Contribution to improvement of knowledge management in the construction industry - Stakeholders’ perspective on implementation in the largest construction companies

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Abstract: Knowledge management (KM) is crucial to ensure that business enterprises effectively leverage existing knowledge within the organization and produce faster and more effective decision-making. This article analyses the importance of KM in the construction industry in Portugal and investigates the perception of experienced professionals on the implementation of KM in this industry, its benefits, and restrictions to its implementation, and how knowledge is obtained and shared. A survey was conducted among experienced professionals working in the largest construction companies in Portugal—administrators, project managers, and budget officers. The validity and reliability of the results were achieved by statistically evaluating the respondents’ answers to the variables under study. From the analysis of the results, the relevance of KM is evident, and its greatest benefits are the sharing of information and the exchange of experiences. The lessons learned from completed projects and work meetings are pointed out as the most effective and usual ways to obtain knowledge, but there is a pressing need for a change in mentality to overcome the main barrier to the implementation of KM. This study aims to help construction companies in Portugal to develop strategies to implement KM and knowledge sharing.

Subjects: Customer Relationship Management; CRM; Enterprise Resource Management; ERP; Engineering Project Management

Keywords: knowledge management; knowledge sharing; restrictions to the implementation of knowledge management; construction sector

1. Introduction

Nakamori (2020) defines knowledge management (KM) as “the identification, optimization and active management of knowledge to create value, increase productivity, make gains and sustain competitive advantages”. The subject of KM has been receiving increasing attention from construction companies, resulting in a reinforcement of related studies, which fit with the need to study the determining factors that influence the performance and competitiveness of the construction sector. Therefore, with the growing use of the Building Information Modeling (BIM) methodology in construction projects, there is an increasing need for knowledge management practices, grounded in sound theoretical basis (Singh & Mirzaeifar, 2020). In addition, a lot of data is generated and captured through tracking and monitoring devices such as sensors and scanners, which also needs to be collected, stored, and shared. Robinson et al. (2005) consider construction organisations as a knowledge-based industry willing to improve their business performance and achieve sustainable...
competitive advantage in global markets, and they are looking to implement KM tools that lead improving their “learning capability” (Francisco, 2009). But KM requires an environment that allows workers to create, capture, share, and leverage knowledge to improve business performance.

Malhotra (2004) has argued that the main reasons behind the inexistence of such an environment results from a lack of robust application in defining, implementing and executing effective KM. For example, Ofek and Sarvary (2001) conducted a study on competitive advantage through the use of KM in the construction industry and its impact on the competitive dynamics of this sector, noting that KM implementation is essential to attract more clients and improve the quality of construction projects.

Since then, several studies have been conducted to determine which factors cause delays in the implementation of construction projects. Later, Yap and Shavarebi (2019) conducted a study to assess how learning and skills development of construction professionals improve performance in the delivery of construction projects. The authors concluded that the construction sector suffers from ineffective KM in construction projects. They also concluded that factors such as continuous learning, the collaborative environment, consultation of completed projects, and lessons learned from completed projects enrich the quality of construction projects, avoid wasting time and resources in reinventing the same knowledge and increase the success of construction projects.

A lesson learned is a piece of knowledge or understanding gained from experience, whether positive or negative, and which, if applied to other projects, can reduce or eliminate potential failures (Carrillo et al., 2013). These lessons learned from completed projects make it possible, on the one hand, to gather information about the problems and risks faced, and, on the other hand, to understand the recommendations/suggestions for improvement actions based on techniques and processes that have obtained good results in the past (Rowe & Sikes, 2007).

Eleven experts from the construction sector were surveyed on the nature of communication and learning of the construction project and its role in its duration and cost control, and the results showed that using the knowledge gained from completed projects helped to reduce the duration of the construction project and promoted better cost control in future projects (Yap & Skitmore, 2020). Still, as the construction sector is based on unique and distinct projects, there are still hindrances to the use of effective KM. As a result of the complexity and heterogeneity of the construction projects, a large part of the work is carried out by ad hoc teams that vary from project to project, thus making it difficult to share knowledge (McCarthy et al., 2000). Despite these adverse factors, the construction sector has recognized the importance of KM and some companies use conventional approaches, from telephone calls to meetings, to facilitate knowledge sharing (Yu & Yang, 2018).

To increase KM effectiveness and efficiency, organizations use information and communication technologies to implement knowledge management systems specifically designed to facilitate and support the organizational processes of knowledge creation, storage, retrieval, transfer, and application (Said et al., 2014).

However, implementing KM systems differs from the implementation of traditional business information systems, for there are no exact specifications on the KM system’s inputs, processes, and outputs. As a result, implementing KM is comparatively more difficult, riskier and technologically more innovative (Wang & Wang, 2016).

These characteristics of knowledge and knowledge management in the construction sector underline the need to understand and identify the benefits and constraints affecting knowledge management implementation by companies (Lin, 2013; Taghavi et al., 2021; Wang & Wang, 2016).

This article analyses the importance of KM in the construction industry and the barriers of KM implementation, by surveying administrators, project managers and budget officers of the largest
construction companies in Portugal regarding the following research questions: (1) What is the perception on the implementation of KM in the construction industry? (2) What are the benefits of KM? (3) What are the benefits of knowledge? (4) How is knowledge obtained? (5) What is the perception on knowledge sharing? And (6) What are the constraints to the implementation of a KM system?

The results of this study will provide empirical evidence to achieve a comprehensive understanding regarding the corporate decision whether to implement a knowledge management system. The study will provide researchers and practitioners with insightful implications for the evaluation and implementation of a KM system.

To facilitate reading, this article is organized in five sections. Section 1 consists of this introduction and defines the framework, objectives, and contribution of this article. Section 2 focuses on the review of the literature on knowledge and knowledge management in the construction sector. Section 3 presents the research methodology adopted for data collection and analysis. Section 4 presents the results obtained, and their analysis. Finally, Section 5 presents the discussion, and Section 6 presents the main conclusions of this study and proposals for future research.

2. Literature review

2.1. Knowledge management

Since the introduction of knowledge management (KM) technologies in the late 1980s, this area of study has grown and diversified. However, KM initiatives are still vague and ambiguous, for there are many interpretations of what KM really represents (Cheng et al., 2014; Hayati et al., 2020). In an environment characterized by competitiveness, innovation and constant change, knowledge and KM are, more than ever, indicators of an organization’s path towards success or failure (Leliaert et al., 2003). But making knowledge available is not enough to promote its distribution; it is also necessary to involve people in that process, motivating them to seek, transfer and use available knowledge (Davenport & Prusak, 1998).

For Anon (1998), the construction sector is based on knowledge and this knowledge must therefore be constantly updated and shared among the various stakeholders throughout the life cycle of the construction project. Fifteen years later, Zhang et al. (2013) confirmed that this was the only way to contribute to effective KM. The approaches to an integration model, such as the concept of the live capture of knowledge (Udeaja et al., 2008), knowledge sharing and learning behaviours, contribute to a better performance and business process improvement with a direct application in the construction industry (Wibowo & Waluyo, 2015). For Sommerville and Craig (2006), good decisions are also the result of careful management and the analysis of project information and knowledge. What has been identified is that organisations encounter a vast range of knowledge zones; however, difficulties are encountered in differentiating between what is essential, important, or merely interesting.

