SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2023
ORGANIZATION AND MANAGEMENT SERIES NO. 189

KNOWLEDGE MANAGEMENT CHALLENGES IN PROJECTS IN BUILDING AND CONSTRUCTION SECTOR

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Purpose: The objectives of the article are focused on identifying and evaluating mainly the information technologies that are currently used to manage knowledge in the building and construction industry, highlighting the strengths and weaknesses of particular IT tools for KM, and analyzing how to combine different information technologies together to support knowledge transferring process between construction professionals.
Design/methodology/approach: The objectives of the research were achieved by a questionnaire survey. The respondents were professionals, mainly project managers in projects executed in a building and construction sector. An on-line questionnaire was elaborated to get the information on knowledge management in building and construction projects.
Findings: It was found that knowledge management is an increasing challenge in projects in a building and construction sector. Barriers of applying knowledge management in construction industry have been identified. As project teams in construction projects are often disbanded at the end of a project, the knowledge generated in a project is difficult to track after the project is accomplished. The knowledge generated in the project should be stored and coded within the project.
Practical implications: The research proved that knowledge management processes are of great importance and the use of IT tools is crucial for effective knowledge management in building and construction projects.
Originality/value: The value of the research is the deep analysis of tools and technologies applied in selected building and construction projects. The respondents, professionals in project management, assessed what is important in the area of knowledge management in building and construction sector. The paper is dedicated to managers participating in construction and building projects.

Keywords: knowledge management, IT tools, building and construction sector.

Category of the paper: research paper, case study.

1. Introduction

The building and construction industry needs information and knowledge input to be effective. The products of the construction industry are larger than others, and the project execution takes more time and resources. Knowledge is treated as a vital organizational resource that resilts in competitive advantages. Managing knowledge assets is a sophisticated process, especially in the building and construction industry, as it is a project-based business which creates one-of-a-kind product and highly fragmented working environment (Egbu, Botterill, 2002). As teams in construction projects are often disbanded at the end of the project, the knowledge generated in the project should be stored and coded within the project. The reason is that projects do not have any organizational memory, as they are temporary in nature (Fong, 2005). Knowledge, when you compared it with non-project organizations that are supported both by the organizational structure and knowledge-absorbing routines, becomes reutilized and socialized into the organization, Project-based organizations generally do not have support mechanisms that enable knowledge transfer to occur.

Although the construction industry is featured by many small and medium enterprises (SMEs), which make up over 90% of construction organizations (Egbu, Robinson, 2005), knowledge management efforts have been focused predominantly on large companies. This is because large organizations generally have more resources and higher employee turnover, and are more geographically spread, which urges them to develop efficient ways for knowledge retaining and sharing. On the contrary, to some extent, SMEs need knowledge management even more. SMEs cannot compete with large companies in terms of tangible resources such as capital, labour, equipment, and physical commodities, but the intangible knowledge assets can provide them a leverage to survive the fierce competitive market (Boyd, Xiao, 2006).

This research is addressing knowledge management facilities for small and medium sized construction organizations. Knowledge Management technologies used for SMEs may be smaller in scale and cheaper in cost but can be advanced in functionality to support its usability in order to encourage knowledge sharing. Many construction projects involve team members from distributed sites and organizations, and this requires ways to support team members to work across distance to adapt project tasks to changes in the environment. However, research on the knowledge sharing-support software only started very recently (Wang, 2004). Functional software with high-level ability of data analyzing, knowledge sharing, and collaborative process is rare in the construction industry.

The present article approaches the analysis and case study of knowledge management in projects in the building and construction industry. The objective of the article focuses on identifying and evaluating the information technologies that are currently used to manage knowledge in the building and construction industry, highlighting the strengths and weaknesses of particular IT tools for KM, and analysing how to combine different information technologies together to support knowledge transferring process between construction professionals.

2. The literature review on knowledge management in building and construction projects

Research on knowledge management, organizational memory, and organizational learning is focused on the development of models and mechanism for the capturing, storage, and delivery of knowledge in organizations (Lee et al., 1992). Organizational knowledge management is a social process, involving interactions among many individuals leading to well-informed decision making. Thus, a culture that learns and adapts as part of everyday working practices is essential. Reuse must equal or exceed reinvent as a desirable behavior. Adapting an idea must be rewarded along with its initial creation. Sharing to empower the organization must supersede controlling to empower an individual. Knowledge can either be generated within organization or accessed externally that is knowledge flows may view as intra-organization or inter-organization.

