

# INNOVATIVE TOOLS FOR BETTER USE OF KNOWLEDGE IN FACILITY MANAGEMENT FOR CONSTRUCTION

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## Abstract

Successful operation and maintenance of buildings relies on facility management (FM). Effective implementation of FM practices still poses diverse challenges. Through a comprehensive literature review, this research examines the current state of facility management and identifies the key gaps and challenges faced in this field. The findings indicate that major challenges concern inadequate information infrastructure, a lack of standardized processes, poorly identified required data, bad information quality and insufficient training. Common to the listed challenges is a need for a better management of knowledge. In this context, the paper explores the possible tools for better utilization of knowledge in management processes including centralized information sharing, continuous learning and improvement, and effective use of technology. This contribution demonstrates that the future research should focus on optimizing stakeholder engagement, streamlining processes, and supporting knowledge, enhancing cognitive requirements, and the supporting technology to make better use of knowledge in the construction industry.

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**Keywords:** construction, facility management, knowledge, knowledge management.

## 1. Introduction

Facility Management (FM) is an integrated approach that helps organizations, facility managers, owners, and end-users to achieve their main objectives by ensuring the functionality of the built environment [1]. In other words, FM encompasses multiple disciplines that work together to ensure that the built environment is optimized for the people who use it. The most recent definition of facility management is “a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process, and technology.” It is interesting to note that this newest definition highlights the importance of technology, which was lacking previously [2, 3].

Facility managers require access to accurate and reliable information about building systems and components, which enables them to make informed decisions and take actions that enhance efficiency and productivity [1]. However, FM presents many challenges, including data loss, time wasted searching for information, lack of interoperability, and data inconsistency [4]. Due to the increasing demand for a high quality of life, globalization, and the development of information technology, managing properties and facilities in the built environment has become increasingly important. To meet these challenges, facility managers are constantly looking for new approaches that enable them to harness the power of technology and leverage data to improve their operations to fulfil the evolving needs of their stakeholders [5].

The Architecture, Engineering, Construction and Operation (AECO) industry and FM play a vital role in shaping the built environment and ensuring that it meets the needs of people. The rapid changes in the technology and societies affect the construction sector as well as the requirements of an efficient facility management system today. In the following section, the research presents the literature review that was used for examining the current state of facility management and identifying key gaps and challenges faced in this field.

The rest of this paper is organized as follows: Section 3 provides a comprehensive examination of the significance of knowledge management in the realm of facility management. Section 4 elaborates on the six essential steps involved in the knowledge management process. Section 5 subsequently outlines the various concepts and tools that can be leveraged for effective knowledge management. Ultimately, the paper investigates how these tools can potentially mitigate the identified gaps and challenges and improve the field of facility management within the construction sector and concludes the research.

## 2. Current Gaps and Challenges of Facility Management in Construction Sector

As part of a broader research investigation, a literature review and analysis were conducted by using the keywords “facility management”, “construction, and “gap” on Scopus database to detect existing research on this focus area. The inclusion criteria were English journals and conference papers. Total 97 papers were found on the database. After removing irrelevant content and private access papers, 45 articles remained.

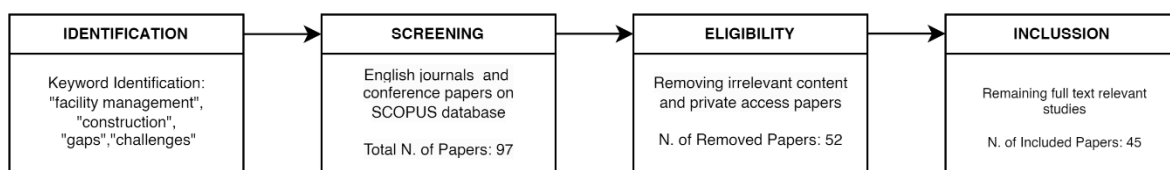


Fig. 1. Search process

Firstly, the main gaps and challenges have detected in the research, then the articles are grouped according to the gaps and challenges pointed in the research. Total five categories identified, which are the inadequate information infrastructure, the lack of standardized processes, the poorly identified required data, bad information quality, and insufficient training.