Allameh et al. (2011) concluded that technology, company structure, and organizational culture are intrinsically related to KM processes. This type of knowledge that is rooted in experience, action and the involvement of a specific context, composed of cognitive and technical elements—i.e., obtained via the learning process (Ni et al., 2018)—is considered tacit knowledge. On the other hand, knowledge that can be articulated, codified and communicated in natural language or through a symbolic form—i.e., that can be exteriorized through formal language—is considered explicit knowledge (Igbinovia & Ikenwe, 2018).

KM is crucial to ensure that construction companies take advantage of existing knowledge to make faster and more efficient decisions (Yap & Toh, 2020). KM is a methodology that involves several processes. In the literature, the discrepancies in the delineation of processes are small, namely regarding the number and identification of processes. Several authors (Hwang, 2020; Yap & Toh, 2020) define four main processes of KM:
- **Knowledge creation**: consists in developing and/or updating an organization’s tacit and explicit knowledge. It is a continuous process, involving individuals and teams within the same organization and/or among different organizations (Bloodgood & Salisbury, 2001);
- **Obtaining knowledge**: implies a set of activities such as coding, classification and organization of knowledge (Terzieva, 2014). Only explicit knowledge can be stored (Davenport & Prusak, 1998) and this implies that tacit knowledge has to be converted into explicit knowledge to avoid being lost when individuals leave their organizations;
- **Sharing knowledge**: consists in sharing knowledge by other members of the organization, thus allowing knowledge to be present where it can and should be applied (Alavi & Leidner, 2001; Gupta & Govindarajan, 2000). For effective sharing, communication and information flows between organizations are important (Bergeron, 2011; Jallow et al., 2017; Wiig, 2012), as making knowledge available may not be sufficient to promote its distribution, and thus requires involving people in the process and motivate them to seek, transfer and use the available knowledge;
- **Application of knowledge**: consists in the use of knowledge acquired by individuals and/or organizations, thus becoming a source of competitive advantage, because efficient application of knowledge helps organizations to increase efficiency and reduce costs (Davenport & Prusak, 1998).

As construction projects have become more complex and challenging in recent years, knowledge has become a critical resource for construction companies. Knowledge as a source of competitive advantage has been widely mentioned in the literature (Okudan et al., 2021). Although many efforts have been devoted to the development of effective KM mechanisms in the construction management literature, this research area is not mature and there is still some distance to be covered (Eken et al., 2020).

### 2.2. Restrictions on the implementation of knowledge management

Forcada et al. (2013) conducted a study in Spain on the perception of KM in major construction and design companies based on data collected via questionnaires. The authors concluded that KM lacked implementation, although construction companies were aware of its benefits. They also demonstrated that successful KM involves, on the one hand, introducing changes in the culture and organizational mentality (which are considered the main obstacles to the implementation of a KM strategy) and, on the other hand, emphasizing teamwork rather than individual work, and involving all employees. Subsequently, Manley and Chen (2017) found that the capacity of collaborative learning maximizes project performance. They identified the three main factors affecting the implementation of an efficient KM system: “high time pressures in the final phase of the project”, “too much focus on short-term deliveries” and “the professionals’ fear of suffering repercussions by disclosing project errors”. To assess the central factors in the success of KM and the results of project management performance in the main construction companies in Sri Lanka, in 2018 these same authors found that the use of benchmarking, teamwork and individual skills are the main priorities that construction organizations should consider when implementing a KM system. They also stressed that administrations should empower their project managers and delegate responsibilities to them, as well as maintain the motivational level of team members—i.e., they should exercise leadership to motivate knowledge sharing.

### 3. Research methodology

To address the objectives of this study, a multi-method model of research approach was adopted (Gable, 1994). The approach consists of a structured review and content analysis of the literature on knowledge management in the construction sector and a questionnaire survey for data analysis.

### 3.1. Literature search parameters

Multiple databases, including Google Scholar and Scopus, and specific publishers such as Elsevier, Taylor and Francis, and Emerald were used to search for and identify useful publication (published between 2012 and 2021) by using keywords in different combinations: “knowledge management”, “restrictions”, “benefits” and “construction projects”. Subsequently, an integrate review of literature was conducted to identify the process and restrictions to the implementation of KM in the construction sector. This review process has been adopted by previous construction KM related
studies to identify key factors related to knowledge, KM processes, and restrictions to the implementation of KM in the construction sector.

Regarding the six research questions identified in the introduction, the present study conducted a synthesis of previous relevant work, mainly based on the results of Forcada et al. (2013), Zhang et al. (2013), Gunasekera and Chong (2018), and Hwang (2020).

3.2. Questionnaire
The surveys were developed based on the following objectives: to know the perception of professionals on the sharing of knowledge and KM implementation in the construction sector; to assess the benefits both of knowledge and KM; to identify the way of obtaining knowledge within the organization; and, finally, to identify restrictions to the implementation of a KM system. The developed survey questionnaire was then sent to a small group of industry professionals. The professionals and the author made a minor revision to the questionnaire, mainly word choices, through e-mail and telephone communication.

Subsequently, a questionnaire was sent by e-mail and at the same time the companies were contacted to clarify doubts and encourage their participation in the study. Each company was asked to forward the survey to (1) an administrator or manager, (2) a project manager, and (3) a budget officer, as they can be considered as the main stakeholders regarding KM implementation in the construction sector.

It was sought to capture the interest of these specialists in the subject, and they were guaranteed the confidentiality of all the data provided, which would only be used for statistical treatment and analysis. The questionnaire was based on the structures designed by previous studies and was divided into 2 sections. Section 1 aimed at collecting information and characterizing the sample, namely regarding the type of enterprise, the respondents’ function in their enterprises, and respective professional experience.

Based on their professional experience within their organizations, in Section 2 the respondents were asked to indicate their perception on the implementation of KM in the construction sector; to assess the benefits of KM and the benefits of knowledge; to identify how they obtained knowledge; to indicate their perception on knowledge sharing; and, finally, to refer to restrictions on the implementation of a KM system. This section aimed to rank and evaluate the consistency of the results, using a Likert scale ranging from 1 to 7, where 1 corresponded to “I completely disagree” and 7 to “I completely agree”.

3.3. Sample general information
The literature review shows that KM is a particularly challenging task for larger organizations because their size and geographical distribution make it difficult to establish their knowledge (Forcada et al., 2013). Since it was not possible to study the entire Portuguese population of contractors, we chose to analyse a random sample obtained through consulting both the IMPIC (Institute of Public Procurement, Real Estate and Construction) for general contractors with Class A building license, and companies with a turnover greater than 70 million Euros according to PORDATA, the Portuguese Database, resulting in 17 companies. Although the sample is small, it is representative of the Portuguese context, given its characteristics, size and criteria established for the selection.

Therefore, for a population of 51 respondents matching the sample criteria, we obtained 45 answers (resulting in a confidence interval of 5.06%), which are acceptable rates in comparison to previous studies based on questionnaire surveys in the construction sector: for example, 7.4% in the study by Abdul-Rahman et al. (2006), and 13.0% in the study by Jin et al. (2017).