Projects exist in almost every organization as of today. Sahlin-Anderson et al., (2002) gave a definition of project: "A project is an organization unit dedicated to the attainment of a goal - generally the successful completion of development product on time, within budget, and in conformance with predetermined performance specifications". Within the project-based industry, the need for innovation and improved business performance requires the effective deployment and utilization of the intellectual assets of project team members. Hall J. et al., (2000) pointed out that knowledge capturing, and transferring can be regarded as strategic issues, in that they benefit the organization as a whole. However, the process of accumulating and documenting "lessons learned", is more tactical in nature, as it involves costs, may be on conflict with the pressure of a specific project, such as completion on time within budget. If there are inappropriate or non-existing incentive structure to address this inherent conflict, knowledge management policies will be inadequate.

For a project-based organization, its main activities happen within every individual project they carried on; its goal is to successfully complete the next project on time and within budget. Lessons learned from past project or best practice collected from past project is project knowledge, but to share this knowledge with all the employees in the organization and encourage employees to apply it in their next projects are the process of transforming project

knowledge to organizational knowledge. Francisco (Francisco, 2001) examined how web technologies may support knowledge management in construction organizations. Some early web technologies such as email, HTML, XML and EDI were discussed in his paper; however, tacit knowledge was not supported by the system. To support both explicit and tacit knowledge, a knowledge management system needs to be built with content and collaboration technologies. As Duffy (2001) pointed out, technologies to support tacit knowledge sharing are more likely to require human interaction than those to support data and information sharing. Romaldi (2002) also stressed the value of using "technologies with hyper-linking and hyper-media capabilities" to effectively capture experts' tacit knowledge and make it explicit.

Based on the fact that researchers generally agree that tacit knowledge management needs human intervention and can be enhanced by advanced IT technology. There are some attempts to build computer systems to support tacit knowledge sharing. Woo et al. (2004) presented a Dynamic Knowledge Map which showed us an approach that can assist in the reuse of experts' tacit knowledge. Dynamic Knowledge Map is a Web-based knowledge navigator that searches for experts and facilitates communications with the experts by using Internet technology. Tserng and Lin (2004) proposed a concept of activity-based knowledge management and presented a system which uses a knowledge sharing platform for construction projects.

3. IT role in knowledge management in building and construction projects

The role of technology, especially IT in knowledge management, is still valid (Mohamed et al., 2006; Dohn et al., 2013). The identification perspective views knowledge management as mainly a re-naming of computer-based technology' s various monikers and variants. Dent & Montague (2004) asserted that the primary role of technology within a knowledge management strategy is not as a driver but as an enabler. Davenport and Prusak (1998) described knowledge management as involving organizational, human, and technical issues, with the advice that the technical should be treated as the least important of the three. Similar idea on organizational knowledge model was proposed by Egbu & Botterill (2002) and is given in Figure 1.

IT offers unique opportunities to overcome barriers of space and time, but it has also been criticized that it offers only limited opportunities for truly "social" communication (Kiesler et al., 1984). But others argue that lack of social cues and absences of status differences have potential benefit for knowledge sharing, as status differences are frequently considered to be significant barriers for knowledge sharing.