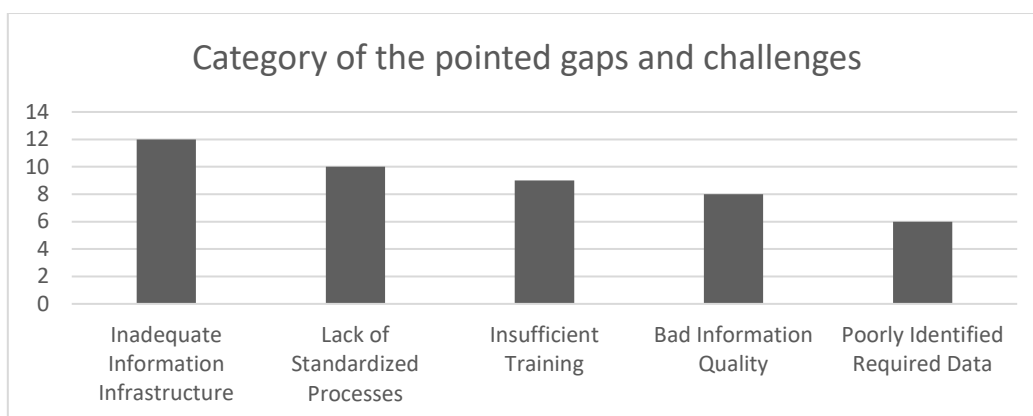


Fig. 2. Category of the pointed gaps and challenges

All the 45 papers gathered are summarized in Table 1. While 12 paper are concerning about inadequate information infrastructure, 10 papers point lack of standardized processes, 9 papers highlight insufficient training. Total 8 paper discuss bad information quality and 6 paper underline the challenges of poorly identified data. Not all papers were referenced due to limitations required on the length of this paper. The difference between the number of papers in the archive and the referenced ones can be worked out from columns no.3 and no.4 in Table 1, respectively.

Table 1. Categorization of the papers.

<i>Category</i>	<i>Sub-Category</i>	<i>N. of Total Papers</i>	<i>N. of Referenced Papers</i>	<i>Selected Referenced Papers</i>
Inadequate Information Infrastructure	information gap	2	1	(De Silva et al., 2017)
	integration gap	1	1	(Wang et al., 2013)
	interoperability gap	1	1	(Ozturk, 2020)
	knowledge gap	2		
	tool gap	4	1	(Wu & Lepech, 2020)
	validation gap	2		
Lack of Standardized Processes	collaboration gap	1	1	(Mehedi & Shochchho, 2021)
	information gap	3		
	interoperability gap	1		
	knowledge gap	5	2	(Kamaruzzaman et al., 2016); (Abideen et al., 2022)
Insufficient Training	awareness gap	1		
	education and training gap	5	3	(Maile et al., 2007); (Low et al., 2019); (Edirisinghe et al., 2017);
	knowledge gap	2		
	technical skills gap	1	1	(Marocco & Garofolo, 2021)
Bad Information Quality	communication gap	2	1	(Hilal et al., 2019)
	integration gap	1		
	knowledge gap	1		
	validation gap	4	1	(Chen & Tang, 2019);
Poorly Identified Required Data	collaboration gap	3	3	(Mervi, 2003); (Wen et al., 2021); (Sedhom et al. 2022)
	information gap	2	1	(Ozturk, 2020)
	validation gap	1		

One of the primary gaps identified on literature is the inadequate information infrastructure that hinders the effective management of facilities. Wang et al. (2013) emphasized the need for an integrated data source that provides information support for the building lifecycle, and the suggestion that Building Information Modelling (BIM) can fill this gap [6]. De Silva et al. (2017) pointed the gaps and lack of relationships among stakeholders, indicating a need for better communication, collaboration, and information sharing among stakeholders to achieve better value and performance in total facilities management [7]. The text also discusses the difficulty of achieving design for adaptability without the relevant information from the FM team and appropriate integration platform. Ozturk (2020) mentioned the lack of interoperability in BIM in order to increase knowledge-integrated, ontology-based, IT-based managed, collaborative, automated, well-visualized, and sustainable outcomes [8]. Wu & Lepech (2020) highlighted there exist no fundamental tools for the life-cycle management of durability performance of built structures leveraging multi-physics models and building information models (BIM) [9].

