MATEC Web of Conferences **146**, 01003 (2018) https://doi.org/10.1051/matecconf/201814601003
Building Defects 2017

The role of managing knowledge and information in BIM implementation processes in the Czech Republic

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Abstract. Czech construction sector is at the initial stages of implementing and assessing Building Information Management (BIM) on pilot projects. Object modeling developed over the last 20 years is seemed as a stable ground for many professionals. 3D data models are basis for further concepts associated with BIM, helping to support Co-ordinated Project Information (CPI) and Integrated Project Delivery (IPD). This paper presents the role of managing knowledge, information and critical success factors (CSF) associated with BIM implementation within the construction industry in the Czech Republic. Determining the CSF in the context of BIM maturity levels should support BIM implementation processes within the construction industry and also within the associated bodies (education, government, technology).

1 Introduction

The concept of BIM was addressed as it is perceived today in Eastman's Building Description Systems (BDS) in the 1970s [1] and the term was first used as it is used today in van Nederveen's 1992 paper [2] However, it was not until 2003 that commercial BIM tools became abundant and the industry slowly started adopting BIM in its processes [3]. During the mid- to late 2000s, many firms across the world had to work through technical and organizational issues without clearly knowing the direction in which they were moving. The industry level and organization level of this period are referred to as the early stage of BIM adoption, or the first wave of BIM adoption. During this period, some firms failed to adopt BIM, whereas others succeeded. Nevertheless, a sufficient number of BIM cases succeeded to lead other firms to adopt BIM, and many recommendations were made based on the experience and lessons learned throughout this period [1]. However, a company with limited resources cannot adopt all the recommendations simultaneously.

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2 Understanding Information

Exploring Knowledge systems, we may conclude: objects are “documents” if they meet the following four criteria [4]:
- “materiality (they are physically – including the digital form – present),
- intentionality (they carry meaning),
- development (they are created),
- perception (they are described as a document).”

This definition is exceedingly broad, and the meaning is that anything can be a document, if someone decides consider it as such.

Documents are either available in digital or non-digital form; indeed, it is possible for both documents to coexist side by side. (e.g. real wall, and its digital representation). The complete versions of documents can only be entered into information (retrieval) systems if they are digitally available.

The fact that we can distinguish between structure and data on the syntactical level of digital documents means – at least in theory – that we are always capable of automatically extracting the data contained in a document and to save or interconnect them as individual factual documents. “In principle, any quantity of data carrying information can be understood as a document”, as Voss [5] writes. In order for all documents – text documents, data documents, graphical documents or whatever – to be purposefully accessible (to both men and machines), they must be clearly designated. “This is accomplished by the Uniform Resource Identifiers (URI) or the Digital Object Identifiers (DOI).” [6]. Under these conditions, it stands to reason that sets of factual knowledge which complement each other should be brought together even if they originate in different documents or in different systems. This is the basic idea of “Linked Data” [7].

In cases of automatic fact extraction in the context of Linked Data, the original document fades into background, in favor of the received data and their factual documents. It must be noted that the data must be defined in commonly agreed manner (with help of standards like RDF, the Resource Description Framework). Additionally, we absolutely require a Knowledge Organization System (KOS) that contains the needed terms and sets them in relation to one another.

In addition to extracted or received facts there are data files which cover certain topical areas, e.g. economic data, geographic data, production data, database of products, national libraries of objects, real-time data, etc.

3 Knowledge representation

Ingwersen and Järvelin [8] create model for information retrieval and knowledge representation that places the cognitive work of the actor at the foreground (see Figure 1).