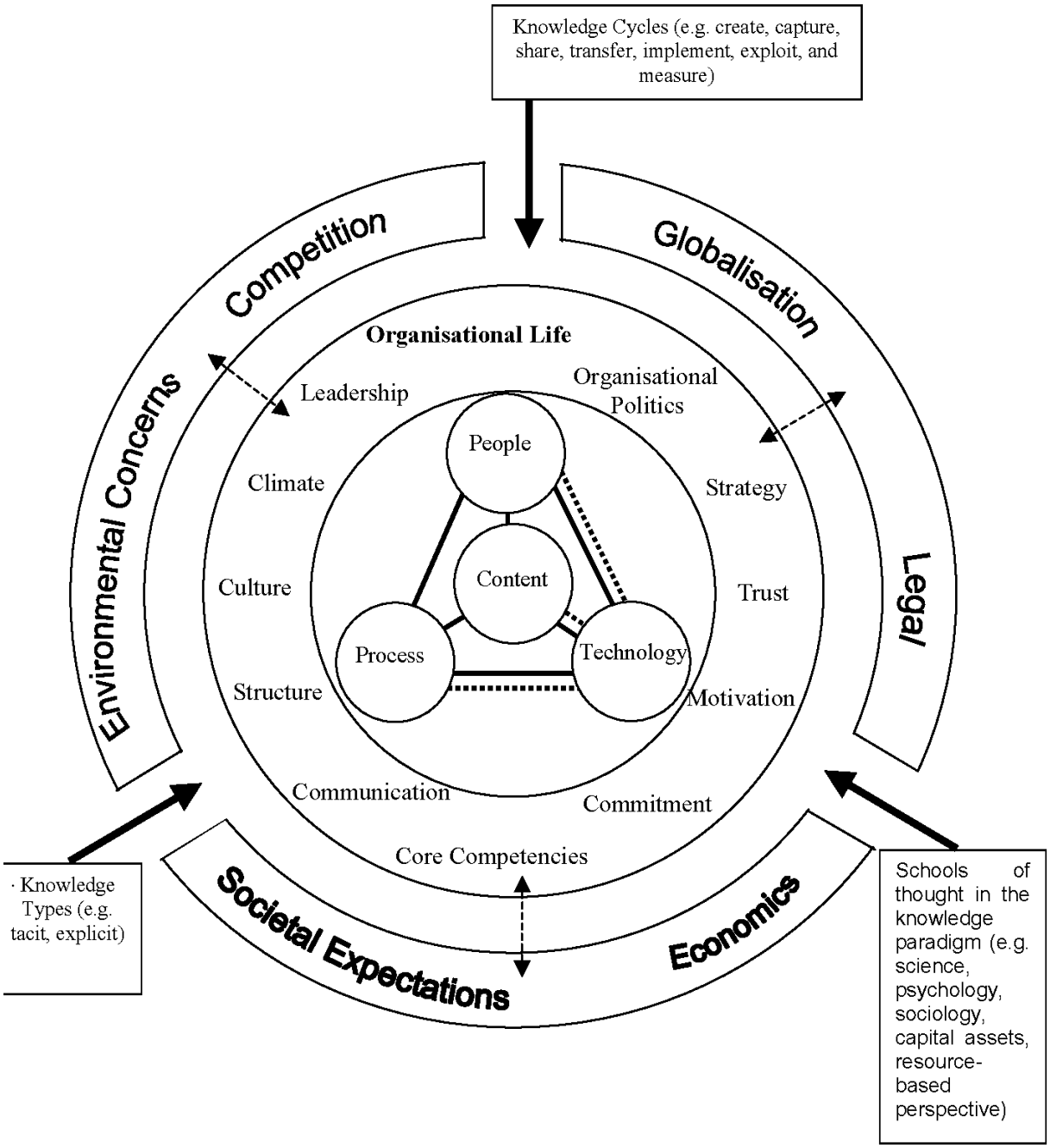

Figure 1. Organization knowledge network.

Source: Egbu, Botterill, 2002.

IT has also been challenged for failing to adequately address the problems of managing tacit knowledge. Tacit knowledge by definition is at best, difficult or, at worst, impossible to articulate. Nonaka and Takeuchi (1995) suggested that tacit knowledge becomes explicit knowledge through the process of externalization, i.e., by sharing metaphors and analogies during social interaction. Some researchers also argue that to abstract tacit knowledge from its context of application is to lose much of its intrinsic meaning and value, i.e., "knowledge dilution" (Swan, Newell, 2000; Mohamed et al., 2006). Current technology may not offer the entire cognitive dimension, because the cognitive process involves socio-cultural perspectives which were built and sustained by social activities (Mohamed et al., 2006). A successful

KM practice requires both an effective organizational KM strategy and an appropriate IT infrastructure to support it (Dent, Montague, 2004).