Another gap is the lack of standardized processes that hinder the effective management of building data. Mehedi & Shochchho [10] stressed lack of standardization and interoperability in the construction industry, which hampers the adoption of BIM technology. Kamaruzzaman et al. (2016) identified lack of focus on the roles of professionals and their coordination towards enhancing the implementation of BIMFM, including establishing a process workflow and guidelines [11]. Abideen et al. (2022) noted the need for a general facility maintenance knowledge database with an emphasis on the maintainability assessment at different life cycle phases and decreasing the number of maintenances interventions [12].

Insufficient training is the following challenge mentioned in literature that inhibits the efficient facility management. Maile et al. (2007) pointed educational gap among engineers and other stakeholders that needs to be overcome [13]. Low et al. (2019) stressed that future graduate students lack the soft skills needed by Industry 4.0 [14]. Edirisinghe et al. (2017) points that BIM-enabled FM is still in its infancy and has not yet reached its full potential [15]. This is partly due to the fact that organizations need to undergo a learning curve to fully implement BIM and realize its productivity gains. The text also highlights the importance of internal leadership and knowledge management in the BIM-enabled FM implementation process. Marocco & Garofolo (2021) mentioned the lack of the technical skills to manage cutting edge technology in the operational phase, especially for maintenance management [16]. They also recommend developing a platform which allows multiple FM teams to work at the same time in the same building zone by sharing information, such as position and time span of tasks and whether including potential hazards.

Bad information quality is also discussed as a challenge which obstructs the effective management of facilities for the construction sector. Hilal et al. (2019) pointed out the construction project delivery systems have enormous communication gaps, especially between the constructor and operator/owner [17]. Chen & Tang (2019) draw attention to the knowledge gap between maintenance theories and practical maintenance management in the design and construction phase [18].

Lastly, the poorly identified required data creates challenge for successful facility management. Mervi (2003) discussed the gaps between scientific information and the information needs of industry and other businesses have been a main concern of dissemination of research results. Therefore, he suggests consulting activities for co-operation between scientists and industrial partners to bridge the gap [19]. Ozturk (2020) urged the need for practical research that focuses on the full integration of cognitive technologies and the BIM platform to turn it into a digital twin of a built entity for increasing knowledge utilization for effective decision-making and efficient outcomes throughout the project lifecycle in the near future [8]. Wen et al. (2021) realized that few researchers focus on the continuous information transfer solution from the BIM model to FM systems during the building in-use phase. They also suggest an interface to be established for the “conversation” between the frequent changes of building and the FM systems in the post-construction period [20]. Sedhom et al. [21] discussed the lack of involvement and participation required by stakeholders. There is a lack of clarity in identifying the required data that is needed to manage stakeholders effectively.

These gaps and challenges have been noted by researchers across several studies, and they can be addressed through effective knowledge management. In the following chapter, we will explore in detail the ways in which knowledge management can be utilized to improve facility management practices in the construction sector. This will include a discussion of the various tools and concepts that can be implemented to ensure that the necessary knowledge is effectively created, captured, shared, and utilized, ultimately leading to better outcomes. By taking a proactive approach to knowledge management, stakeholders in the construction sector can stay ahead of the curve and improve their overall performance.

### **3. Knowledge Management for Facility Management**

In today's dynamic and competitive environment, the ability to acquire and utilize knowledge is increasingly recognized as crucial for survival. Knowledge management (KM) is the set of methods for creating, sharing, using and managing an organization's knowledge and information [22]. Integral to knowledge management is incorporating the socio-technical perspective of people, processes, and technologies [23]. Knowledge is the most fundamental organizational resource in FM services and has the highest strategic value in understanding and managing the relationships between physical resource performance and its impact on the people they serve.[24].

The subject of knowledge opens to a particular view within FM services, starting from the conceptual chain, that links [25]:

- data (i.e., numbers, texts, images, etc.), that obtain meaning and value only in relation to a context and processing;
- information that is data processed according to specific goals, referred to a context and managed to be used, shared, and combined;
- knowledge that is the result of applying, processing, relating, combining information in specific contexts. The process, that leads information to enter in a system able to develop knowledge, creates the actual value and competitive advantage for an organization.

