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Building Information Management as a Tool for Managing Knowledge throughout whole Building Life Cycle

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Abstract. The essence of successful implementation of BIM in practice is knowledge about objects, their behaviour and other properties with higher overlap and throughout the life cycle of the building. In addition, other structurally and unstructured knowledge (historical experience, needs and requirements of users, investors, the need to perform revisions to some objects, etc.) is added to this. Taking all of these attributes into a building lifecycle management system requires the creation of both a knowledge management and knowledge management system and a time management system. Learning creates knowledge and "knowledge organization" is an organization that uses knowledge to develop and achieve (long-term) goals. In general, there is no guaranteed procedure, no universal set of tools to help build a knowledge-based organization. If knowledge creation is to be used to better achieve results, it should not be separated from other activities of the organization. Knowledge Management represents the establishment and subsequent managing special network structure that includes all existing knowledge units. Knowledge management is often perceived as a survivor of the company today, but managers often do not realize that it is a much more complex process than generating large tables in Excel for comprehensive reporting to senior management and owners. Well-organized Knowledge Management can create concepts of knowledge, review and consolidate them, prepare action plans to create, secure, combine and coordinate knowledge, as well as set up clear ways to extract them from knowledge bases at the time of need and hunger for quality.

1. Introduction

In order to understand the benefits of the "Knowledge Base" in BIM and for modern management in general, let's first look at what "Knowledge Management" can contribute to managing processes. Knowledge Management supports and employs processes that create value for company of their intangible assets. We observe combining the technological possibilities of artificial intelligence and knowledge bases with the traditional concepts of managing people in the organization, whether it is personal management, organizational behaviour, corporate culture, or Business Process Reengineering concepts. It turns out that decisive for the successful use of knowledge in management processes is not only (but still very important) the creation of knowledge bases and storing information, but rather the ensuring of connectivity between individual "knowledge islands" that are stored and made available in the files, including knowledge bases enterprise intranets, and in the heads of individuals, teams and managers. The highest added value appears to be to support the sharing of knowledge and the creation of bridges that these isolated knowledge islands will effectively combine. Many authors now support the concept of a "knowledge organization", sometimes also called "Learning Organization", as a higher form of knowledge management for managing processes. This concept will then be able to help us



understand the real needs for the knowledge base architecture and their connection to the management processes within organizations working in the BIM environment.

2. Knowledge management in the BIM according to the concept of the knowledge organization

To begin with, it is necessary to define the terms, as it is often referred to as a "knowledge organization", but also to a "learning organization". Some authors distinguish both terms others use them as a synonym. It is recommended to understand a learning organization as an organization where the principles of permanent learning are applied to all its members. Learning creates knowledge and "knowledge organization" is an organization that uses knowledge to develop and achieve (long-term) goals. But mere learning would have no purpose without goals. What is important, therefore, is not the precise distinction between concepts, but rather their nature (or usefulness) - what they have to bring us to the organization.

The definitions of the knowledge organization itself can be found in recent literature as:

- "Organizations where people gradually improve their ability to achieve the desired results ... where people continually learn how to learn with others ... where people are gradually discovering how to participate in creating reality and how to change it." [1]
- "An organization that supports the learning of all its members and which is gradually transformed by learning". [2]
- "An organization that deliberately uses the learning process at the individual, group, and system level as a whole to gradually transform the organization into a more satisfying way for interest groups." [3]

If we want to apply the principles of a knowledge-based organization, we need to achieve three basic elements. Concentration should be balanced, none of these elements can work on its own. Major importance seems to be consistency among all of them.

- Link people who have knowledge and are willing to share them - ask and listen
- Introduce processes to enable and facilitate information sharing and knowledge creation
- Implementation of (technological) infrastructure to enable and facilitate the sharing of information

Other authors talk about the same when they say that the organization is the socio-technical environment that needs to be recognized and respected in change.

The most extensive research on how to implement a knowledge-based organization was carried out by Senge [1]. He described several in the "Fifth Discipline" book, but there is no methodology to use. Therefore, it is recommended to describe the objective (what impact on the reality should be achieved by introducing the knowledge organization), to set it up for a particular organization the right way and if necessary also taking into account the characteristics that the knowledge organization should meet.

In general, there is no guaranteed procedure, no universal set of tools to help build a knowledge-based organization. The application itself is more than just the analytical deployment of individual tools, rather organic looking for what could be a particular organization to function with respect to the unique conditions in which it is located.