The survey was addressed to the managing directors, project manager and budget officers of the companies based in Portugal. The respondents consisted of: GF1—Administrator or manager
Table 1. Respondents’ population summary

| Item                        | Detail                                                                 |
|-----------------------------|-------------------------------------------------------------------------|
| Position in company         | GF1—Administrator or manager (n = 17)                                    |
|                             | GF2—Project Manager (n = 16)                                           |
|                             | GF3—Budget Officer (n = 12)                                            |
| Experience in the sector    | 10 to 15 years (0 cases)                                                |
|                             | 15 to 20 years (28 cases)                                               |
|                             | over 20 years (17 cases)                                                |

Table 2. KM-related factors that promote the efficiency of the construction sector

| Item                                              | % frequency |
|--------------------------------------------------|-------------|
| Levelling of knowledge and good practice         | 6.7 %       |
| Centralization of information                    | 7.2 %       |
| Contribution to the further training of technicians | 4.6 %       |
| Anticipation of problems, improved competitiveness, and increased innovation | 52.1% |
| Improvement of established procedures            | 5.7 %       |
| Basic support for business                       | 3.6 %       |
| Promotion of sharing experiences and lessons learned from completed projects | 13.4% |
| Process optimization                             | 6.7 %       |

(52.92%); GF2—Project Manager (58.82%); and GF3—Budget Officer (52.92%). Table 1 presents the respondents’ population summary. In total, nine responses were collected from administrators or managers, ten responses from project managers, and nine from budget officers. Regarding the respondents’ professional experience, all of them have more than 15 years of experience; and over 20 years in the case of 8 of them.

Additionally, by group analysis, it was found that 41.2% of the administrators/managers and 66.7% of budget officers had more than 20 years of experience, in contrast to only 12.5% project managers with more than 20 years of experience. It can then be inferred that the budget officers are the most experienced professionals in this sector.

3.4. Statistical analysis of the data

The questionnaires were organized in a matrix using the Statistical Package for the Social Sciences (SPSS), version 26 for Windows. For each item, simple statistics were calculated: mean, median, mode, standard deviation, and amplitude. Then a Cronbach’s alpha was used to assess the internal consistency of the data collected, which translates into the degree of uniformity or coherence between the respondents’ answers to the questionnaire items. According to DeVellis (2016), the value of Cronbach’s alpha can vary from 0.7 to 0.9, indicating a good internal consistency. Other authors consider that a value greater than 0.9 indicates a very good consistency; between 0.8 and 0.9, a good consistency; between 0.7 and 0.8, a reasonable consistency; between 0.6 and 0.7, a weak consistency; and less than 0.60 corresponds to an inadmissible interrelationship between the items (Pestana & Gageiro, 2014; Schuenemeyer et al., 1989; Tonglet et al., 2004). The Friedman test was used to classify the items of each question.

The Central Limit Theorem (CLT) states that the sampling distribution of a sample mean is approximately normal if the sample size is large enough, even if the population distribution is not normal. Therefore, to evaluate the adherence to normality, i.e., to test whether the sample can be assumed to be normal, it was used the Shapiro-Wilk (S-W) test, for it allows to determine whether a given sample comes from a population with normal distribution. The rejection or acceptance of
normality is found by determining the critical value of the distribution of S-W statistics. For this purpose, it was calculated the hypothesis p-value (the probability of obtaining a test statistic equal to or greater than that observed in a sample), and if the p-value is less than or equal to $\alpha$ (probability of error), the normality of the sample must be rejected. The level $\alpha$ chosen was 0.05 for all tests. On the other hand, to test the null hypothesis (“$H_0$: Is there any difference in the answers stemming from the respondents’ function in their companies?”), it was verified if the normality is observed.

Therefore, if the normality is observed, the parametric test (which uses the mean as a measure of central tendency) is adequate, and the unidirectional ANOVA test is performed. However, if normality is not observed, the non-parametric test (which uses the median as a measure of central tendency) of Kruskal-Wallis (K-W) is applied. In both tests, it was evaluated if the p-value was less than 0.05 to validate the null hypothesis.

In the following section are analysed the results based on the six research questions described in the Introduction and in the literature review: (1) What is the perception on the implementation of KM in the construction sector? (2) What are the benefits of KM? (3) What are the benefits of knowledge? (4) How is knowledge obtained? (5) What is the perception on knowledge sharing? And, finally, (6) What are the restrictions to the implementation of a KM system?

4. Data analysis

4.1. Perception on the implementation of KM in the construction sector

Although there are several dimensions of knowledge within organizations, including individual and group knowledge, internal and external knowledge, and tacit and explicit knowledge (Robinson et al., 2005), according to authors Forcada et al. (2013), many professionals confuse KM with information and communication technology (ICT) systems. These authors indicate that 50% of respondents from construction companies considered KM to be an ICT system.

Contrary to the results reported by Forcada et al. (2013), in the present study only 17% of the respondents considered KM an ICT system for managing intellectual assets (question 1 of Section 2 of the questionnaire).

Also, when asked about the importance of companies implementing a KM system, the answer was unanimous and positive. However, only one company claimed to have already implemented a KM system and, when questioned about how they created or organized information, they stated that they used the intranet through an online server organized around thematic areas and through regular meetings.

Regarding the question whether KM can make the construction sector more efficient and which factors promote its efficiency, all respondents considered that KM makes the sector more efficient.

As for the factors related to KM that promote the efficiency of the construction sector, 50% of the respondents consider that KM helps companies to “anticipate problems, improve competitiveness, increase innovation”, and 16.4% consider that it “promotes the sharing of experiences and lessons learned from completed projects”. Table 2 presents the KM-related factors that promote the efficiency of the construction sector, as well as the respondents’ answers and their frequency.

4.2. The benefits of knowledge management

Table 3 presents the eleven items proposed to the respondents to identify the benefits that KM can bring to the construction sector (question 2 of section 2 of the questionnaire). This table summarizes the mean, median, mode, standard deviation, and range for each item. By analysing the data obtained, it was obtained a Cronbach's alpha of 0.91, which demonstrates a remarkably high consistency of the results obtained. The S-W test was performed to evaluate the normality of items
A1 to A11, and it was obtained a p-value <0.05]—therefore, normality is rejected. The non-parametric K-W test was used to verify the null hypothesis, and it was verified that the p-value is higher than 5% (according to the result identified in Table 3), and therefore there are no significant differences between the answers given by the different professionals.

After analysing the data identified in Table 4, the respondents considered that all the items presented are important for the management of construction projects (median higher than 5). However, item A8 (“Exchange of experiences between employees”) was considered as the most beneficial by the respondents, followed by item A9 (“Ease of information sharing between stakeholders”), both obtaining a median of 6.50 values and the highest score in the Friedman test.

