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Applications of Knowledge Management in Construction: A Literature Review

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Abstract

Knowledge is considered one of the effective assets which control the success of organizations, and its effective management is crucial. Although knowledge has existed and has been used along all projects, the way it was managed was almost intuitive and highly reliable on in-house systems. As a consequence, knowledge management was introduced in the late 1990s to help companies create, share, and systematically use knowledge. Knowledge management can be defined as the identification, optimization, and active management of intellectual assets that create value, increase productivity, and gain and sustain competitive advantage.

Construction field, as one of the most complicated fields, is considered a project-based field where numbers of investments in it are in millions every year. Although knowledge in construction is among the main factors for project success, most of this knowledge lies in the minds of the people, which makes it hard to be captured and stored. Accordingly, effective knowledge management in construction is affected by different factors, including the willingness of people to share their knowledge and the mobilization of the workforce from one project to another without sharing lessons learned and previous knowledge. Here comes the role of application of KM, which could help prevent "reinventing the wheel" in construction. This paper aims at offering a comprehensive overview of the application of KM in construction through reviewing extant literature sources. Topics discussed included factors affecting KM, KM tools and techniques, the processes of KM, and the main benefits and challenges facing KM. There are many factors affecting knowledge management and many tools and techniques to manage knowledge. As for the findings of this paper, they took the form of an analysis of the main benefits and challenges facing the application of KM in construction.

Keywords

Knowledge Management; construction sector; construction project

1. Introduction

"Knowledge is power" (Uriarte, 2008)

In the past, knowledge was an important element for many fields, especially the political and the war fields. It was the main motive for many decisions. By time, the strength of knowledge existence grows and has become an important element in business. The existence of knowledge is not enough in business competitiveness but in managing and sharing knowledge as well.

In the construction sector, knowledge is essential for a project success. The nature of knowledge in construction is

different as it depends mainly on the learned lessons and the experience of people involved in the project. Thus, managing knowledge in construction has become so important in the last few years, especially as construction projects have become more complicated and many disciplines have been involved in them.

2. Data, Information and Knowledge

Data, Information and knowledge are basic terms in knowledge management needed to be defined. It is important to differentiate between these terms first to understand the field of KM.
Data: is the raw material of knowledge. It is numbers, words, facts, etc. that have no meaning without being in a context.
Information: is data, processed and leads to results in a meaningful context.
Knowledge: is information in human minds, it is the experience of people. It is the using of information and data to make actions. (Uriarte, 2008)

3. History of KM

The concept of knowledge is an old term, which existed thousands of years ago and had different images. There would not have been civilization or development in all fields of life without the existence of knowledge. Our ancestors understood the value of knowledge and using it, so they created several ways to share and save knowledge. They didn't recognize knowledge management term, but they used the available tools and techniques to get the benefit of knowledge. The timeline of the field of KM since 1970s and its main turning points are stated below.

1970s: It was the beginning of the appearance of the term knowledge management, as management theorists and practitioners published their papers, showing how knowledge and information are valuable assets in organizations. Among those management theorists and practitioners are Peter Drucker, Paul Strassman, Chris Argyris, Christoper Bartlett, Dorothy Leonard-Barton, etc.... In the late 1970s, early knowledge management systems included technology solutions such as the early hypertext/groupware application systems, which were introduced to help in sharing knowledge. In addition, Rop Acksyn and Don McCraken developed a hypermedia tool for KM systems, a decade before the existence of the World Wide Web. (Uriarte, 2008)

1980s: The importance of KM as a professional competitive asset was not recognized until the mid-1980s. According to Kimiz Dalkir (2005), some concepts like "knowledge acquisition", "knowledge engineering" and "knowledge-based systems" were developed by the late 1980s, and they enhanced KM systems. In 1989, the term KM became popular and a formal part of the lexicon of management. It began to appear in business-oriented journals like Sloan Management Review, Harvard Business Review, and others and conferences began to be held for it. The International Knowledge Management Network (IKMN) started in Europe and meanwhile the consortium of the U.S. companies started the "Initiative for Managing Knowledge Assets". Not only that but also the first book about KM was published by Sakaiya and was entitled *The Knowledge Value Revolution* (Dalkir, 2005; Uriarte, 2008).

1990s: By that time, KM has become one of the subjects in the new business practice. It has gone through several turning points as follows:

- In 1990, many companies in the U.S., Europe and Japan founded programs for knowledge management. It became widespread in business journals and a main subject to be discussed in the business conferences' agendas. It was published in journals and magazines as a theory in the management field but it didn't get the full attention from business professionals.
- In 1994, the International Knowledge Management Network (IKMN) became online and then the Knowledge Management Forum in the U.S. joined it. Numbers of groups related to KM were founded and the number of KM publications, conferences and seminars increased, focusing on the KM importance in the

business competition. In addition, The European Strategic Program for Research in Information Technologies (ESPRIT) began offering funds for KM related projects, as stated by F. A. Uriarte, Jr. (2008).

