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POSSIBILITIES OF USING KNOWLEDGE ENGINEERING IN KNOWLEDGE MANAGEMENT

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Purpose: The main goal is to discuss using some methods of knowledge engineering in knowledge management (to improve knowledge management).
Design/methodology/approach: The article presents the possibilities of using knowledge engineering in knowledge management in three areas. The first is the codification of knowledge in order to create an ontological knowledge base. The second concerns the use of methods applied by knowledge engineering in the field of knowledge acquisition. The third area presents a more forward-looking approach – the proposal to apply a formal verification of knowledge before its final recording in the form of text regulations or guidelines.
Findings: Based on the presented literature research it is possible to indicate knowledge engineering approaches that can be used in knowledge management, in particular in the field of codification of knowledge, acquisition of knowledge and formulation of knowledge having the nature of legal regulations or guidelines.
Originality/value: The author's main goal is not to discuss the well-known role of information systems in supporting knowledge management. The author proposes to look at both fields from the point of view of the specificity of the applied methods. The article can be useful for people responsible for knowledge management in the organization.

Keywords: knowledge engineering (KE), knowledge management (KM).

Category of the paper: Conceptual paper.

1. Introduction

The relationship between knowledge engineering (KE) and knowledge management (KM) is clear and often underlined in the literature in various contexts. These areas include, inter alia, areas combining both fields, such as acquiring knowledge in KM and knowledge acquisition in expert systems, or knowledge repositories in KM and knowledge representation in KE. Knowledge engineering methods and tools can support the processes of knowledge acquisition, codification, as well as verification and validation. On the other hand, the developed knowledge

bases can support such KM processes as knowledge gathering, its distribution and use by supporting decision making (Michalik, 2014).

Two KM approaches are mentioned - codification strategy and personalization strategy, that is, caring for proper communication and cooperation with experts, and transfer of tacit knowledge (Jemielniak, Koźmiński, 2012). The relationships between KM and KE are clear not only in relation to the codification strategy. As Michalik points out, the problem of the existence of tacit knowledge in an organization occurred in knowledge engineering in the process of developing the first expert systems, and thus before creating the field of management called KM. This problem was defined as a "bottleneck" in the construction of expert systems (Michalik, 2014). Therefore, it seems reasonable to refer to the experience and methods of knowledge engineering in this field.

In the third chapter, the article will present the roles of KE in KM regarding both the strategy of codification and personalization. Perspectives for the use of KE during formulation of knowledge having the character of legal regulations or guidelines are also indicated. Earlier, however, the definitions of KM and KE will be presented.

2. Knowledge management and knowledge engineering – concepts

Knowledge management is one of those concepts that have many definitions. Their fuller review can be found, among others, in the works by K. Michalik (Michalik, 2014) and M. Kłak (Kłak, 2010). For the purposes of this article, three definitions will be provided. Jashapara defines KM as “the effective learning process associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that uses appropriate technology and cultural environments to enhance an organization’s intellectual capital and performance” (Jashapara, 2006). The second definition also puts emphasis on the effectiveness of the flow of knowledge. Namely, NASA defines KM as "providing the right knowledge, to the right people, at the right time and helping to create it, share and make decisions based on it, in such a way as to achieve measurable results" (Kłak, 2010). Gołuchowski defines KM as "a process of the effective impact on knowledge resources and processes of its creation and processing" and lists four main processes of creating and processing knowledge in an organization: knowledge acquisition, knowledge storage, transfer of knowledge and the use of knowledge (Gołuchowski, 2005). The last of the quoted authors devotes quite a lot of space in his work to the technological concept of KM. The main tasks of the technological layer of the knowledge management system include: knowledge discovery in databases, representation of human and computer-readable knowledge (ontology), natural language text processing, support of electronic cooperation, localization of knowledge and learning, personalization of knowledge presentation (Gołuchowski, 2005).

The term knowledge engineering initially concerned mainly expert systems. Expert systems are programs that use human knowledge to solve complex problems, usually in a specific, narrow field (Michalik, 2014). An important distinctive feature of expert systems compared to other IT systems was the explicit separation of knowledge from control procedures. Knowledge has become a resource, as has previously been the data in databases. In that perspective, knowledge engineering concerned mainly knowledge acquisition from experts for the needs of creating expert systems. Along with the development of IT technologies, the possibilities of acquiring knowledge for expert systems and other knowledge-based systems have expanded. They also include resources of the Internet, corporate databases, data warehouses, electronic documentation (e.g. e-mail). Currently, apart from expert systems, there are more and more concepts of knowledge-based systems, which can include semantic search engines based on ontologies and increasingly popular conversational systems (Gołuchowski, 2011).

The development and broadening of KE competences is reflected in the evolution of the definition of this concept. Originally the definitions of knowledge engineering were closely related to expert systems and their construction, and an expert creating the knowledge base for an expert system was referred to as a knowledge engineer. Newer concepts of KE definitions are not limited to expert systems, they involve the designing and maintenance of various knowledge-based systems (Michalik, 2014).

