/>				

12. Who is responsible for knowledge management activities in your company?

- Top management
 Department manager
 Others. Please state:

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