Fikri & Anumba [26] argue that most construction knowledge is tacit wherefore appropriate KM mechanisms must be allocated. In the realm of knowledge management, there are a variety of factors to consider, including information, communication, human resources, and intellectual capital. It involves facing a number of challenges such as usefulness of the knowledge, its transfer to others and its quantity. Therefore, effective facility management requires a range of cognitive skills such as critical thinking, problem-solving, decision-making, and analytical skills. It requires formulating and implementing strategies, improving processes, and monitoring and evaluating what knowledge exists, and its effective management. It is important yet difficult to scope, define and understand the processes, but to do so is necessary if organizations are going to be able to cope [27].

#### **4. Knowledge Management Processes**

Knowledge management is a systematic process which involves the development of policies, strategies, and tools to support the acquisition, sharing, and utilization of knowledge, with the ultimate goal of improving organizational performance and achieving strategic objectives. A well-designed set of processes is essential for successful knowledge management because they allow the business to collect, maintain, and share knowledge throughout the organization. The discourse surrounding knowledge management processes has been extensively examined by numerous scholars and has constituted the focal point of numerous investigations. From the findings of the questionnaire survey, the research of Fong & Choi confirms the six knowledge management processes namely acquisition, creation, storage, distribution, use, and maintaining [28].

1. Knowledge acquisition: It is the initial step in the knowledge management process that involves the identification and collection of knowledge from various sources. This process enables organizations to create a knowledge base that can be used for decision-making and problem-solving.
2. Knowledge creation: The process of generating new knowledge by combining existing knowledge through research, experimentation, and collaboration. This process leads to innovation and helps organizations to stay competitive.
3. Knowledge storage: The process involves organizing and preserving knowledge for future use. Knowledge is easily retrievable when needed, and it also helps to prevent information loss due to employee turnover or system failure.
4. Knowledge distribution: The process of disseminating knowledge to those who need it, whether through training programs, documentation, or other means.
5. Knowledge use: The process of applying knowledge to solve problems, make decisions, and improve organizational performance. So, the knowledge is not just stored but is utilized to make a positive impact on the organization.
6. Knowledge maintaining: It involves keeping knowledge up-to-date and relevant over time. This process ensures that knowledge does not become obsolete and is continuously improved to meet changing organizational needs.

## 5. Innovative Tools for Knowledge Management

Innovation in KM can be defined as an organization's willingness to apply new methods to knowledge management [29]. According to empirical findings technological, social, and organizational factors are equally important for KM processes and they show a possible categorization for innovations in the KM field [30]. The technological KM innovations are related to ICT in knowledge management systems (e.g., intranet platforms for storing knowledge) which are socio-technical systems [31]. Social innovations involve the human factor and the interaction between individuals such as motivational incentives for knowledge sharing. Moreover, organizational innovations are related to structure and hierarchy, for example, the breaking down of knowledge silos by interdisciplinary knowledge exchange groups.

The primary focus on knowledge management systems which are socio-technical systems that have the ability to assist KM processes using information and communication technology (ICT) as well as organizational and sociological theory. Schenk's research points to eight innovative concepts in the field of knowledge management which are Artificial Intelligence (AI), Big Data (BD), Communities of Practice (CoP), Digital Artifacts (DAs), Enterprise Social Media (ESM), Gamification Open Innovation (OI), and Virtual Reality (VR) [29]. The concepts range in scope and degree from practical approaches to full models (Figure 3).

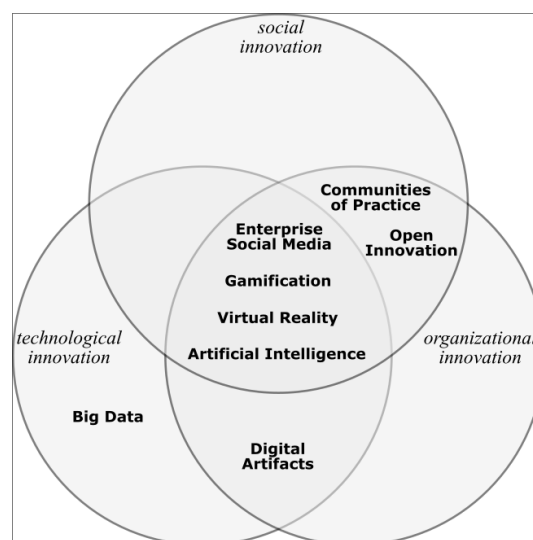


Fig. 3. Classification of identified KM concepts [29]