A variety of IT has been used as knowledge management enablers. They can be classified in the following categories (Tsui, 2002):

- Communication Tools,
- Information Repository,
- Groupware/Collaborative Tools/Social Network,
- Expert System,
- Case-Based Reasoning,
- Taxonomy/Ontology,
- Knowledge Maps,
- Data Mining/Knowledge Discovery System.

Below, there are a few examples of applying the above-mentioned technologies in the building and construction industry:

- CBR-CURE is a CBR system for building construction duration and cost estimation (Yau, Yang, 1998),
- CACP (Computer-aided construction planning) a project-based planning software, also employs a CBR tool which is designed to capture and reuse planning knowledge and the application of this knowledge to computer-assisted planning. (Rankin, Froese, 2002),
- iKonnect, an organizational knowledge management system, implemented by BLL (Bovis Lend Lease) is mainly based on telephone connection (Zou, 2003),
- LCPL a major subsidiary company of Leighton Holdings Limited set up their KM infrastructure namely EDMS (Electronic Document Management System) to capture information in digital format and to share them online throughout the project (Zou, 2003),
- bxXML is a construction taxonomy which was designed to support the eBusiness communication needed between clients, architects and engineers, suppliers, and contractors for the procurement of products, components, and services (Lima et al.,2003),
- ConABKM (Construction Activity-Based Knowledge Management) is an example of web-based, on-line organizational knowledge repository (Tserng, Lin, 2004).

A technology integration which links several information technologies together is considered as a possible solution. Ontology and collaborative tools, along with some newly emerged technologies such as semantic web and blogging showed their potential in KM and have drawn researchers' attention (Cayzer, 2004). Knowledge management is a very complex issue in general. When knowledge management is researched in the sub-domain of the construction industry, some features of this industry should be considered, and they are presented as follows.

- The industry is dominated by small and medium enterprises (SMEs), which make up over 90% of all organizations, with a relatively small number of large companies (Egbu, Robinson, 2005). In Australia especially, 94% of business in this sector employs fewer than five people and only 800 firms among 158,000 – or less than 1 % - employ more than 20 people (Love, Irani, 2004). Compared to large organizations, these SMEs usually are technologically weak, cannot invest heavily in innovation and development, and take a less-formal strategy in management with an emphasis on survival and cash flow. The knowledge in SMEs tends to be local, oral, tacit, and contextual. Therefore, some of the KM concepts and methods dedicated developed for large company may not apply to SMEs (Boyd, Xiao, 2006).
- Construction projects are often unique in their design, location, end-user, supply chain, budget, and partner (Fong, 2005). Knowledge generated in a project is embedded within its unique contexts. Therefore, how to express its context while codifying knowledge, how to identify contexts while retrieving knowledge, and how to recontextualize while applying knowledge become important considerations when applying KM in construction industry.
- The construction sector consists of a huge number of disparate companies of all sizes and representing very wide-ranging expertise and activities. In one project several very different companies often work together, communication between project participants and between organization employees becomes very important issue to share common understanding and eliminate misinterpretation (BSI, 2003).
- The construction industry is characterized as project-based business and delivers one-of-a-kind product. As project teams in construction projects are often disbanded at the end of a project, the knowledge generated in the project is difficult to be tracked after the project is completed unless there is an organizational KM system that maintains historical project knowledge. The reason for lack of keeping knowledge within the organization and effectively sharing between projects is that no organizational memory is kept for future retrieval as projects are temporary in nature.
- Lack of time has been identified as another significant barrier to recording and sharing knowledge. With the core project team is likely to be dispersed at the end of the project, little time or resources are generally devoted to capturing 'what people know'. Effort is often focused on immediate deliverables (e.g., drawings, reports, calculations, the building, or facilities itself), with no emphasis on what could be done now to help future projects (Fong, 2005).
- The industry still relies on conventional techniques for KM process. Egbu and Botterill (2002) investigated the role of IT for KM in the construction industry. They found that perceptions about more conventional techniques for KM process seem unchanged. Telephone and face-to-face meeting still are the most common means to acquire and transfer knowledge.

In summary, keeping knowledge context and historical knowledge, providing social communication, and making an easy-to-use system are the main challenges that to be faced by knowledge management practitioner in the construction industry.