If knowledge creation is to be used to better achieve results, it should not be separated from other activities of the organization. Learning and work are therefore one and the same - learning is a standard part of every individual's work. This is ultimately the so-called Action Learning principle - learning only happens if you are able to apply the knowledge in practice. Therefore, the tools of a knowledge-based organization can be seen as a set ensuring:

- Learning before the action - learning from others, someone did it before you
- Learning during an action - time to reflect
- Learning after action - Learn from what you've done

Knowledge generation is not separable from people - because knowledge is created in their heads, not in files or on computers. Other tools are therefore mainly focused on people. Collison [4] summarizes the meaning of tools into a simple sentence:

- "It's about how to bring together people who know with those they need to know":
 - How to find the right people (only if I knew who)?
 - Creating work networks and communities

Each of the above categories contains a number of tools. An example may be the post-action After Action Review (incidentally developed by the US Army) or the so-called "rotating assistance" method for pre-action learning.

3. The role of Knowledge Management in an organization

Knowledge Management represents the establishment and subsequent managing special network structure that includes all existing knowledge units. These knowledge units identify knowledge, information and data carriers and are generally of two basic types.

- First category of knowledge holders includes all employees of the company. Knowledge stored in the staffs' heads is one of the most valuable. This knowledge has the highest degree of readiness that is possible at all. In addition to being immediately available for a given knowledge unit, it is also true that transfer of knowledge to other employees takes place in the easiest way, namely interpersonal communication.
- Second category includes all elements of the company's integrated information system, which are the data carriers. This information system should be as close as possible to the functioning of the company it should be virtually ubiquitous and prosperous with the corporate organizational structure. Here in the area of the information system, the main advantage is the total capacity of collapsible information, which is considerably higher than that of individual employees. In addition, data exchange between information system components (computers) is already a technical problem [5].

Knowledge definition:

Knowledge is (in computer terminology) considered the highest form of organization of structured data - it is defined by:

- data elements (or their representatives)
- properties of data elements
- sessions between data elements
- operations (actions) over data elements

Knowledge representation methods:

- logical systems
- production systems (rule-based)
- frameworks
- semantic networks
- procedural systems and special programming languages

4. Knowledge management as part of BIM management within projects and programs in the company

Even companies in the construction sector are finding that their competitiveness is increasingly dependent on the intellectual and knowledge capacities of their employees and management. This is increasingly the case for companies participating, for example, in tenders for the supply of a project, the delivery of a construction project in the field of capital construction. Much of them literally drown in surplus information, but they feel the lack of knowledge. In order to maintain a competitive environment, it has to acquire a balanced ratio of knowledge both from internal and external sources. Nowadays, the available technologies, such as Internet connectivity to external resources, and data mining capabilities in the internal information system associated with Business Intelligence provide sufficient information

infrastructure to build knowledge in the company. Knowledge management is often perceived as a survivor of the company today, but managers often do not realize that it is a much more complex process than generating large tables in Excel for comprehensive reporting to senior management and owners. Well-organized Knowledge Management can create concepts of knowledge, review and consolidate them, prepare action plans to create, secure, combine and coordinate knowledge, as well as set up clear ways to extract them from knowledge bases at the time of need and hunger for quality.

What makes Knowledge Management a discipline that is so difficult for many companies to grasp?

It is possible to identify 5 obstacles to the development of knowledge management:

- a) The Company must create the conditions for the emergence and development of a corporate culture supporting the sharing of knowledge and to maintain and develop these conditions. Some companies provide employees with bonuses (financial or material) to support the development of a knowledge sharing culture of a company until the "knowledge culture" becomes a norm or a natural component. Others have chosen to require employees to actively contribute to and use their knowledge base, with the regular monitoring of these activities and the inclusion of annual bonuses. However, as it turns out, most employees still do not take heart, preferring to keep their knowledge for themselves to maintain their competitive advantage within the company or beyond. And there are those who refuse to use the knowledge created by others and of course refuse to share with others.
- b) Another problem is how should organization, its top management, evaluate the knowledge it has created, which is naturally inalienable in order to present its tangible and graspable benefits. A number of authors have developed techniques and methodologies to "evaluate" them at a global level as well as at a company level. Some of these techniques will be mentioned further and will be used as one of the bases for determining the knowledge base requirements. Of course, it is not unambiguous and simple to evaluate intellectual and especially "human" capital in organization. Until this organization would fail, management cannot push too hard to use and share knowledge and cannot emphasize the importance of intellectual capital for society.
- c) The third obstacle is the idea that Knowledge Management is the same as information management. In many companies, knowledge management is given to the same managers as information management. Thus, the important aspect of managing corporate culture changes, which, for understandable reasons, overlooks ICT managers, is completely neglected, and they lack the skills and motivation to make such changes.
- d) The fourth, also a frequent obstacle, is that Knowledge Management works best when it is actively utilized from the very top of the organization, that is, the Chief Executive Officer. Without active engagement and full support of top-level management, any knowledge management technology, including self-contained knowledge bases, is pushed away from the mainstream of company management.
- e) The last fifth obstacle to the development of Knowledge Management is often the incorrect naming and labelling of almost every tool as a tool for knowledge management. This exaggeration works the opposite way and eventually kills all what is good on the principles of knowledge management in the same way as it used to be when developing other modern disciplines (e.g. reengineering). There are a number of consultants who boast of being able to deliver expertise in knowledge management, but the simple fact is that this whole area of management is too young to have any real experts who already grew up.