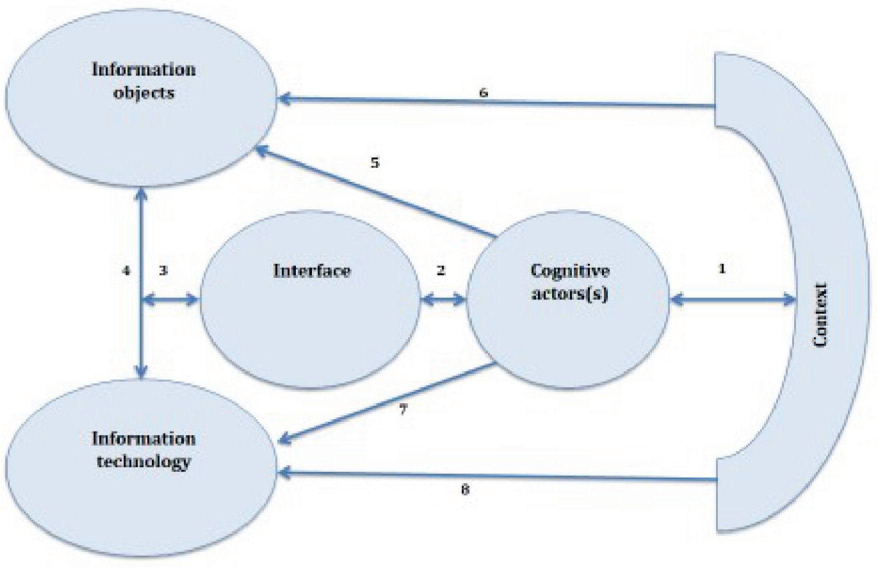

Fig. 1: The Cognitive Actor in Knowledge Representation and Information Retrival. Source: [8], p. 261. Arrows: Cognitive Transformation and Influence Double Arrows: Interactive Communication of Cognitive Structures.

The actor (or a team of actors) is anchored in cultural social and organizational horizons (context – Relation1). Actors are, for instance, authors, architects, designers, system engineers, interface designers, creators of KOSs, users of any origin. Through a man-machine interface (relation 2), the actor comes face to face with the information objects as well as with information technology (relation 3). "Information objects" are the documentary units (surrogates) as well as the documents (where directly digitally available) that are accessible through methods and tools of knowledge representation and that have been indexed by form and content. "Information technology" summarizes the programming-related building blocks of an indexing and retrieval system (database, BIM database, retrieval software, Industry Foundation Classes (IFC), etc.) as well as retrieval models. Since the information objects can only be processed through information technology, there is another close link between these two aspects (relation 4).

The actor always interacts with the system through the interface, but he requires additional knowledge about the characteristics of the information objects (relation 5) as well as the information technology being used (relation 7) additionally, information objects and information technology do not work independently of the social, cultural and organizational backgrounds (relations 6 and 8). As opposed to the interactive relations 1 through 4, relations 5 through 8 feature cognitive influences "in the background", which – as long as an information system (Building Information Model) is "running" – must always be taken into consideration, but cannot be interactively influenced.

Together with (Stock & Stock [8] try to look at "all objects in real world putting into information systems as surrogates of these objects. Then call all these surrogates as documents in information systems, what helps us to unify how to handle with all different objects in different level of granularity." So the indexer (the information system engineer) is an active and important part in the process of maintaining the institutional (BIM) memory. He decides whether a document should be stored or not, and which metadata are used to describe the document. Such decisions are of great importance for the preservation [9] and retrievability of documents. “Thus the information system engineer as indexer is embedded in social context” ([10], p. 13) of an institution that may be represented also as Knowledge Organization System (openBIM).

The object of knowledge representation is – without any restriction – explicit objective knowledge. In the case of subjective knowledge, this knowledge must be externalized in order to make it accessible for further processing. This externalization is clearly limited by implicit knowledge. Explicit objective knowledge is always contained in documents.

In knowledge representation, the documents from which the respective knowledge is to be determined are available. The object at hand is the documents` content. What is “in” a database, a website, a building model, an image, a patent, an architectonic exhibit.

4 Managing knowledge sharing

In information science, knowledge is regarded as something static, which is fixed in a document and stored on a memory. This storage is either digital (such as the World Wide Web), material (as on library shelf) or psychical (like the brain of a company employee). Information, on the other hand, always contains a dynamic element; one informs (active) or is informed (passive). “The production and the use of knowledge are deeply embedded in social and cultural processes; so information science has a strong cultural context” [4].

Burita et al [11] conclude: “When referencing to a knowledge system, we have to realize that knowledge cannot be separated from human beings. Therefore, we have to think in terms of “biological systems”, where functions define structures, and to avoid thinking of “physical systems”, where structures define functions.”