4. The research analysis on knowledge management in building and construction sector

4.1. Research methodology

The data collection was done through a survey with a questionnaire that was sent to the research participants. The sample population is composed of 32 professionals holding various roles in the construction industry. In this sample, different professionals from project managers, architect or design engineers, site engineers, quality controllers, foremen, land valuation officers, counterpart engineers contributed as they gave their feedback on the survey. The responded time of the participants was on an average of ten minutes per one survey and overall, the questions were applicable to the professional areas of the target population.

The questionnaire is composed of over 100 questions, that are subdivided into sections that provide information about the respondent's details, the knowledge at the business level, the level of knowledge and the tool processes applied in project management and of used and planned IT applications.

4.2. Results and discussion

It turned out that 32 respondents answered questions, 12 (37.5%) worked in small companies (less than 50 employees), 11 (34.4%) worked in large companies (more than 250 employees) and the rest - 9 respondents (28.1%) worked for medium companies (not less than 50 employees but not more than 250 employees).

One of the questions is related to the role of the respondent in a company. 45.2% of respondents held the position of project manager, 29% of respondents held the position of architect or design engineer, 12,9% of respondents held the position of site engineer. The rest held various positions like quality controller, foreman, land valuation officer and counterpart engineer.

Table 1.
General questions concerning knowledge management system in projects

Ld.	Question	Realized	Planned in a longer term	Not planned at all
1.	the development of a knowledge management strategy	56,2%	31,3%	12,5%
2.	formal knowledge management procedures	42,0%	40,0%	18,0%
3.	the existence of trainings, workshops in the field of knowledge management	22,0%	63,0%	15,0%
4.	the existence and development of "communities of practice"	31,0%	38%	31,0%

Source: own elaboration.

The next question concerned the type of projects in which respondents participated. 31 respondents answered the question and the majority, 71% of respondents mainly conduct non-residential (commercial and institutional, heavy industrial) projects. 45,2% of respondents executed residential (houses, multi-unit apartments, townhouses) projects. 25,8% of respondents executed transport projects. The rest were involved in infrastructure and heavy construction projects.

The respondents' answers for general questions concerning knowledge management systems in analysed projects are given in the Table 1.

Likert's scale was used to get the feedback from respondents on knowledge processes. In table 2 the rate 5 means the highest level, the rate 1 means the lowest level and the rate 0 means the respondent didn't decide on any level.

Table 2.
Questions concerning the process of acquiring knowledge

Ld.	Question	Rate 0	Rate 1	Rate 2	Rate 3	Rate 4	Rate 5
1.	the acquiring knowledge from suppliers	9,7%	12,9%	9,7%	25,8%	29,0%	12,9%
2.	the acquiring knowledge from customers	9,9%	16,7%	6,7%	26,7%	26,7%	13,3%
3.	the acquiring knowledge from competitors	6,1%	19,4%	29,3%	19,4%	12,9%	12,9%
4.	the acquiring knowledge from business partners	10,0%	10,0%	13,3%	16,7%	30,0%	20,0%

Source: own elaboration.

When analyzing the usage of knowledge, it has been necessary to take a close look at the effectiveness and non-effectiveness of different technologies used in terms of management and communication of enterprise information resource. The technologies have been given to respondents in order to figure out how and to which level they were used. It is given in Table 3.

Table 3.
Questions concerning different technologies/methods used in terms of management and communication in projects