Similar to the study by Forcada et al. (2013), item A8 (“Exchange of experiences between employees”) is also very relevant. However, according to these authors, item A9 (“Ease of information sharing between stakeholders”) was mentioned as one of the least beneficial benefits and ranked last, but the present study contradicts that result.

| Item | μ | x | Mo | σ | Δ | K-W | R |
|------|---|---|----|---|---|-----|---|
| A8—Exchange of experience between employees | 6.11 | 6.50 | 7 | 1.28 | 5 | 0.15 | 1 |
| A9—Ease of sharing information between stakeholders | 6.11 | 6.50 | 7 | 1.18 | 4 | 0.19 | 2 |
| A2—Continuous improvement of processes | 6.17 | 6.00 | 7 | 0.86 | 2 | 0.22 | 3 |
| A10—Risk minimization of tasks/activities | 5.89 | 6.00 | 7 | 1.23 | 4 | 0.54 | 4 |
| A1—Improved decision-making | 6.00 | 6.00 | 6 | 0.91 | 3 | 0.93 | 5 |
| A11—Characterization of procedures within the organization | 5.89 | 6.00 | 7 | 1.08 | 3 | 0.93 | 6 |
| A3—Improved efficiency of tasks/activities | 5.72 | 5.50 | 5 | 1.07 | 3 | 0.12 | 7 |
| A7—Improved quality of products and/or services | 5.78 | 6.00 | 6 | 1.22 | 4 | 0.17 | 8 |
| A4—Improved group work | 5.78 | 6.00 | 7 | 1.26 | 4 | 0.20 | 9 |
| A5—Cost reduction for the company | 5.56 | 6.00 | 7 | 1.42 | 4 | 0.13 | 10 |
| A6—Reduction of the time of execution of tasks/activities | 5.22 | 5.00 | 4 | 1.35 | 4 | 0.30 | 11 |

*mean; b median; c mode; d standard deviation; e amplitude; f ranking based on the Friedman test.
### Table 4. The benefits of knowledge for the construction sector

| Item                                                                 | $\mu_F$ | $x_{F1}$ | $x_{F2}$ | $x_{F3}$ | $x^b$ | $Mo^c$ | $\sigma^d$ | $\Delta^e$ | $K-W$ | $R^f$ |
|---------------------------------------------------------------------|---------|----------|----------|----------|-------|--------|------------|------------|-------|-------|
| B4—Performing a correct risk analysis and safety control of construction tasks | 6.50    | 6.00     | 7.00     | 7.00     | 7.00  | 7      | 0.79       | 3          | 0.08  | 1     |
| B3—Performing good planning and good time management                | 6.56    | 6.50     | 7.00     | 7.00     | 7.00  | 7      | 0.715      | 2          | 0.55  | 2     |
| B2—Assessing the project’s uncertainty and managing its risks      | 6.28    | 6.00     | 6.00     | 7.00     | 6.50  | 7      | 0.89       | 3          | 0.05  | 3     |
| B1—Learning best practices                                         | 6.33    | 6.00     | 6.00     | 7.00     | 6.50  | 7      | 0.77       | 2          | 0.23  | 4     |
| B5—Estimating and managing costs                                   | 6.22    | 6.00     | 6.00     | 7.00     | 6.00  | 7      | 0.80       | <α         | 5     |       |
| B8—Learning about relevant legislation for each project            | 5.83    | 4.50     | 6.00     | 7.00     | 6.00  | 7      | 1.29       | <α         | 6     |       |
| B7—Preparing the budget correctly for bidding                      | 5.72    | 6.00     | 6.00     | 5.00     | 6.00  | 6      | 1.12       | 4          | 0.48  | 7     |
| Item                                      | $\mu_a$ | $x_{d1}$ | $x_{d2}$ | $x_{d3}$ | $x_{f1}$ | $x_{f2}$ | $x_{f3}$ | $\sigma^d$ | $\Delta^e$ | $K-W$ | $R_f$ |
|------------------------------------------|---------|----------|----------|----------|----------|----------|----------|------------|------------|-------|-------|
| B6—Learning from local practices        | 5.83    | 6.00     | 6.00     | 6.00     | 6.00     | 6.00     | 6.00     | 0.98       | 3          | 0.50  | 8     |
| B9—Selecting material or equipment      | 5.72    | 6.00     | 6.00     | 6.00     | 6.00     | 6.00     | 6.00     | 0.89       | 3          | 0.72  | 9     |
| B10—On-the-spot quality control         | 5.39    | 6.00     | 6.00     | 6.00     | 6.00     | 6.00     | 6.00     | 1.29       | 4          | 0.83  | 10    |

Note: $a$ global mean; $b$ median; $c$ mode; $d$ standard deviation; $e$ amplitude; $f$ ranking based on the Friedman test.
It should be noted that the study by Forcada et al. was conducted in 2013, and at that time the importance of stakeholders had not yet been given due relevance, unlike the findings of our study, which concludes that by imposition of collaborative methodologies, and because of the evolution of the sector, stakeholders are a key factor for the success of projects.

4.3. The benefits of knowledge

Table 5 presents the results of question 3 of section 2 of the questionnaire, in which respondents were asked to indicate, among the ten items proposed, which ones represented the greatest benefits of knowledge for the construction sector. Table 5 summarizes the mean, median, mode, standard deviation, and range for each item.

To check the reliability of the results, Cronbach’s alpha was calculated and was obtained a value of 0.84, which shows a high consistency. Then, by analysing the S-W test, a p-value of less than 0.05 was obtained for all items—therefore, normality was rejected. As a result, and to check the null hypothesis, the non-parametric K-W test was performed, and it was found that there are group effects on items B5 and B8.

The pairwise comparisons of items B5 and B8 were performed via the Kruskal-Wallis 1-way ANOVA test, which showed a distinct opinion between the budget officer (GF3) and the administrator (GF1) and the project manager (GF2). There only exists consensus of the results between GF1 and GF2; therefore, GF3 considers item B5 (“Estimating and managing costs”) and item B8 (“Learning about relevant legislation in each project”) to be highly relevant knowledge benefits for the construction sector.

After a Friedman analysis, and considering the median value, it was verified that all respondents agreed that item B4 (“Performing a correct risk analysis and safety control of construction tasks”) was the greatest benefit of knowledge, followed by item B3 (“Performing good planning and good time management”).

In Seokyon Hwang’s (2020) study of small and medium-sized construction companies in the United States, the best ranked item is item B1 (“Learning best practices”), followed by item B4 (“Performing a correct risk analysis and safety control of construction tasks”). However, in both studies, the respondents consider item B4 to be important and a benefit of knowledge for the construction industry.

4.4. Obtaining knowledge

Table 5 presents the results of question 4 of section 2 of the questionnaire, which was composed of three parts: the first allowed to identify the source of knowledge that respondents often use to obtain knowledge; the second sought to identify the medium or way the respondents used to obtain knowledge through information and communication technology (ICT); and the third investigated the most effective way of obtaining knowledge based on ICT. Table 5 summarizes the frequencies of data relating to administrators, project managers and budget officers; the total responses per item; and the percentage of responses given by the total number of respondents for each item.