The presented definitions of KM and KE express similarity between the two discussed concepts related to the resource which is knowledge. However, this relationship needs further clarification. The next part of the article will present selected possibilities of using knowledge engineering in knowledge management.

3. Knowledge engineering in knowledge management

The author's main goal is not to discuss the well-known role of information systems in supporting knowledge management. Let us try to look at both fields from the point of view of the specificity of the applied methods. The main tasks of knowledge engineering include: knowledge acquisition, knowledge representation, as well as validation and verification. These technical stages have their counterparts in specific areas of KM, within which knowledge is obtained, saved, verified and evaluated, and used appropriately. This similarity gives rise to the temptation of basing KM largely on KE, i.e. creating an ontological knowledge base and an intelligent system allowing this database to be maintained and used. The first subchapter describes an example of such an approach. The next subchapter describes the possibilities of using the experience of KE in knowledge acquisition. The last one discusses the possibility of using KE in the area of knowledge formalization, which is supposed to be recorded in the form of text regulations or guidelines in an organization.

3.1. Knowledge management through knowledge engineering

Lien Fu Lai in the study (Lai, 2007) proposes an approach called "Knowledge Management through Knowledge Engineering (KMKE)". In KMKE, KM activities are integrated within the framework including knowledge modelling, verification, storage and knowledge querying. Figure 1 shows the diagram of the presented approach.

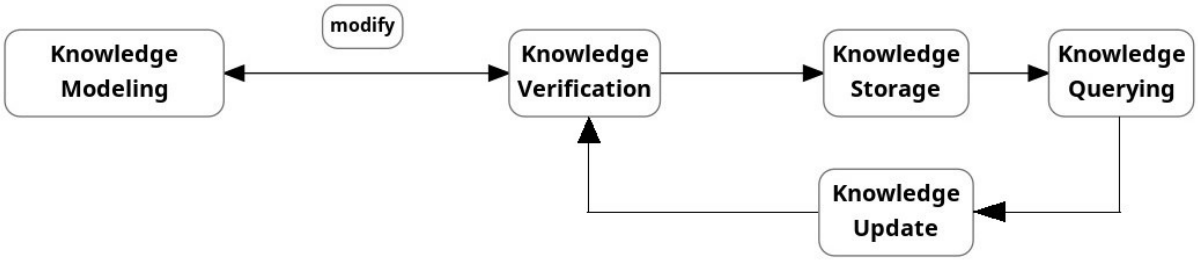

Figure 1. Knowledge Management through Knowledge Engineering. Adapted from: "A knowledge engineering approach to knowledge management" by L.F. Lai. Copyright 2007 by Information Sciences.

The author presents his concept on the example of a knowledge management system that supports the diagnosis of computer failures. At the modelling stage, knowledge is analysed and acquired to the form of a set of ontological knowledge models. Formal knowledge representation allows for determination of semantics and thus gives the possibility of inference. Conceptual graphs were used to build ontologies. This formalism allows for natural language processing and a human-readable presentation of logic (Sobczak, 2006).

In the following part, the knowledge is verified. In KMKE, knowledge models are verified not only on the syntactic level but also on the semantic level. This allows for detecting contradictions and other anomalies. Knowledge models can be classified and stored in a hierarchical ontological system. This approach also provides a query language that aims to increase the dissemination of knowledge. The Knowledge Query Language (KQL) was used to create queries. The discussed concept also provides for a process of updating knowledge, which allows for modifying the knowledge base and adapting it to the current requirements of users.

The discussed article (Lai, 2007) presents the possibility of integrating KM and KE in the context of the codification strategy. Among many other examples of similar attempts to codify knowledge in an organization, this one could be distinguished because of the presentations of the concept of KM called by the author knowledge management through knowledge engineering. In this concept, the workshop of KM is largely based on the technological aspects of KE. This approach has its limitations and is not possible everywhere. The experiences of KE can also be used in knowledge acquisition, as described in the next sub-chapter.

3.2. Knowledge acquisition

One of the most important roles of knowledge engineer is to acquire knowledge from experts and sources indicated by them. The study (Gavrilova, Andreeva, 2012) presents the possibilities of using in KM the experiences of KE in knowledge acquisition. A wide range of

opportunities for cooperation between a knowledge engineer[1] and an expert – two essential roles in KE – was presented here. The authors note that in KM a great emphasis is placed on the selection of experts, i.e. finding people who have the necessary knowledge. But it is often expected that the competent employees found will show readiness for knowledge acquisition efforts and will be motivated accordingly. However, these assumptions have some limitations and are not realistic. The authors suggest that the introduction of the role of a knowledge engineer at this stage may help overcome some of these limitations, and thus enrich the practice of KM in an organization, facilitating knowledge acquisition. Such an approach can be valuable for managerial practice by presenting the diversity of knowledge acquisition techniques with direct recommendations for their feasibility in KM context.