Ld.	Question	Hard to say	Definitely ineffective	Rather ineffective	Rather effective	Definitely effective
1.	Internet	3,2%	9,7%	0,0%	6,5%	80,6%
2.	Intranet	41,9%	3,2%	0,0%	32,3%	22,6%
3.	Extranet	41,9%	9,7%	6,4%	22,6%	19,4%
4.	Portals	19,4%	16,1%	12,9%	25,8%	25,8%
5.	Videoconferencing	10,0%	10,0%	10,0%	20,0%	50,0%
6.	Newsletters	25%	23,3%	12,5%	26,7%	12,5%
7.	Meetings	12,9%	3,2%	6.5%	22,6%	61,3%
8.	Data warehouses	12,9%	6,5%	9,7%	32,2%	38,7%
9.	Document management systems	9,7%	6,5%	9,7%	15,7%	58,4%
10.	Decision support systems	10,0%	3,3%	13,3%	36,7%	36,7%
11.	Group work support systems	10,0%	0,0%	10,0%	36,7%	43,3%
12.	Customer Relationship Management	40,0%	3,3%	20,0%	16,7%	20,0%
13.	ERP/MRE systems	41,4%	3,5%	6,9%	24,1%	24,1%
14.	E-learning	16,7%	6,7%	10,0%	26,6%	40,0%
15.	Content management systems	6,9%	6,9%	6,9%	31,0%	48,3%
16.	Knowledge expert localization systems	10,0%	16,7%	3,3%	33,3%	36,7%
17.	Artificial intelligence systems	10,0%	10,0%	13,3%	36,7%	30,0%
18.	Knowledge management systems	3,4%	13,3%	10,0%	40,0%	33,3%

Source: own elaboration.

The most considerable technologies in the prosses of knowledge is still Internet – respondents find it effective (totally 87,1%) which delivers a wide spectrum of possible tools and solutions to implement. Highly recommended technologies (as effective) are: meetings (totally 83,9%), group work support systems (totally 80,0%), and content management systems (totally 79,3%). On the other hand, Customer Relationship Management (36,7%) and newsletters (39,2%) are treated as ineffective.

Recommendations dedicated to building and construction sector companies are as follows:

1. For companies in the building and construction industry, the adoption of an organizational-based system structure rather than project-based structure can facilitate knowledge transfer beyond the project scope and duration.
2. “Collaboration in construction” simply means that teams are working together towards one project goal. Everyone can access the main plans and goals of a project at any time, without having to rely on gatekeepers or slog to faraway offices to get the information they need.
3. Transmitting information between contractors, designers, suppliers, and stakeholders is risky business. It also results in gaps in understanding and data loss. To reduce those gaps and foster collaboration in construction, it’s important to take measured steps towards that goal, which requires usage of the right tools.
4. By using collaborative software in construction industry, construction professionals may not only benefit from the advantages of working effectively without geographic and time restriction, but also enjoy the virtual collaboration that enables them to

simulate a real social environment and promotes tacit knowledge transfer. A collaborative software could help to extract tacit knowledge, and to encourage and support people to share their tacit knowledge in construction organizations.

Knowledge management is challenging in the analyzed sector. The knowledge is crucial to avoid some pitfalls in the future executed project. What is more, collaborative tools make project processes more effective and more resistant to disturbances.

5. Conclusions

1. Barriers of applying knowledge management in construction industry have been identified in the research. As project teams in construction projects are often disbanded at the end of a project, the knowledge generated in a project is difficult to track after the project is accomplished.
2. Irrespective of the type of projects implemented, results show that the majority of companies have invested or are planning to invest into knowledge management tools and solutions which are important for the effective knowledge sharing and using.
3. Sources of knowledge identified for construction and building projects mainly include knowledge from suppliers, customers, and business partners.
4. The tools for acquiring tacit knowledge are mainly based on collaboration with other organizations, work placements and internships in other domestic enterprises, taking part in conferences, customer knowledge acquisition, hiring new employees with appropriate knowledge and competences training workshops teaching specific skills are highly used.
5. Results of the research have proven that in the building and construction industry the main knowledge development tools are creation of research and development initiatives, connecting different departments or people leading to the creation of new knowledge systems and new solutions, building a community of practitioners and professional networks.
6. IT applications are widely used for customer management operations (storing customer records and supporting market research), human resources management (employee's data storage, budgeting purpose and managing employees working time), management of fixed assets, logistics, orders, and service. Knowledge management processes are present, and it has been proven that the use of ICT tools is crucial for effective knowledge management in the construction and building projects.

The undertaken research was limited to projects in the construction and building sector. The respondents' answers gave important information how knowledge management is realized in analyzed sector. The future study should be deepened and focused on precisely chosen decisive factors. The research should be undertaken in a quantitative way.

However, the achieved results could be observed in other sectors with similar structure of executed projects e.g. in the logistics sector. Recommendations should be considered to emphasize the significance of team collaboration in project teams.

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