Companies that fail to understand and overlook the above factors are likely to be in a state where everything that Knowledge Management can bring with their best technologies remains foggy and

untraceable for them. Let's look at how to reconcile the development of Knowledge Management technologies with the changes that companies have to undertake.

5. Impact on BIM: Knowledge Worker - an important human element in the BIM Knowledge management process

Knowledge Management introduces the concept of "Knowledge Worker" (KW) - a knowledge worker who is a typical employee (a company employee or an outsourcer) who has certain competencies, knowledge and skills. In a BIM environment, such a KW is typically a member of a work team that uses BIM technology very intensively to communicate with each other, and which is typically based on joint work on time-limited construction projects that follow up or overlap on time and information. It may be involved in the life cycle of a building at any stage, whether as a designer, an investor, a building manager, a subcontractor of a construction company, a facility manager, etc. The teams in which they are often involved need support for different types of cooperative activities, ranging from routine activities to very complex and creative work on projects. Such teams build the right mix of professionals with the knowledge and experience of their professions, they have the information, the competencies and the authority needed to perform specific activities and solve complex problems quickly and easily. It is these workers who can be characterized as highly qualified professionals who need to accept or support a large number of decisions that are outdated by routines and are often unstructured. Their close mutual cooperation is much more important than the cooperation of workers in other areas. However, since many top professionals understand themselves and their colleagues as professionals and expect a certain range of autonomy for their work, based on past experience and outcomes, it may be difficult to bring specialists from different fields of expertise to match their common goals. Therefore, it is the biggest challenge for companies to get this fragmented knowledge of their KWs who collaborate on projects or across the program into a well-structured knowledge base. See Figure. 1.

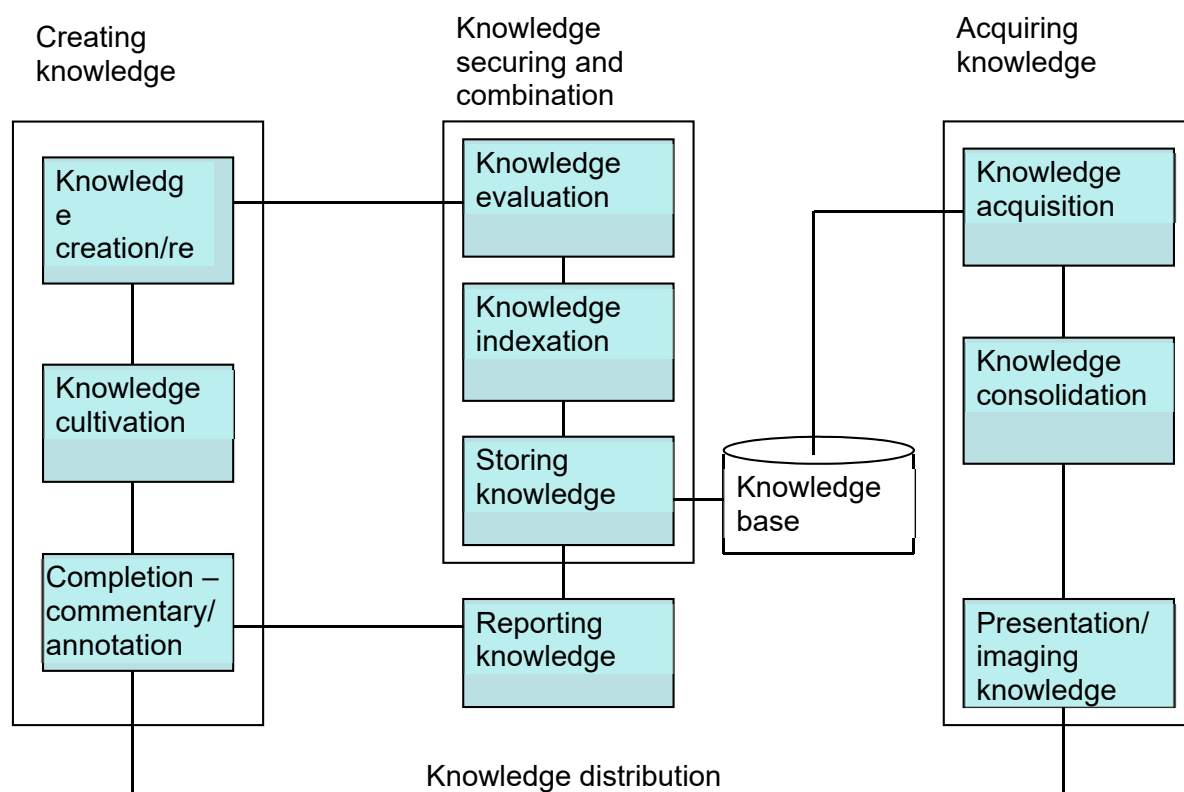


Figure 1. Overview of Knowledge Management Processes. Source: [6]