– In 1995, Ikujiro Nonaka and Hirotaka Takeuchi published a book in Japan entitled The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation. It was the start to get the corporations and organizations' attention towards KM as a valuable asset to organizations. By the end of the year (September 1995), "A Knowledge Imperative" symposium was held in Houston by Arthur Andersen and the American Productivity and Quality Center APQC (Uriarte, 2008).

– By the end of the 1990s, professionals and practitioners recognized the role of KM in the market competition and business organizations began to apply KM in their businesses. Also, major international consulting firms such as Ernst & Young, Arthur Andersen, and Booz-Allen & Hamilton used knowledge management projects as a big source of revenue A number of organizations, such as the American Productivity and Quality Council and the American Society for Information Science, began to study and find the relation between KM and other management areas like benchmarking, best practices, risk management, and change management (Uriarte, 2008).

In 2003, KM became an important academic course, as there were more than 100 universities, business and library schools which offered KM courses and degrees (Dalkir, 2005).

Many people talk about the benefits of KM and how to apply it. In each stage of KM development, there was a pioneer who assisted through his writing to show the importance of KM. (Table 1) shows the known pioneers who contributed to this field and their works since 1970s.

Table 1. Contribution of management theorists and experts (Uriarte, 2008).

Pioneers	Year	Their work
- Peter Drucker Paul **- Strassman**	1970s	They were the first to write about KM in papers. They talked about the importance of information and knowledge for organizations.
- **Chris Argyris** - **Christoper Bartlett- Dorothy Leonard-Barton**	1970s	They participated in developing the KM theory through their publications.
Dorothy Leonard-Barton	1995	She wrote the book Wellsprings of Knowledge – Building and Sustaining Sources of Innovation, which was published by Harvard Business School. She documented the case study of Chaparral Steel company that implemented an effective KM strategy since 1970s.
Thomas Allen at MIT	Late 1970s	He made studies on information and technology transfer and was largely responsible for the current understanding of how knowledge is produced, used and diffused within organizations.

Continued on next page

Table 1 continued

Pioneers	Year	Their work
- **Peter Drucker** - **Matsuda** - **Sveiby**	In the mid-1980s	They coined the term "knowledge worker" and wrote in depth about the role of knowledge in organizations.
Peter Senge	1989	He wrote one of the first books on organizational learning and KM *The Fifth Discipline*.
Sakaiya	1989	He wrote one of the first books on organizational learning and KM *The Knowledge Value Revolution*.
Tom Stewart	1991	He published the article "Brainpower" in Fortune magazine, which was the introduction of knowledge management.
- **Ikujiro Nonaka** - **Hirotaka Takeuchi**	1995	They published an influential book entitled *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation.*
Karl Erik Sveiby	1995	He wrote one of the most popular articles in KM field, entitled "The New Organizational Wealth."
Verna Alle	1995	He wrote one of the most popular articles in KM, entitled "The Knowledge Revolution."
Butterworth-Heinemann (Publishing Company)	1995	It launched the series "Resources for the Knowledge-based Economy" and started publishing an annual yearbook on KM.

4. KM Definition

What is KM? What is its definition? And what are the fields it is involved in? Researchers and professionals in business practice began to put definitions and rules for KM in the last two decades. Some of them found that KM has a multi-disciplinary nature and is used in many domains all over the world (Dalkir, 2005; Girard & Girard, 2015).

To start with, Kimiz Dalkir (2005) identified more than 100 definitions for KM through an informal survey for the published definitions in this field. Also, John and JoAnn Girard (2015) gathered more than 100 definitions for KM from different domains. They collected these definitions from 13 countries and from 23 domains, representing the points of view of the authors of the definitions, based on their domains and cultures.

According to what is mentioned above, it is clear that there are too many definitions for KM and until now there is no one definition that is agreed on by researchers (Uriarte, 2008). However, there are common points and concepts among the presented definitions.

The following are some of the published definitions for KM from different countries and domains:

Knowledge management (KM) is the process of capturing, developing, sharing, and effectively using organizational

knowledge ("Knowledge management," 2014). International Knowledge management is the process of efficiently organizing, analyzing, retrieving, using and – in some cases – monetizing knowledge ("Knowledge Management definition, HRZone,"). United Kingdom

Strategies and processes designed to identify, capture, structure, value, leverage, and share an organization's intellectual assets to enhance its performance and competitiveness. It is based on two critical activities: (1) capture and documentation of individual explicit and tacit knowledge, and (2) its dissemination within the organization ("knowledge management. Business Dictionary Online.,"). USA