After analysing the results presented in Line C in Table 5, the most usual way of obtaining knowledge, with a response rate of 89%, is by consulting the most experienced colleagues in the company (item C1). Hwang’s study (Hwang, 2020) also measured a very similar rate (90%) for this same item. The importance of internal communication and collaboration in sharing knowledge within organizations can thus be highlighted. The second-best rated item was item C8 (“Lessons learned from completed projects”), with 78%, thus revealing its importance, as evidenced in the Introduction.
Table 5. Obtaining knowledge in the construction sector

| Item | CF1<sup>a</sup> | CF2<sup>b</sup> | CF3<sup>c</sup> | N<sup>d</sup> | %N<sup>e</sup> |
|------|-----------------|-----------------|-----------------|------------|-------------|
| C    |                 |                 |                 |            |             |
| C1   | 31.3%           | 37.5%           | 31.3%           | 16         | 88.9%       |
| C2   | 100%            | 0.0%            | 0.0%            | 2          | 11.1%       |
| C3   | 44.4%           | 11.1%           | 44.4%           | 9          | 50.0%       |
| C4   | 25.0%           | 25.0%           | 50.0%           | 8          | 44.4%       |
| C5   | 25.0%           | 41.7%           | 33.3%           | 12         | 66.7%       |
| C6   | 20.0%           | 40.0%           | 40.0%           | 10         | 55.6%       |
| C7   | 16.7%           | 41.7%           | 41.7%           | 12         | 66.7%       |
| C8   | 35.7%           | 35.7%           | 28.6%           | 14         | 77.8%       |
| D    |                 |                 |                 |            |             |
| D1   | 30.8%           | 30.8%           | 38.5%           | 13         | 72.2%       |
| D2   | 35.7%           | 35.7%           | 28.6%           | 14         | 77.8%       |
| D3   | 44.4%           | 11.1%           | 44.4%           | 9          | 50.0%       |
| D4   | 45.5%           | 18.2%           | 36.4%           | 11         | 61.1%       |
| D5   | 26.7%           | 40.0%           | 33.3%           | 15         | 83.3%       |
| D6   | 37.5%           | 12.5%           | 50.0%           | 8          | 44.4%       |
| D7   | 40.0%           | 20.0%           | 40.0%           | 10         | 55.6%       |
| D8   | 35.7%           | 28.6%           | 35.7%           | 14         | 77.8%       |
| E    |                 |                 |                 |            |             |
| E1   | 33.3%           | 50.0%           | 16.7%           | 6          | 33.3%       |
| E2   | 30.8%           | 46.2%           | 23.1%           | 13         | 72.2%       |
| E3   | 20.0%           | 20.0%           | 60.0%           | 5          | 27.8%       |

(Continued)
| Item                              | CF1<sup>a</sup> | CF2<sup>b</sup> | CF3<sup>c</sup> | N<sup>d</sup> | %N<sup>e</sup> |
|----------------------------------|-----------------|-----------------|-----------------|-------------|-------------|
| E4—Exchange of e-mails           | 50.0%           | 50.0%           | 0.0%            | 2           | 11.1%       |
| E5—Internet search               | 33.3%           | 22.2%           | 44.4%           | 9           | 50.0%       |
| E6—YouTube videos or similar     | 33.3%           | 0.0%            | 66.7%           | 3           | 16.7%       |
| E7—Company intranet             | 40.0%           | 40.0%           | 20.0%           | 5           | 27.8%       |
| E8—Analysis of completed projects| 35.7%           | 28.6%           | 35.7%           | 14          | 77.8%       |

<sup>a</sup>Frequency of data obtained by CF1 function (manager); <sup>b</sup> frequency of data obtained by CF2 function (project manager); <sup>c</sup> frequency of data obtained by CF3 function (budget officer); <sup>d</sup> total number of responses per item; <sup>e</sup> percentage of responses given by the total number of respondents.

By analysing the respondents’ positions in their companies (GF1, GF2 and GF3 groups), it was found that the respondents from the GF1 group were the only ones who considered consulting their “colleagues from college” (item C1) to obtain knowledge. In turn, 11% of the GF2 respondents reported obtaining knowledge via the “internal company records” (item C3), in contrast with the other groups (GF1 and GF3), with 44% of the respondents reporting having used this source (item C3).

On the other hand, item C8 (“Lessons learned from completed projects”) obtained around 28% in the group of budget officers (GF3), thus proving to be an option little used by this group. It therefore appears that budget officers do not usually analyse completed projects to obtain knowledge and prefer to use internal company records for this purpose.

Regarding the ICT tools for obtaining knowledge, the results presented in Line D in Table 5 show that the most used means by the respondents were: item D5 (Internet search), with a rate of 83.3%; item D2 (Working meetings) and item D8 (Analysis of completed projects), both with 77.8%. These results are different from those of Hwang’s study (Hwang, 2020), which identifies item D1 (Informal talks) and item D2 (Working meetings) as the most widely used means to obtain knowledge. Forcada et al. (2013) concluded that item D5 (Internet search) was the most used ICT means to obtain knowledge.

The results regarding the effectiveness of the different ICT tools to improve KM in construction companies, presented in Line E in Table 5, show that although the respondents obtained more knowledge through item D5 (Internet search), this means is not considered effective. However, item E8 (Analysis of completed projects) is considered to be the most effective means to obtain knowledge, with 78%, followed by item E2 (Working meetings), with 72%.

### 4.5. Perception on knowledge sharing

The respondents’ individual awareness and perception on knowledge affect their attitude towards sharing knowledge. Table 6 presents the seven items proposed to the respondents to identify their perception on knowledge sharing, as per question 5 of section 2 of the questionnaire. This table summarizes the mean, median, mode, standard deviation, and range for each item.

The Cronbach’s alpha was calculated and a value of 0.76 was obtained, which indicates a reasonable consistency of results. After the S-W test, a p-value lower than 0.05 was found, thus rejecting normality. The non-parametric K-W test was used to confirm the null hypothesis and it identified that there are group effects on items F4 and F5.
Table 6. Perception on knowledge sharing in the construction sector

| Item                                                                 | μ<sup>a</sup> | x<sub>F1</sub><sup>f</sup> | x<sub>F2</sub><sup>g</sup> | x<sub>F3</sub><sup>h</sup> | x<sub>b</sub> | Mo<sup>c</sup> | σ<sup>d</sup> | Δ<sup>e</sup> | K-W  |
|---------------------------------------------------------------------|---------------|-----------------|-----------------|-----------------|-----------|-------------|-------------|---------|------|
| F1—Construction is a sector based on knowledge sharing             | 4.67          | 5.00            | 5.00            | 5.00            | 5         | 1.61        | 6           | 0.58    |      |
| F2—Knowledge sharing is a competitive asset in the construction sector | 5.06          | 5.00            | 6.00            | 5.00            | 5         | 1.47        | 6           | 0.14    |      |
| F3—I am not familiar with the process of sharing knowledge at my workplace | 3.28          | 3.50            | 3.00            | 3.00            | 1         | 1.78        | 5           | 0.72    |      |
| F4—Knowledge sharing benefits all company employees                | 5.61          | 5.00            | 6.00            | 6.00            | 5         | 1.24        | 4           | < α     |      |
| F5—Knowledge sharing is beneficial for teamwork in the workplace    | 5.83          | 5.00            | 6.00            | 6.00            | 5         | 0.92        | 3           | < α     |      |
| F6—Knowledge sharing leads to a much more transparent construction process | 5.89          | 5.50            | 6.00            | 6.00            | 6         | 1.02        | 4           | 0.31    |      |
| F7—Knowledge sharing is a competitive advantage among employees    | 2.83          | 2.00            | 2.00            | 4.00            | 2         | 1.86        | 5           | 0.43    |      |

<sup>a</sup>mean; <sup>b</sup>median; <sup>c</sup>mode; <sup>d</sup>standard deviation; <sup>e</sup>amplitude; <sup>f</sup>median of GF1 group; <sup>g</sup>median of GF2 group; <sup>h</sup>median of GF3 group
For the comparisons of items F4 and F5, the Kruskal-Wallis 1-way ANOVA test was performed, and it was found that only the GF1 group considered that item F4 (Knowledge sharing benefits all company employees) and item F5 (Knowledge sharing benefits teamwork in the workplace) are not relevant.