In economics and business administration, information has long time been discussed in the context of entrepreneurial decisions. “Information always proves imperfect, and so becomes a motor for innovative competition” [8]. “With conceptions for learning organizations, and, later knowledge management the subject area of industrial economics and of business administration on the topic of information has broadened significantly from around 1980 onward” [12]. “The objective is to share and safeguard in-company knowledge” [13] and “to integrate external knowledge into an organization” [14]. Knowledge is employed, information signals can be observed more closely from three points of view [8]:

- “in their relations to each other (syntax)
- in the relations between signs and the objects described (semantics)
- in the relations between signs and their user (pragmatics)”

Disciplines of pragmatics and semantics investigate the meaning and usage of signs. Stock & Stock [8] also propose knowledge to be:

- “partly a skill of conceiving of an object as it really is on the one hand, and that of successfully dealing with objects of knowledge on the other,
- partly the epistemic state that a person occupies as a consequence of successfully performing his or her cognitive tasks,
- partly the content that cognitive person refers to when doing so.”
- Looking at this description of knowledge, we can see that knowledge falls into two aspects of skill and state:

1. Knowledge as the skill

a. of correctly comprehending an object (TO KNOW THAT)

b. of correctly dealing with an object (TO KNOW HOW)

2. Knowledge as the state

a. of a person that KNOWS (something)
b. that which is known itself, the CONTENT
c. its linguistic expression

Knowledge has two fixed points: the knowing subject and what is known, in which aspects (1a,b and 2a) belong to subjective knowledge and (2b,c) are objective knowledge [17]. Of course, (2c) is of our special interest, because it can only be objective if the linguistic expression is permanently fixed on a physical carrier, a document. Document may be any "surrogate" of real object. In civil engineering industry, what is of our major focus here, it can be, as an example:
-drawing or any unique part of drawing
-description of an building element with static calculations,
-graphs,
-contracts
-etc…

In further text, word "document" has the meaning of a "digital surrogate" in information system of any kind of real object in the real world, including "paper" documents.

According to Brookes [15], p.131), "the connection between knowledge and transmitted information can be expressed through a (pseudo-mathematical) equation. Knowledge (K) is understood as a structure (S) of concepts and statements; the transmitted information (Δ I) carries a small excerpt from the world of knowledge." The equation goes:

$$K[S] + \Delta I = K[S + \Delta S] \quad (1)$$

The knowledge structure of the receiver is modified through Δ I. This effects a change to the structure itself, as signified by the Δ S. The same Δ I, received by different receivers with different K[S] than each other, can effect different structural changes Δ S. The process of information differs "from person to person and from situation to situation" [15]. So the "understanding of a person`s knowledge structure" [16] is essential for information science.

Information activities process knowledge, present it in user-friendly manner, represent it through condensation and the allocation of "information filters", and prepare it for easy and comprehensive search and retrieval. All aspects that go beyond the original knowledge are informational added values, which can be found in private as well as public information sources. In addition to "knowing how" and "knowing that" the informational value added is "knowing about". Information activities lead to knowledge "about" documents and "about" the knowledge fixed in the documents. For Buckland [4] "knowing about" is more concerned with information science than "knowing how" and "knowing that".

5 Conclusion

Managing knowledge and information seems to be the most crucial point in implementation of BIM within any country specific industry. It is obvious that we are challenged by how to transfer basic thinking about processes within building industry. It is not only about BIM in meaning of Model or Modeling, and we need to look even further that to BIM in meaning of Management. There is big potential, supported by technology development, to employ LIM (Land Information Modeling) – geographical data together with BIM-Model and to step towards "Better Information Management". Managing knowledge sharing and to change and/or improve processes within whole industry becomes challenge we are facing just now. It seems to be a way, how to deal all barriers, BIM adoption must overcome.

Of course, the lack of trained personnel remains a significant barrier to BIM adoption, forcing many companies to retrain experienced CAD operators in the new tools. Because BIM requires different ways of thinking about how designs are developed and building construction is managed, retraining requires not only learning but the unlearning of old habits, which is difficult. New graduates, whose entire undergraduate experience was influenced by their familiarity with BIM and its use for the full range of student projects, are likely to have a profound influence on the way companies of all kinds deploy BIM. Inevitably, a good deal of innovation in work practices is to be expected.

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