*Knowledge management is the systematic management of an organization's knowledge assets for the purpose of creating value and meeting tactical & strategic requirements; it consists of the initiatives, processes, strategies, and systems that sustain and enhance the storage, assessment, sharing, refinement, and creation of knowledge (Frost, 2010). Denmark*K*nowledge management is achieving organizational goals through the strategy-driven motivation and facilitation of (knowledge-) workers to develop, enhance and use their capability to interpret data and information (by using available sources of information, experience, skills, culture, character, personality, feelings, etc.) through a process of giving meaning to these data and information (uit Beijerse, 1999). Germany*

The purpose of knowledge management is to provide support for improved decision making and innovation throughout the organization. This is achieved through the effective management of human intuition and experience augmented by the provision of information, processes and technology together with training and mentoring programs (Snowden, 2009). United Kingdom.

Knowledge management is a conscious, hopefully consistent, strategy implemented to gather, store and retrieve knowledge and then help distribute the information and knowledge to those who need it in a timely manner (Stuhlman, 2012). USA

Knowledge Management is therefore a conscious strategy of getting the right knowledge to the right people at the right time and helping people share and put information into action in ways that strive to improve organizational performance (O'Dell & Grayson, 1998). USA

The definitions mentioned above are some of the definitions definitions stated by John Girard & JoAnn Girard (2015). Other definitions are stated by other researchers as follows:

Knowledge management is the conversion of tacit knowledge into explicit knowledge and sharing it within the organization, it is the process through which organizations generate value from their intellectual and knowledge based assets (Uriarte, 2008).

Knowledge management is the deliberate and systematic coordination of an organization's people, technology, processes, and organizational structure in order to add value through reuse and innovation. This coordination is achieved through creating, sharing, and applying knowledge as well as through feeding the valuable lessons learned and best practices into corporate memory in order to foster continued organizational learning (Dalkir, 2005).

From these definitions and the mentioned references further reading, the following points are noticed:

- Most of the definitions say that KM is a process to achieve goals.
- KM is an organization process.
- Capturing, sharing, storing, using, and their synonyms are used in most of the definitions in all domains, as the processes of KM to get advantage from knowledge.

5. KM Life Cycle

As stated in the KM definitions, KM is a cycle, which consists of a number of processes. Interestingly, there is no one model for KM cycle agreed on among researchers and pioneers, but the differences between models are

not great. Kimiz Dalkir (2005) and Sanjay Mohapatra, Arjun Agrawal and Anurag Satpathy (2016) , selected four models for KM cycle, which are clear and had a full comprehensive and detailed description for the cycle processes; besides they could be applied in the real world (Table 2).

5.1. The Zack KM Cycle

Table 2. KM cycle models (Dalkir, 2005; Mohapatra, Agrawal & Satpathy, 2016)

Author	Meyer and Zack
Year	1996
Concept of the model	In this cycle the main factor is the information products, Meyer and Zack proposed that the processes applied on the design of products can be extended to the intellectual field. At the same time each stage of the KM cycle adds value to the knowledge product that is created through the model. They suggested that knowledge products are presented as a repository comprising information content and structure. This repository holds the raw material of knowledge, data and information, to be the basics for knowledge products.
The stages of the model	**Acquisition:** is to get information from its source. The source of information must be of high quality to get good information product. **Refinement:** is the process of refining the content of knowledge through a statistical analyses to add value to the knowledge product and get use of it. **Storage/retrieval:** is the process of storing knowledge acquisition and refinement in the first two stages. It is the process where knowledge could be usable and accessible to everyone in the organization. Storage may be physical such as file folders, printed information, etc. or digital such as database, knowledge management software, etc... **Distribution:** is the process by which knowledge is transferred to users through many ways (e.g., fax, print, and e-mail). In this stage, it is important to select not only the of transferring but also its timing, frequency, form, language, etc… **Presentation or use:** is considered the evaluation of the whole cycle and the value-added through previous stages. If the user have the context where to use the content of the knowledge product, so the cycle succeed to add value to people and organization.

5.2. The Bukowitz and Williams KM Cycle

Author	Bukowitz and Williams
Year	2000

Continued on next page

Table 3 continued

Concept of the model	*"How organizations generate, maintain and deploy a strategically correct stock of knowledge to create value"* - this is the concept that Bukowitz and Williams (2000) emphasized on in their framework. Therefore it deals with knowledge repositories, relationships, information technologies, communications infrastructure, functional skill sets, process know-how, environmental responsiveness, organizational intelligence, and external sources. In addition to depending on the long range processes that make knowledge management is convenient for organization objectives.
The stages of the model	**Get:** is to gather information to be able to take decisions, solve problems, or innovate. The most important issue in this stage is not to obtain knowledge but to deal with the huge amount of available information. **Use:** is the process of dealing with information to extract important knowledge to help in organization innovation. **Learn:** is the process of learning from previous experiences and get the benefit of lessons learned. **Contribute:** is the process by which employees share their knowledge with others through the organization database or network. **Assess:** is the process by which an evaluation of intellectual capital is held to define the mission-critical knowledge and manage existing intellectual capital to be convenient with the future knowledge needs. **Build and sustain:** is to Ensure that the organization's future intellectual capital will keep the organization viable and competitive. **Divest:** Organizations need to examine their intellectual capital in terms of the resources required to maintain it and whether these resources would be better spent elsewhere. This involves understanding the why, when, where, and how of formally divesting parts of the knowledge base.