Although the construction sector is considered conventional, the respondents disagree with this view, as they consider that knowledge sharing leads to a more transparent sector (item F6) and is beneficial for teamwork in the workplace (item F5), based on the highest median of the groups and the lowest standard deviation. However, the respondents do not consider knowledge sharing to be a competitive advantage among employees (item F7), which corresponds to the lowest median of the groups.

Regarding the value of knowledge in business (item F2), again there was consensus among the respondents, who considered this item to be a competitive asset in the construction sector. However, it was found that the respondents are not familiar with the process of knowledge sharing at the workplace (item F3).

4.6. Constraints to the implementation of a KM system

Finally, Table 7 presents the fourteen items that were proposed to the respondents to identify restrictions to the implementation of a KM system (question 6 of section 2 of the questionnaire). This table summarizes the mean, median, mode, standard deviation, and range for each item. After analyzing the data obtained, a Cronbach's alpha of 0.82 was verified, which demonstrates a high consistency of the results (according to Section 3.3). The S-W test was performed to assess the normality of items G1 to G14, and a p-value of less than 0.05 was obtained, thus rejecting normality. The null hypothesis was tested by applying the non-parametric K-W test and it was identified that there are group effects on items G5 and G12.

Comparing the items through the Kruskal-Wallis 1-way ANOVA test, it was found that the GF1 group has a different opinion and attributes a lower classification than the GF3 group to item G5 (Low employee interest) and to item G12 (Dispersed information systems and different technological means) as restrictions to the implementation of a KM system.

As in the study by Forcada et al. (2013), the KM implementation restriction factor that obtained the highest median value was item G1 (A change of mentality is required to use this system). Identified by several researchers, the “change of mentality” factor is a recurring problem in the sector (Kagioglou et al., 2000), as most companies are divided into departments and business units that operate independently and have little contact among themselves.

Carrillo and Chinowsky (2006) identified that the main obstacle to implementing KM in construction companies was “lack of time”. Thus, through individual analysis of the respondents' positions in their companies, the GF3 group also gave a high rating to item G13 (Lack of time and extra workload), regardless of the median rating of the other groups. In the case of the GF1 group, the most hindering factor to the implementation of KM in the sector was item G2 (Implementing a KM system takes time and entails high cost).

5. Discussion

The results demonstrate the need to integrate information and communication technologies and the business environment, particularly regarding issues related to internal organization and external factors. The collaboration between workers is one of the most appropriate ways to capture tacit knowledge, but the increasing pressure of cost and time reduction, delivering better projects and fighting ever increasing environmental challenges have made the effective use of managing explicit knowledge the core focus of the construction industry in past few years. However, capturing tacit knowledge within the construction sector remains a challenging area of research and development (Venkitachalam & Willmott, 2017).
Table 7. Restrictions to the implementation of a KM system

| Item                                                                 | $\mu^a$ | $x_{F1}$ | $x_{F2}$ | $x_{F3}$ | $x^b$ | $Mo^c$ | $\sigma^d$ | $\Delta^e$ | $K-W$ |
|----------------------------------------------------------------------|---------|----------|----------|----------|-------|--------|------------|------------|-------|
| G1—A change of mentality is required to use this system             | 5.67    | 5.50     | 6.00     | 6.00     | 6.00  |        | 1.283      |        | 5     | 0.28 |
| G2—Implementing a KM system takes time and entails high cost        | 4.83    | 5.00     | 4.00     | 6.00     | 5.00  | 5      | 1.505      | 5         | 0.07  |
| G3—Lack of proven methods for KM advantage in construction projects | 4.72    | 4.00     | 5.00     | 5.00     | 4.50  | 4      | 1.406      | 5         | 0.70  |
| G4—Low executive board interest                                      | 4.44    | 2.50     | 6.00     | 6.00     | 5.50  | 6      | 2.307      | 6         | 0.21  |
| G5—Low employee interest                                             | 3.89    | 3.00     | 4.00     | 5.00     | 4.00  | 4      | 1.451      | 5         | < $\alpha$ |
| G6—Lack of employee confidence                                       | 3.78    | 2.00     | 5.00     | 4.00     | 4.00  | 2 $^f$ | 1.437      | 5         | 0.26  |
| G7—Lack of employee motivation                                       | 4.50    | 3.00     | 5.00     | 4.00     | 4.50  | 4 $^f$ | 1.654      | 5         | 0.32  |
| G8—Emphasis on individual rather than team level, and fear of sharing knowledge | 5.00    | 5.50     | 6.00     | 4.00     | 4.50  | 4      | 1.680      | 5         | 0.49  |

(Continued)
Table 7. (Continued)

| Item                                                                 | \( \mu^a \) | \( x_{F1} \) | \( x_{F2} \) | \( x_{F3} \) | \( x^b \) | \( Mo^c \) | \( \sigma^d \) | \( \Delta^e \) | K-W |
|----------------------------------------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------|
| G9—Lack of government incentive system                              | 3.94        | 4.50        | 4.00        | 4.00        | 4.00        | 5           | 1.552       | 5           | 0.54 |
| G10—Workspace layout does not allow KM implementation               | 2.28        | 2.00        | 2.00        | 1.00        | 2.00        | 1           | 1.638       | 6           | 0.73 |
| G11—Lack of technological infrastructure needed for its implementation | 3.00        | 2.00        | 4.00        | 1.00        | 2.00        | 1           | 2.196       | 6           | 0.91 |
| G12—Scattered information systems and different technological means (involves need for integration) | 4.56        | 3.00        | 5.00        | 6.00        | 5.00        | 6           | 1.917       | 6           | \( < \alpha \) |
| G13—Lack of time and extra workload                                 | 4.22        | 4.00        | 4.00        | 7.00        | 4.00        | 4           | 2.045       | 6           | 0.16 |
| G14—The concept is not known                                        | 4.28        | 3.00        | 6.00        | 5.00        | 4.00        | 3 \( f \)   | 1.708       | 5           | 0.06 |

\( ^a \) mean; \( ^b \) median; \( ^c \) mode; \( ^d \) standard deviation; \( ^e \) amplitude; \( ^f \) multiple modes exist—the smallest value is shown.
5.1. Perception of KM in the construction sector
Regarding research question 1 (“What is the perception on the implementation of KM in the construction sector?”), the results highlight that most of the professionals inquired are familiar with the concept of KM and all are aware of its importance, namely as a support for business, as a strategy to anticipate problems, improve competitiveness and increase innovation.

There are several dimensions of organizational knowledge: individual and group; internal and external; and tacit or explicit knowledge. However, the respondents consider that KM is an ICT system for managing intellectual assets, which indicates a growing awareness of the benefits of KM compared to ICT systems. Only one company claimed to have already implemented a KM system, but only using a repository for documents.