A variety of tools are available to support the KM concepts and processes. These include tools for accessing knowledge, which provide access to explicit knowledge that can be shared and transferred through enterprise information systems. Semantic mapping tools, including ontology tools, allow users to quickly organize and analyze information, as well as create visual representations of their research and analysis. Knowledge extraction tools support structured queries and replies and interpret relationships among different elements and documents to help with text mining. Tools for expertise localization enable quick location of knowledge holders within the enterprise and facilitate collaboration and knowledge exchange. Finally, tools for collaborative work enable teams to globally share dedicated spaces for managing project lifecycles, conducting live discussions and interactions, and maintaining a repository of materials associated with every step of the process [32].

KM tools focus on the assimilation, understanding and learning of knowledge by individuals who will transform data and information into knowledge [32]. Regardless of the amount of other individual knowledge embedded in it, the visible part of explicit knowledge is just information. Therefore, there is a need of KM tools, which can collect, categorize, organize, and share knowledge. Also, it is required to transfer information hidden in various forms and types of documents and media for facilitate information contextualization, intelligently transfer information, facilitate social interactions and networking, and present a customized human-computer interface.

Table 2 presents the web-based IT tools created by Ghani in 2009. In his study, Ghani discussed the emergence of a new group of web-based information management tools based on freeform social software that enhance individual knowledge work, group communication, and collaboration, referring to them as Web 2.0. However, more than a decade later, Web 2.0 cannot be considered a new technology and should be discussed along with many other existing KM tools.

Table 2. Web-based Information Technology Tools for Knowledge Management. (Adopted by Ghani, 2009)

Technology	Description/examples
Traditional Database Tools	These tools attempt to allow users to create general data properties implicitly within a database. They allow for the creation of objects that have certain properties, can communicate with other objects and so on.
Process Modelling and Management Tools	Processes that involve the transformation of physical material have been the focal metaphor. Tools have been built to support these processes encode considerable knowledge of the process.
Workflow Management Tools	These are the process management tools for information-intensive organizations. Workflow tools allow for the specification of the movement of documents in information processes.
Enterprise Resource Management Tools	Enterprise modelling tools are being developed to provide all the modelling capabilities of ERP/ERM systems along with the explicit representation of organizational and environmental knowledge.
Agent Tools	These tools rely on agents, relatively autonomous programs that can perform a variety of tasks. Agents may be provided with the specifications of the information that the user is interested in, and these will then search the web and specified other databases to find the information.
Search Engines, Navigation Tools, and Portals	Some of the search engines perform automatic text-only searches while others relied on human interpreters who would access web pages and then analyze and classify them.
Visualizing Tools	Tools to investigate the structure of knowledge domain and knowledge within domains. These tools have been used for data visualization in the areas of financial market to molecular biology.
Collaborative Tools	For setting of bulletin board and for real-time video conferencing, whiteboards, and chat rooms.
Web 2.0 Tools	A set of web-based tools such as wikis, blogs, tags. Social media platforms including Facebook, Twitter, Instagram, LinkedIn, and wikis, blogs, tags.

## 6. Discussion

The literature review has identified several technologies and tools that can be used for knowledge management. These technologies and tools can be utilized to improve facility management practices in the construction sector by addressing the identified gaps and challenges. Figure 4 shows the mapping of the tools for improving gaps and challenges in FM for the construction industry.