5.3. The McElroy KM Cycle

Author	McElroy
Year	1999

Continued on next page

Table 4 continued

Concept of the model	He emphasized that *organizational knowledge is held both subjectively in the minds of individuals and groups and objectively in explicit forms.* In this model he proposed that knowledge of the organization is used in business processing environment and evaluated through loop of feedbacks. If it matches the organization expectations it reuse and become part of the the organization intellectual capital, and if not the business process behavior is adjusted and reused again
The stages of the model	**Individual and group learning** represents the first step in organizational learning. Knowledge is information until it is validated and used in context. **Knowledge claim formulation** involves codification at an organizational level. Is a formal way to codify individual and group knowledge and innovations in the organization. **Information acquisition** is the process by which an organization acquires knowledge claims in the organization or from external sources in general. These knowledge claims are library services, research initiatives, think tanks, consortia, and personalized information services. **Knowledge claim evaluation** is the process of evaluating knowledge claims to determine their validity and value. And also show that these claims have great value more than the existing knowledge in the organization knowledge repository. **Knowledge integration** is the process of exchanging the old knowledge claims with new one. Besides making sure that new knowledge is integrated in organization knowledge system.

5.4. The Wiig KM Cycle

Author	Wiig
Year	1993
Conceptof the model	He focused on the three conditions that need to be present for an organization to conduct its business successfully: - A business (products/services) and customers. - Resources (people, capital, and facilities). - The ability to act In this model he emphasized on the concept that knowledge is the way to make decisions and solve problems. Therefore the KM is important to facilitate the best use of knowledge in organizations. He suggested the expression "working smarter" *which mean making use of all the best knowledge we have available*. Therefore Wiig's KM cycle stated how knowledge is built and used as individuals or as organizations.

Continued on next page

Table 5 continued

The stages of the model	**Building knowledge** refers to activities ranging from market research to focus groups, surveys, competitive intelligence, and data mining applications. Building knowledge consists of five major activities: obtaining knowledge, analyzing knowledge, reconstructing/synthesizing knowledge, codifying, modeling knowledge and organizing knowledge. **Holding knowledge** consists of remembering, accumulating knowledge in repositories, embedding knowledge in repositories, and archiving knowledge. **Pooling knowledge** consists of coordinating, assembling, and accessing and retrieving knowledge. To coordination the knowledge a collaborative teams must work together to create a "who knows what" network. After getting knowledge it collected together to sored in a library or repository, to make it easy to be accessed and retrieved. **Applying knowledge** in this last process, knowledge is applied to work tasks. When knowledge is applied to routine tasks the compiled knowledge in human minds is used which almost used unconsciously. But on the other hand difficult tasks need to get more concentration and to dig for the needed knowledge well.

6. KM Types

In the modern economy, the knowledge that it is able to harness is the organization's competitive advantage. This competitive advantage is realized through the full utilization of information and data coupled with the harnessing of people's skills and ideas as well as their commitments and motivations (Uriarte, 2008). Knowledge is divided into two types; tacit and explicit knowledge. Explicit knowledge is a tangible knowledge and tacit knowledge is intangible knowledge. Knowledge can be transformed from tacit knowledge into explicit knowledge and vice versa. In (Table 3), there is a comparison between tacit and explicit knowledge to clarify the meaning of each of them and the differences between both of them (Dalkir, 2005; Uriarte, 2008; Anumba, Egbu & Carrillo, 2005).

Table 6. Tacit and Explicit Knowledge

	Tacit knowledge	Explicit knowledge
Location	It is stored in people minds.	It is stored in documents, databases, websites, emails and the like.
Where does it come from?	It is accumulated through people's experiences, interactions, studies, trials and practices.	It is stored through the process of codifying knowledge into documents such as reports, memos, business plans, drawings, patents, trademarks, customer lists, methodologies, and etc.

Continued on next page

Table 6 continued

	Tacit knowledge	Explicit knowledge
Knowledge characteristic	-It is personal -It depends on the success and failure trials and could be useful or not. -It is hard to record, codify and articulate. -It is considered a subjective insight as it is related to the person's experiences and point of view. -It depends on the personal willingness to share own knowledge. -It is a unique knowledge as when an organization employs a person who has such knowledge, it is an advantage for it.	-It is codified, documented and archived. -It is sharable. -It could be stored by using computers and information technologies. -It is tangible can be accessed. -It could be duplicated as it is stored in documents and databases so any one can get it.
Managing it	The first step is to identify it through differentiating between the useful and the unuseful knowledge. Next, use different ways such as conversations, workshops, training, technologies (e-mail, groupware, etc.. . .) to share it.	First step is to identify the knowledge that could be articulated. Next, it is documented and stored. Then, it is shared and used.