5.2. Benefits of KM and knowledge
Regarding research question 2 (“What are the benefits of KM?”) and 3 (“What are the benefits of knowledge?”), the respondents consider that all the KM benefits presented are important for the construction sector. However, they highlighted the exchange of experiences among employees and the ease of information sharing among stakeholders as the main KM benefits that contribute to a continuous improvement of the internal processes of organizations. As for the benefits of knowledge, opinions diverged, particularly in the case of budget officers, who attached greater importance to the estimation and management of costs, as well as to learning the relevant legislation for each project. But all the professionals considered that the greatest benefits of knowledge are the following: it allows a correct analysis of risks, safety control in construction tasks, good planning, and effective time management.

The most significant benefits of KM are the exchange of experience between employees and the ease of sharing information between stakeholders, the possibility of performing a correct risk analysis and safety control of construction tasks combined with the possibility of a good planning and appropriate time management. General awareness of KM benefits is fuelled by the need of a more efficient sector, helping companies to anticipate problems, improve competitiveness, increase innovation and promoting the sharing of experiences and continuous improvement from lessons learned from completed projects. These characteristics support the collaboration and coordination of all actors involved in the project.

In the context of technological innovation, perceived benefits, complexity, and compatibility act as determining factors on whether a company should implement KM.

5.3. Obtaining and sharing knowledge
Research question 4 (“How is knowledge obtained?”) allowed to identify how respondents seek knowledge and what means of information and communication technology (ICT) they use to obtain knowledge and how effective they are. In short, the respondents seek knowledge from more experienced colleagues and from lessons learned from completed projects. They also consider that the most used and effective ICT means were the analysis of already completed projects and working meetings.

Regarding research question 5 (“What is the perception on knowledge sharing?”), the surveyed professionals considered that knowledge sharing leads to a more transparent sector and contributes to increasing the business of companies. However, it is noted that some employees are not familiar with the process of knowledge sharing.

Most professionals obtained knowledge mostly via meetings with more experienced colleagues, but they also used the internet and resorted to lessons learned from completed projects. They also considered that knowledge sharing leads to a more transparent sector and is beneficial for teamwork in the workplace. However, the respondents did not consider knowledge sharing to be
a competitive advantage among employees, so they did not create an environment that allowed workers to create, capture, share, and leverage knowledge to improve performance.

5.4. Restrictions to the implementation of a KM system

Finally, in relation to research question 6 (“What are the restrictions to the implementation of a KM system?”), it is found that the main barrier to the implementation of KM is the imperative need for a change in mentality. The budget officers also considered that lack of time and extra workload were restrictions to the implementation of a KM system. For their part, administrators or managers considered that time and high costs of its implementation were a harmful factor.

Low employee interest, lack of interest of companies to share knowledge among employees, and dispersed information systems are recurring problems in the construction industry that have been studied by many researchers (Forcada et al., 2013; Hwang, 2020). Most companies are divided into departments and business units that operate independently and have little contact with one another. There is growing evidence that organizations are restructuring their processes before implementing KM initiatives. Lack of time and extra workload are other obstacles that companies consider to be particularly important. Companies 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 practice KM.

6. Conclusion

This study was based on a survey conducted with a selected group of professionals with high experience in the construction sector—administrators or managers, project managers and budget officers—to understand the level of knowledge sharing in construction companies in Portugal. The research focused on the following aspects: perception on the implementation of KM in construction companies; evaluation of KM benefits; evaluation of the benefits of knowledge; ways and means of obtaining knowledge; perception on knowledge sharing; and restrictions to the implementation of a KM system.

In construction companies, time is often associated with the need to deliver projects according to schedule and often the idea persists that there is no need to exploit knowledge. Employees may even be willing to share knowledge, but the pressure from tight deadlines to deliver projects and the need to take on additional responsibilities for KM process activities make it difficult to successfully implement a knowledge sharing system. Through the survey and statistical analysis, this study discovered some crucial issues that should be addressed in order to facilitate knowledge sharing in construction companies. The respondents considered KM as an important and capable intellectual asset that can anticipate problems, increase competitiveness and innovation. Their benefits are the exchange of experience between employees and sharing of information. Despite a high level of perception on the merits of KM and willingness to share knowledge, the respondents still need to achieve a higher understanding of the process. The respondents did not consider knowledge sharing to be a competitive advantage among employees, and therefore employees should be given time to learn the process of KM and involved in sharing activities.

Despite growing awareness of the need for implementing KM in the construction sector, no study has yet been really developed in Portugal. Thus, the analysis of the results of this survey sent to the largest construction companies provides a pioneering and relevant perspective on the current landscape of KM in Portugal.

The results help construction companies to understand the key factors for implementing KM and provide theoretical foundations for designing a model suitable for the construction industry for implementing a knowledge management system. The main findings of this study are as follows: (1) the decision to implement KM should not be based only on technological factors, but also on organizational factors; (2) involvement of all stakeholders is necessary for successful
implementation; and (3) top management support, organizational culture, and simplicity of the adopted model are crucial for KM implementation in construction companies.

By developing a better understanding of the factors that influence KM implementation, companies can make more accurate decisions and assess whether they have the capacity to implement KM. Managers can also use the results of this study to effectively maximize their efforts in promoting KM implementation.

The main contribution of this paper is to identify the main restrictions, advantages, and benefits of KM in construction projects, and therefore be able to define a strategy for KM implementation. The results of this study cannot be considered for small and medium-sized companies because they have a different structure. However, they may serve as a basis for future studies focused on complementary and more incisive objectives, as this study is limited to the ten largest companies in the construction sector in Portugal. But these results can be used as a starting point for the sector’s regulators to develop methodologies and/or standards to promote the adoption of KM systems.

This study is limited by the number of companies selected based on the sample criteria; therefore, a wider study needs to be carried out covering more cases across other countries. Also, the results of this study cannot be taken into account for small and medium-sized enterprises because they have a different structure. However, they can serve as a basis for future studies with complementary and more incisive objectives.

For future research, it would be important to conduct studies evaluating KM and knowledge sharing in small and medium-sized enterprises, to analyse and define a KM methodology in the construction companies. It would also be important to evaluate and study how KM integrates current practices of the BIM (Building Information Modelling) methodology and of relational contracting in the public works contract award processes.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Disclosure statement
No potential conflict of interest was reported by the author(s).

Citation information
Cite this article as: Contribution to improvement of knowledge management in the construction industry - Stakeholders’ perspective on implementation in the largest construction companies, António Joaquim Coelho Marinho & João Couto, Cogent Engineering (2022), 9: 2132652.

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Appendix Questionnaire

Section 1—General Information

1. What is your role in the company?
   - Administrator or manager
   - Project manager (e.g., construction director or production director)
   - Responsible for budgeting

2. What is your experience in the construction sector?
   - 0–9 years
   - 10–20 years
   - over 21 years

Section 2—Knowledge management in companies

1—Perception on the implementation of KM in the construction sector

3. How do you consider Knowledge Management (KM)?
   - An ICT system for the management of intellectual assets
   - A methodology for identifying, optimizing and managing intellectual assets

4. Have you implemented any Knowledge Management system in the company?
   - yes
   - no

5. Has your company implemented any Knowledge Management system?
   - yes
   - No

6. Do you use any knowledge management software?
   - yes
   - No

7. How do you create or organize information?

8. Why is it carried out in this way?

9. What is the software?

10. What are the greatest advantages you identify in the use of Knowledge Management?
### 2—Benefits of Knowledge and Knowledge Management

What is the advantage of the KM? What is the advantage of knowledge?