6. Structure of the knowledge system within BIM environment

Mellor [6] describes the basic structure of the knowledge system as follows:

There is a fundamental difference in the structure and way of work of classical and expert systems.

- The classical system works with a certain set of data, transforming the input data into an output based on the specified algorithm of the embedded program.
- On the other hand, the knowledge system consists of three components
 - The fact basis corresponds to a set of classic data needed for program purpose, it is usually stored on hard drives or other external storage devices.
 - The Knowledge Base is a data structure that represents expert knowledge. It is stored in the computer's internal memory and changes the factual basis while searching for solutions.
 - The Inference Mechanism is a derivation algorithm, a custom program that modifies the fact basis using the knowledge base until it finds the required task solution.

From this perspective, we see one important feature of the knowledge system, it is easy to modify the system when conditions are changing.

If dealing with a classic program, each change requires reprogramming, which is laborious and time-consuming, and can lead to mistakes and undesirable side effects in an already debugged program.

If working with program KS, we only modify one or more rules in the knowledge system, the program - the inference mechanism - remains the same.

Knowledge

Knowledge is crucial for the knowledge system. These are interrelated knowledge structures. We can express one's knowledge:

- means of predicate logic
- production rules
- using associative networks
- procedural methods
- using frames

Predicate logic

Predicate logic makes it possible to derive true formulas from axioms or derived true formulas.

Production rules

They are the basis of most knowledge systems. They are defined in the form $p^1 \wedge p^2 \dots p^n \rightarrow d$, where p^i is the assumptions and d is the consequence, which means: if the assumptions are true, the consequence is also true.

The knowledge systems may include hundreds of such rules. It is necessary to distinguish between logical implications and production rules. In logic, the implication can be true, even if the assumption is false, the production rule is the consequence valid only when the assumption is fulfilled. By using the production rule, there is a change in the fact bases. In addition, assumptions and assertions can be entered with a certain probability, and the rule itself may also apply with a certain probability. The likelihood of a consequence can then be increased or decreased by verification by other rules.

As with evolutionary and learning systems, it is necessary to set the initial parameters and only after longer operation allow the experienced user to modify some of them as needed, also in the expert systems it is necessary to prepare a functioning system with all rules and after a certain period of time allow editing rules. The fact that the user can change the rules by which the expert system is looking for solutions, of course, demands the quality of control functions in the system. A well-written knowledge system would reveal any inconsistency between the rules and reveal an error.

Associative knowledge

Associative knowledge is expressed through associative networks. It is a set of vertices and orientated edges that connect vertices.

Procedural knowledge

A typical example of procedural knowledge is the function in the program. However, it is not possible to confuse a knowledge system with procedural knowledge with a common program. Procedures in the procedural system are invoked to meet a particular goal and change the content of the fact bases.

Procedural knowledge has some advantages over production rules and disadvantages:

- Since procedural rules are actually program functions, any changes need to be reprogrammed, which means higher time requirements and the possibility of errors.
- On the other hand, procedural rules are faster when calculating.

Framework representation of knowledge

Frames are data structures in which the knowledge of previous types can be stored.

Space of states

Both production rules and procedures operate on a set of states using a set of operators. By applying knowledge, we change the states from the initial state to the end state. The initial state is explicitly defined, ending either explicitly or by specifying properties. The role of the inference mechanism is to determine steps that lead from the initial state to the final one, [6].

7. Conclusion

The Knowledge Worker, introduced here in terms of BIM participant, as defined by the Knowledge Management disciplines, was considered to be the decisive factor in building a comprehensive BIM system. Knowledge Worker is in the BIM nomenclature in roles from the 3D CAD user through designer, statics, budget manager, building manager, facility manager to eventually to investor. It is everyone who will, to some extent, participate in the processes of creating, sharing, storing, developing and communicating knowledge created over information and data by its own or other BIM participants that equals in this article to concept involving any of the above mentioned roles and is basically the term Knowledge Worker as we know it from the classic "Knowledge Management. This concludes that knowledge management in the BIM is basically very similar to the concept of a knowledge organization.

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