(Uriarte, 2008)

As a matter of fact, explicit and tacit knowledge are integrated, both together form the intellectual assets of the organization and give it its competitive advantage. Tacit knowledge is important to be able to make use of the explicit knowledge and explicit knowledge helps to understand, analyze and share the tacit knowledge. So, the two types of knowledge are so important and the interaction between them is necessary. Nonaka (1996) called this interaction "the four modes of knowledge conversion" (Uriarte, 2008) and they are as following:

Socialization is a process of creating common tacit knowledge through shared experiences. In this mode, people interact and share their experiences with each other. This happens when a person takes a part of other person's experience and enhances his own. The exchanged experience is not documented so in this mode the knowledge is still intangible and could not be shared without the person's willingness.

Externalization is a process of transferring tacit knowledge into explicit knowledge, this happens through articulating and codifying tacit knowledge into documents, drawings, diagrams, etc... This mode helps in extracting knowledge from people's minds to keep it safe in documents and repositories for others to use it. And in the same time it helps to get benefit from this tacit knowledge and create a new product.

Combination is a process of combining several existing explicit knowledge to produce new knowledge in other form. For example, a researcher can assemble an array of previously existing explicit knowledge to prepare a new knowledge such as a thesis or an article. This mode is helpful to gather codified knowledge and get benefit from it through a new product.

Internalization is a process of using explicit knowledge to create tacit knowledge of people. In this mode people get their knowledge by using tangible knowledge such as manuals, videos, books, etc. . . and learn it. The expression "learning by doing or using" is shown clearly in the process of using manuals to know how to use the machine. The instructions are learned and become part of the person's tacit knowledge (Uriarte, 2008).

7. Pillars of KM

There are four main pillars that must exist for any KM initiative. Without these pillars KM implementation will not succeed. They are considered as the four corner columns holding the building. These pillars are:

7.1. Management and Organization

This pillar depends on the high level managers in organizations and their commitment to the implementation of KM. Top management must be involved in the process of KM and must provide the example for the rest of the employees. It is worth mentioning that KM implementation must serve the strategic objectives of the organizations. Therefore, the organization structure needs to include a KM department and define its responsibility. Besides the top management commitment, organizations value chain must be considered. The relation between organizations as customers and suppliers is too important to define the objective of KM and the way to manage knowledge in the organization. Once the customers' needs and feedback are defined, they must be known to the whole organization members to help them develop products, provide services and take decisions.

7.2. Infrastructure

To apply KM, the infrastructure support and technology are required. Information and communication technologies (ICTs) are needed in KM processes - creating, organizing, storing, sharing and using knowledge. There is a number of tools for each process which assist in terminating the process in an easy and fast way. Portals, e-mails, internet, databases and other tools are examples for the ICTs available nowadays. These technologies are developed rapidly to adopt the competitive market and the complexity of the knowledge processes. The use of these technologies makes the implementation of KM more effective in organizations.

7.3. People and Culture

KM depends on the human factor as the main enabler through its processes. It deals mainly with tacit knowledge, which is the knowledge in human minds. People attitudes, culture, social values and aspirations must be considered when managing the knowledge which people possess. To enhance the knowledge flow in the organization, some points must be considered:
-Defining the organization structure relating to its strategies.
-Defining the required knowledge according to these strategies.
-Refining the recruitment process, by choosing people who have the required knowledge and experiences to add new knowledge to the organization.
-Choosing people who have the potentials and attitudes to share and acquire knowledge.
-Providing the required training to the employees, which serves the organization objectives and assist in improving employees' experience.
-Building up an atmosphere of trust and openness to encourage employees to share and gain more knowledge.
-Creating the motivation to help employees to learn and apply their knowledge (Uriarte, 2008).

There is an argument among theorists about the most important factor in KM processes - the human or the technology factor. In fact, there are some organizations that use ICTs in creating and sharing knowledge even if they do not know that they are applying knowledge management. Although using technology spreads widely in organizations, human knowledge is the core and the intellectual asset of the organization; this knowledge is unique and is the competitive advantage of the organization. Therefore, managing people is more important and difficult than managing technology usage (Dalkir, 2005; Uriarte, 2008).

7.4. Content Management System

Is the information assets and systems that support digital information management, these assets and systems could be internal or external. These systems are responsible for the digital content such as websites, internet, intranet, databases, etc.... Content management system is an important pillar to make sure of the knowledge management system performance. Therefore programs for managing this content need to be developed and implemented, and maintaining and updating roles need to be defined. In addition to thie authors should enrich this content through their new articles (Uriarte, 2008).