11. What benefits KM can offer your business. (1—I completely disagree with 7—I fully agree)

| Item                                                                 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|----------------------------------------------------------------------|---|---|---|---|---|---|---|
| A1—Improved decision-making                                         |   |   |   |   |   |   |   |
| A2—Continuous improvement of processes                              |   |   |   |   |   |   |   |
| A3—Improved efficiency of tasks/activities                          |   |   |   |   |   |   |   |
| A4—Improved group work                                               |   |   |   |   |   |   |   |
| A5—Cost reduction for the company                                    |   |   |   |   |   |   |   |
| A6—Reduction of the time of execution of tasks/activities            |   |   |   |   |   |   |   |
| A7—Improved quality of products and/or services                      |   |   |   |   |   |   |   |
| A8—Exchange of experience between employees                         |   |   |   |   |   |   |   |
| A9—Ease of sharing information between stakeholders                  |   |   |   |   |   |   |   |
| A10—Risk minimization of tasks/activities                            |   |   |   |   |   |   |   |
| A11—Characterization of procedures within the organization           |   |   |   |   |   |   |   |

12. Identify some benefit of the unidentified GC (Optional).
### 3—Benefits of Knowledge

13. In turn, knowledge is beneficial for: (1—I completely disagree with 7—I fully agree)

| Item | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------|---|---|---|---|---|---|---|
| B1   |   |   |   |   |   |   |   |
| B2   |   |   |   |   |   |   |   |
| B3   |   |   |   |   |   |   |   |
| B4   |   |   |   |   |   |   |   |
| B5   |   |   |   |   |   |   |   |
| B6   |   |   |   |   |   |   |   |
| B7   |   |   |   |   |   |   |   |
| B8   |   |   |   |   |   |   |   |
| B9   |   |   |   |   |   |   |   |
| B10  |   |   |   |   |   |   |   |

14. Identify some benefit of unidentified knowledge (Optional).
4—Obtaining knowledge

What is knowledge sharing? How do I get knowledge? What is the most effective way?

15. What is your perception of knowledge sharing?

| Item                                                                 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|----------------------------------------------------------------------|---|---|---|---|---|---|---|
| C—To obtain the knowledge I need for my work I resort to:            |   |   |   |   |   |   |   |
| C1—More experienced professional colleagues in my company           |   |   |   |   |   |   |   |
| C2—Colleagues from college                                          |   |   |   |   |   |   |   |
| C3—Internal company records                                         |   |   |   |   |   |   |   |
| C4—Professional orders or associations                              |   |   |   |   |   |   |   |
| C5—Internet-based data                                              |   |   |   |   |   |   |   |
| C6—Scientific papers, PhD theses, monographs, conferences, etc.     |   |   |   |   |   |   |   |
| C7—Specialized training                                             |   |   |   |   |   |   |   |
| C8—Lessons learned from completed projects                          |   |   |   |   |   |   |   |
| D—I obtain knowledge through ICT tools:                             |   |   |   |   |   |   |   |
| D1—Informal talks                                                   |   |   |   |   |   |   |   |
| D2—Working meetings                                                 |   |   |   |   |   |   |   |
| D3—Communication by telephone                                       |   |   |   |   |   |   |   |
| D4—Exchange of e-mails                                              |   |   |   |   |   |   |   |
| D5—Internet search                                                  |   |   |   |   |   |   |   |
| D6—YouTube videos or similar                                        |   |   |   |   |   |   |   |
| D7—Company intranet                                                 |   |   |   |   |   |   |   |
| D8—Analysis of completed projects                                   |   |   |   |   |   |   |   |
| E—I believe that the most effective means of ICT tools to obtain knowledge is: |   |   |   |   |   |   |   |
| E1—Informal talks                                                   |   |   |   |   |   |   |   |
| E2—Working meetings                                                 |   |   |   |   |   |   |   |
| E3—Communication by telephone                                       |   |   |   |   |   |   |   |
| E4—Exchange of e-mails                                              |   |   |   |   |   |   |   |
| E5—Internet search                                                  |   |   |   |   |   |   |   |
| E6—YouTube videos or similar                                        |   |   |   |   |   |   |   |
| E7—Company intranet                                                 |   |   |   |   |   |   |   |
| E8—Analysis of completed projects                                   |   |   |   |   |   |   |   |
16. To get the knowledge I need for my work, I seek to:

- More experienced colleagues in my company.
- Schoolmates.
- Company internal records.
- Records external to the company.
- In professional orders or associations (e.g., OE, ACT, OA, OET).
- Data coming from the internet.
- In scientific articles, theses, monographs, etc.
- At conferences.
- In specialized training.
- Analysis of projects already completed (lessons learned).
- Other ________

17. I obtain knowledge through:

- Informal conversations.
- Work meetings.
- Telephone communication.
- E-mail exchange.
- Internet search.
- Videos on YouTube or similar.
- Company Intranet.
- Lessons learned from completed projects.
- Other ________

18. I believe that the most effective way to obtain knowledge is by:

- Informal conversations.
- Work meetings.
- Telephone communication.
- E-mail exchange.
- Internet search.
- Videos on YouTube or similar.
Company Intranet

Lessons learned from completed projects.

Other _______

5—Perception on knowledge sharing

19. Identify the benefits of knowledge sharing.

| Item | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------|---|---|---|---|---|---|---|
| F1—Construction is a sector based on knowledge sharing |   |   |   |   |   |   |   |
| F2—Knowledge sharing is a competitive asset in the construction sector |   |   |   |   |   |   |   |
| F3—I am not familiar with the process of sharing knowledge at my workplace |   |   |   |   |   |   |   |
| F4—Knowledge sharing benefits all company employees |   |   |   |   |   |   |   |
| F5—Knowledge sharing is beneficial for teamwork in the workplace |   |   |   |   |   |   |   |
| F6—Knowledge sharing leads to a much more transparent construction process |   |   |   |   |   |   |   |
| F7—Knowledge sharing is a competitive advantage among employees |   |   |   |   |   |   |   |
6—Constraints to the implementation of a KM system

20. Identify restrictions for the development of a Knowledge Management system.

| Item | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------|---|---|---|---|---|---|---|
| G1   | A change of mentality is required to use this system |   |   |   |   |   |   |
| G2   | Implementing a KM system takes time and entails high cost |   |   |   |   |   |   |
| G3   | Lack of proven methods for KM advantage in construction projects |   |   |   |   |   |   |
| G4   | Low executive board interest |   |   |   |   |   |   |
| G5   | Low employee interest |   |   |   |   |   |   |
| G6   | Lack of employee confidence |   |   |   |   |   |   |
| G7   | Lack of employee motivation |   |   |   |   |   |   |
| G8   | Emphasis on individual rather than team level, and fear of sharing knowledge |   |   |   |   |   |   |
| G9   | Lack of government incentive system |   |   |   |   |   |   |
| G10  | Workspace layout does not allow KM implementation |   |   |   |   |   |   |
| G11  | Lack of technological infrastructure needed for its implementation |   |   |   |   |   |   |
| G12  | Scattered information systems and different technological means (involves need for integration) |   |   |   |   |   |   |
| G13  | Lack of time and extra workload |   |   |   |   |   |   |
| G14  | The concept is not known |   |   |   |   |   |   |

21. Do you think KM can make the construction sector more efficient? Why?