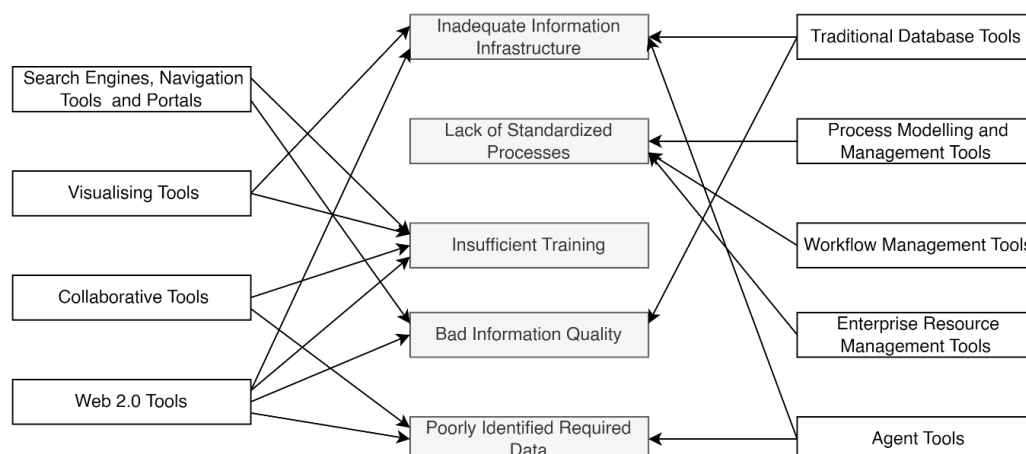


Fig. 4. Mapping of the tools for improving the gaps and challenges.

The challenge of inadequate information infrastructure can be addressed through tools such as traditional database tools and visualizing tools can be used to present complex big data in a more understandable format. Agent tools can help facility managers to process and analyze data more

efficiently. Moreover, Web 2.0 tools such as social media platforms can contribute continuous communication and collaboration between the stakeholders of the projects for a better understanding of project requirements.

The lack of standardized processes can be addressed through tools such as process modelling and management tools to manage the lifecycle of documents and to create a consistent and sustainable building information flow. Workflow management tools share information and computing resources among employees, while enterprise resource management tools automate and manage core business processes for optimal performance.

Insufficient training needs to be supported by a learning system with collaborative tools, visualizing tools and Web 2.0 tools. Collaborative tools can be used to locate people by their knowledge while Web 2.0 tools provide a big support to communicate and share this knowledge. For example, social media platforms created by skilled professionals and supported by videos and visuals, such as YouTube, can provide online learning portals for students and workers.

Bad information quality in the construction project delivery systems or in the maintenance theories can be improved by search engines, navigation tools and portals with Web 2.0 tools. Search engine can be used to search the contents and to validate the relevant information, while Web 2.0 can assist with managing electronic content including multimedia files. Moreover, traditional database tools allow for the creation of objects that have certain properties, can communicate with other objects.

The challenge of poorly identified required data requires Web 2.0 tools and collaborative tools. Web 2.0 tools such as social networking sites, wikis, blogs, and video sharing platforms can facilitate participatory information sharing and communicating, while collaborative tools can be utilized to locate people by their knowledge and to ensure that the right people are involved in the management process. These processes can be supported by social media features. Professionals, workers, or students can connect and interact within the selected platforms. Agent tools may be provided with the specifications of the information that the user is interested in, and these will then search the web and specified other databases to find the information.

Overall, the tools for knowledge management can support FM processes by facilitating knowledge sharing, collaboration and communication among stakeholders, and continuous learning and improvement. By applying these tools and strategies for knowledge management, stakeholders in the construction sector can improve their overall performance and meet the emerging project needs.

## **7. Conclusion**

There are several gaps and challenges in facility management practices in the construction industry. These challenges include inadequate information infrastructure, a lack of standardized processes, insufficient training, bad information quality and poorly identified required data, all of which require a better management of knowledge. The paper explores the possible tools for better utilization of knowledge in management processes, including centralized information sharing, continuous learning and improvement, and effective use of technology. By addressing these gaps and challenges through the utilization of various concepts, tools and strategies, stakeholders in the construction sector can improve their overall performance and meet the evolving needs. Overall, the implementation of these tools and strategies can facilitate knowledge sharing, collaboration, and communication among stakeholders and support continuous learning and improvement in FM processes. The future research should focus on optimizing stakeholder engagement, streamlining processes, and supporting knowledge, enhancing cognitive requirements, and the supporting technology to make better use of knowledge in the construction industry.

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