8. KM Frameworks

The importance of knowledge management increases and spreads in the business world. Many organizations seek to implement KM because if they implement it in a proper way, they will get the benefit of it and improve the work environment and the collaboration in the organization. Thus, theorists and practitioners have developed different frameworks and systems to implement KM. For example, F. A. Uriarte extracted five stages of many knowledge management initiatives in large organizations to implement KM (Uriarte, 2008). Also, Sanjay Mohapatra, Arjun Agrawal and Anurag Satpathy set ten golden steps to be followed in corporations (2016). F. A. Uriarte stages and Sanjay Mohapatra, Arjun Agrawal and Anurag Satpathy's steps are explained below.

Uriarte's stages are:

- Advocate and learn.
- Develop strategy.
- Design and launch KM initiatives.
- Expand and support initiatives.
- Institutionalize knowledge management.

Stage 1: Advocate and Learn
In this stage, the advocates of the concept of KM must introduce to the rest of the organization benefits, problems and other companies' trials to implement KM. In this stage there are five steps to be followed:
a)Introducing knowledge management to the organization members to show them how KM will help them to do their work more efficiently.
b)Identifying the KM team and focal points that will support the development of KM, by choosing people who already make small groups of communication and have a connection with the high level management and by selecting the existing activities that are related to KM.
c)Learning about the experiences of other organizations and defining the benefits and the problems they face to avoid their mistakes.
d)Identifying advocates of knowledge management.

Stage 2: Develop Strategy
In this stage, there are some conditions which need to be available to make it possible to move to the second stage of implementing KM. These conditions are:
a)The organization has established a KM group or committee for KM and it has successfully met a few times.
b)A top management member support further exploration of KM.
c)A group, a section, or a division within the organization is looking for successful, internal grassroots efforts related to KM that are already underway.
d)The IT section or division of the organization is interested in actively supporting the KM initiatives.
e)Availability of an experience of knowledge sharing that helped the organization in the past.
f)Some pilots have been identified allowing the demonstration of how KM will benefit the organization.

g)Ownership of the proposed pilots have been identified and their possible funding has been secured.
After meeting these conditions, the initiative of KM can begin through pilot initiatives. Through these pilot initiatives the organization can choose the best strategy that is consistent with the organization strategy and help to achieve the organizational objectives. The pilots need to have a support team with identified tasks; budget and technologies need to be provided to make these pilots. Finally, an evaluation for the pilot is carried out to measure its suitability.

Stage 3: Design and Launch KM Initiatives
In this stage, the KM pilot projects are measured and lessons learned are shared. Some indicators need to be developed to make the decision to continue in the third stage; these indicators are:
a)The pilot projects have been fully conceptualized and designed, including the detailed implementation strategies and procedures.
b)Communities of practice have been organized and launched or an interactive KM intranet site or other KM-related initiative is operational.
c)The task force team leaders have been enlisted and pilot facilitators and implementers have been trained.
d)Pilot measures and indicators have been established and a system for tracking and reporting results has been developed.
e)Policies and strategies for learning from the KM initiatives have been created and disseminated to all relevant players.
f)Strategies and procedures for expanding the pilot initiatives have been mapped out and desired outcomes from the pilots have been clearly described.
This stage comes after the success of the first two stages, so it is more detailed and focuses on budget and actual performance. The benefits of applying KM is known; there is just a need to show the measurable gains and the ROI to top management.

Stage 4: Expand and Support
This stage could take years to be achieved. At this point, the pilots would have been launched and results gathered, some important lessons would have been learned and captured, and the further continuation of the KM journey would have been already decided.
Some of the following indicators need to be present to continue implementing KM:
a)Other departments in the organization are expressing a desire to actively participate in the KM system as a result of successful pilots.
b)The promotion and marketing of KM throughout the entire organization has started to show positive results.
c)The entire organization has been made aware of the existence of the KM initiative and the results of the pilot activities.
d)An expansion strategy for the KM initiatives is in place, supported by a number of top executives in the organization.
e)Adequate resources have been identified for expanding the KM efforts and the finance and budget departments are supportive of these efforts.
The main objective of this stage is to develop and market an expansion strategy throughout the organization and to effectively manage the growth of the KM system.

Stage 5: Institutionalize Knowledge Management
In this final stage, KM become a part of the organizational processes and the organization has to redefine its strategies, review its organizational structure and revisit its performance assessments. One or more of the following indicators need to be present:
a)The KM system is now directly linked to the business model.
b)A number of KM initiatives are widely deployed throughout the organization.
c)All executives, managers and employees are trained to use KM tools and technologies.
d)The KM strategy is methodically assessed, gaps are being identified, and methods to close the gaps are available.
e)A formal support structure is in place to maintain the operation of the KM system.

f)An employee compensation and rewards program is in place and aligned with the KM strategy.
g)Sharing knowledge is now the norm in the organization and communities of practice are actively operating.

Speaking of Sanjay Mohapatra, Arjun Agrawal and Anurag Satpathy's ten golden steps, they are:

Step 1: Select a business strategy for KM:
This is the basic step to implement KM. It is essential to define the business goal of the organization for which the KM needs to be implemented. This will facilitate the implementation of KM.

Step 2: Align KM strategy with the business strategy:
This step is to make the KM strategy in consistent with the organization objectives. As a result, integration between KM processes and the organization internal processes is done. This would happen through analyzing the internal environment and the interactions in it.

Step 3: Audit and analyze present knowledge:
In this step, the present tacit knowledge available within the organization needs to be checked and audited to analyze the strength and weakness points in the organization knowledge and to have a full picture for the situation of the information flow in the organization. So, the KM strategy could fill the existing gaps and solve problems.

Step 4: Analyze existing infrastructure:
Analyzing the existing infrastructure supports availability and feasibility for implementing the KM strategy. This is because it will give the information about the scale of investment required for fulfilling the gap, ensuring the proper functioning of the KM processes and determining the available potential for these processes and their usage in order to help make use of available resources effectively and efficiently.

Step 5: Build KM team(s):
Building KM teams is one of the important decisions that need to be taken for effective implementation of the KM strategy. The selection of members of KM team must be aligned with the business objectives and goals and community of practice can also be the determinant of the members of the KM team. The number of the teams will depend on the size of the organizations and the team can include sponsors, facilitators and members.

Step 6: Define roles and responsibilities:
Defining roles and responsibilities clearly for each individual in a team is a very important step. This will help to reduce rework and conflicts. It will help everyone in the team to focus on his own activity, which will enhance the performance. Besides, this will help to manage the team and assess its performance.

Step 7: Develop the KM system:
In this step, a KM system is developed to help people to integrate KM activities with their daily working activities and make sure that KM will support their working environment. At the same time this system must be easy to use and help people to take decisions in participatory environment. Therefore, matrices and critical success factors processes should be defined according to the organization internal dynamics and should be suitable for the business goals and objectives of the organization as well.

Step 8: Implement the KM system:
This is the ground part of the KM implementation process. This step will be the initiative of applying KM. It will face some problems and challenges and the most important challenge is the human attitude as employees will have a problem to deal with the KM principles. To change their mindsets and their culture they have to find the motivation and to see the commitment of the top management towards KM. Their performance indicators should also take KM work into consideration, which means the key performance indicators (KPIs) must be aligned with the KM strategy.

Step 9: KM evaluation/audit:
In this step, the organization defines the period of evaluation and the success and the failure of the system will be checked on the basis of predefined matrices and CSFs levels. Who will perform evaluation/audit will mainly depend on the organizational culture and the internal dynamics of the organization. Evaluation could be done by using questionnaires, interviews and focus group discussions.

Step 10: Identification of issues and challenges:
KM is a continuously evolving process. It requires continuous reviewing to define the problems and the challenges that face the KM initiatives. The focus in this step is not only on identifying the problems but on solving them as well. The nature and the size of the problem will decide the type of solution to be process improvement processes (PIPs) or it could be structure improvement processes. Besides, it will define who the decision taker will be; the KM team or the top management team (Mohapatra, Agrawal & Satpathy, 2016).

In these two road maps, F. A. Uriarte's five stages and Sanjay Mohapatra, Arjun Agrawal and Anurag Satpathy's ten steps are explained below, there are some common steps. Both of them depend mainly on having a sequence in implementing KM:

First: knowing KM, the goal of implementing it and how it will help in the organizational objectives and the business goals.

Second: according to the KM goals, its strategy is defined.

Third: the organization infrastructure is defined to know the gaps in the system to be filled and to identify the needed work.

Fourth: applying the system of KM as a pilot project.

Fifth: evaluating the pilot project and identifying the weakness points then trying to find solutions to them.

9. KM in Construction

Knowledge is one of the intellectual assets in organizations and construction sector is no exception. As construction sector is a project-based industry, it needs to manage the knowledge of the project.

10. Construction Projects

The construction industry is a project-based industry. The nature of the construction project is different from other projects like manufacturing or IT projects. It depends on the client's need for a facility. Then, the project phases begin, unlike the manufacturing industry, where there is a product purchased in the market to be sold to customers. Therefore, the construction projects are different from manufacturing since the construction projects have their own nature and special characteristics. Thus, it is important to know how to manage a construction project to achieve best performance (Hendrickson, 2008; Senior & Halpin, 2011).

Construction Project Characteristics:-It has a unique nature as every project has its own requirements and conditions even if they are of the same type. For example, if there are two office buildings which will be constructed, they will not be the same, and they will not be handled in the same way; their circumstances will be different in terms of location, occupation, building skin, budget . . . etc. All of these determinants will differ in the two projects and as a result schedules, cost, cash flow, design, studies . . . etc. will differ too.
-It takes long time.
-It is a multidisciplinary project as many stakeholders collaborate during the project phases. Different disciplines are involved in the project such as architecture, structure, mechanical . . . etc.
-It has a temporary nature as each project has its own team from the early planning phase until the opening time. After that, the team splits up to work in other projects or members of the team stay together to work in another project. For example, the consultant, the contractor and the subcontractor make one team to finish the project and after a project close-out, the contractor would work with another consultant to build another project.

11. KM Tools

There are different classifications for KM tools. Some practitioners classified them into two types of tools; a) IT tools, b) non-IT tools (Table 4). Others classified them according to the processes of KM cycle (Anumba, Egbu & Carrillo, 2005; Young, 2010). Some practitioners stated that knowledge management tools are IT tools only and these tools are more effective to deal with explicit knowledge rather than tacit knowledge.

KM tools need to have the following characteristics/features:
-Facilitate information contextualization by putting information in context and define its characteristics to facilitate reaching the required information.-Consider the nature of the user, the content and the time while transforming information.

-Facilitate social interaction and verbal communication.
-Provide an easy and customized computer interface to help using and searching for information and to keep continuance (Ghani, 2009).

Table 7. IT tools and Non-IT tools of KM

IT tools	Non-IT tools
• Document Libraries leading to a Document Management System. • Knowledge Bases (Wikis, etc.). • Blogs. • Social Network Services. • VoiceandVoice-over-InternetProtocol (VOIP). • Advanced Search Tools. • Building Knowledge Clusters. • Expert Locator. • Collaborative Virtual Workspaces. • Knowledge Portal. • Video Sharing.	• Brainstorming. • Learning and Idea Capture. • Peer Assist. • Learning Reviews. • After Action Review. • Storytelling. • Collaborative Physical Workspace. • APO Knowledge Management Assessment Tool. • Knowledge Café. Community of Practice. • Taxonomy. • Knowledge Worker Competency Plan • Knowledge Mapping. • KM Maturity Model. • Mentor / Mentee Scheme.

These tools and techniques are used to manage knowledge in general and in construction sector as well. But there are some tools - IT tools – that are used especially in the construction field such as CAD (Computer Aided Drafter) and BIM system (Building Information Modeling). Specifically, BIM is considered nowadays the most important tool to manage and coordinate project information and data. There are too many researches that talk about BIM and KM and many AEC organizations around the world that use BIM to develop project performance in the design and construction phases (2014).

12. Conclusion

As mentioned earlier, the term knowledge is not a new concept to introduce. It is known in all fields but the new issue is why we need knowledge management. The problem now is not about the availability of knowledge, rather it is about know-how, know-what and know who. This is why we need knowledge management. As a result of globalization, the world has become “a small village”, business has spread around the world, organizations in different fields and construction sector even the small ones has had different branches and customers all over the world. By the increase of construction business and the complexity of its projects, the need to organize and codify knowledge on organization and project levels increases. Implementing knowledge management has had benefits on different levels and has helped to face challenges too. In fact, there are benefits on the individual, project and

organization levels. According to Kimiz Dalkir (2005) and Anumba, Egbu and Carrillo (2005), the benefits are:

-KM facilitates taking decisions and problem solving, which helps to save people's time and the project time as well, accordingly, it helps to improve the performance of the project.
-KM keeps people up to date with the construction issues.
-KM raises the competitive spirit among employees to get more knowledge and to share it.
-KM creates a collaborative environment in the workplace through sharing knowledge among employees.
-KM keeps organizations ahead of the competition.

-Through fertilizing ideas, KM increases opportunities for innovation.

Meanwhile, challenges that face the implementation of KM are (Anumba, Egbu & Carrillo, 2005; Forcada, Fuertes, Gangolells, Casals, & Macarulla, 2013):Changing the mentality and the culture of the construction organization.
-Most companies are divided into departments and business units that operate independently and have little contact with one another, which makes it difficult to share knowledge.
-The most challenging issue to manage knowledge is the lack of time. Most of the project schedules are condensed and time is limited for employees to take over their tasks and share their knowledge.
-As the human factor is one of the main reasons for KM success, it is also the main challenge to implement KM. This is because without having the culture of sharing and accepting knowledge, KM can't be implemented. Besides, the rivalry between employees makes them keep their knowledge for themselves.
-Selection of the KM tools is one of the major challenges that faces its implementation as it needs to define the organization goals and to define the knowledge nature in the organization, which sometimes become hard to define accurately.

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