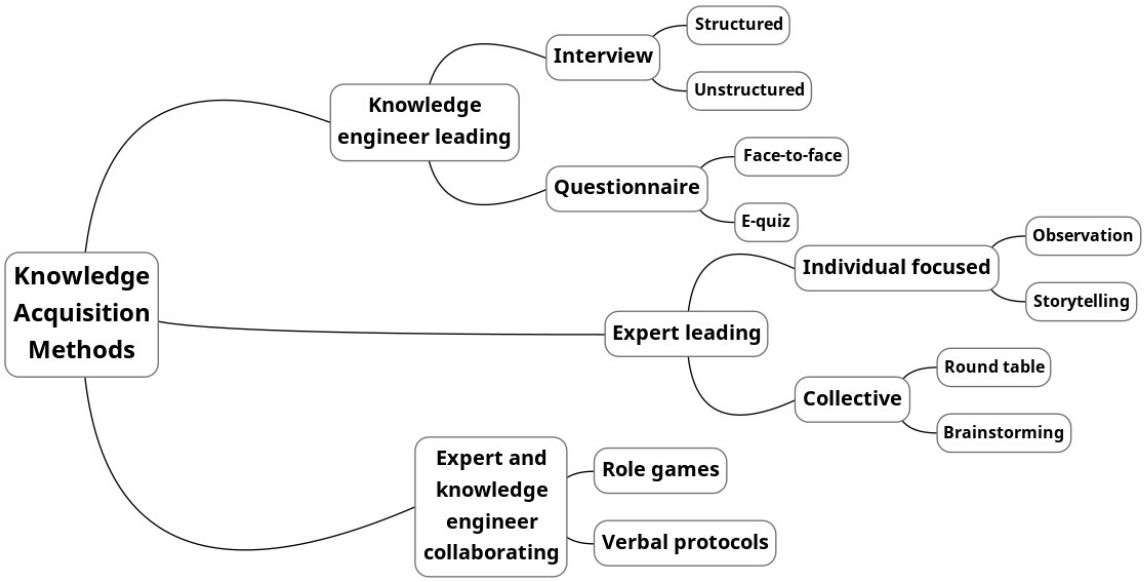

Figure 2. Taxonomy of knowledge elicitation techniques. Adapted from: "Knowledge elicitation techniques in a knowledge management context" by T. Gavrilova and T. Andreeva. Copyright 2012 by Journal of Knowledge Management.

Gavrilova and Andreeva propose a taxonomy of knowledge acquisition methods, taking into account different ways of cooperation between a knowledge engineer and an expert. The classification presented in Figure 2 distinguishes the division of methods into three categories, using criteria such as the level of involvement of an expert and knowledge engineer and the type of cooperation between them:

- methods with the leading role of a knowledge engineer,
- methods with the leading role of an expert, and
- methods of cooperation between an expert and a knowledge engineer.

In **methods with the leading role of a knowledge engineer**, one of the main forms of communication is an interview, during which the analyst asks questions prepared in order to better understand a specific area of knowledge. Interview is a popular method because of its

[1] In the study under discussion (Gavrilova, Andreeva, 2012), the term "analyst" is used instead of the term "knowledge engineer" which is more popular in the context of KE.

apparent simplicity. However, a fruitful interview requires a lot of experience from the knowledge engineer, and readiness to learn more about the studied field.

The present author's own experience of acquiring knowledge in the field of cardiac surgery (Kempa, 2015) allows to formulate a statement that a knowledge engineer should get to know the expert knowledge in the deepened scope, especially if acquired knowledge is to be formalized. In many other forms of business cooperation there is a need to get to know someone else's discipline. For example, a graphic artist preparing a cover for a specialist book also conducts an interview with its author and wants to learn something about this publication. However, they do not need to read the whole book with full understanding to make a good cover. Nevertheless, a knowledge engineer should get to know the given discipline quite deeply. During the interviews, knowledge engineers can support themselves with auxiliary tools, such as questionnaires or electronic surveys.

Methods with the leading role of experts can be divided into individual and collective. Individual methods include observation and storytelling (lecture), and collective methods include round table discussions and brainstorming.

The observation method consists in observing the expert's professional work by the knowledge engineer. An important condition for using this method is to avoid the interference of a knowledge engineer in the work of an expert. Observations can lead to knowing some elements of tacit knowledge.

The lecture is probably one of the oldest forms of knowledge transfer. However, the effectiveness of this form depends not only on specialist knowledge of experts and their level of professionalism, but also on their teaching skills. And with the latter, it can be different. A lecture in the form of a verbal message can be replaced or extended with a description of the problem (Mulawka, 1996) and the appropriate selection and preparation of materials already developed (e.g. books, links) for the knowledge engineer.

The round table method means the discussion of several experts with equal rights. A knowledge engineer is required here to undertake organizational efforts and demonstrate certain psychological competences. This method is rather expensive, thus in practice it is used as an additional one, to resolve disputes.

The brainstorming method aims to facilitate creative thinking by separating the process of generating ideas from critical analysis and evaluation of ideas. This method is particularly useful when working on new solutions. In the process of knowledge acquisition, in turn, it can be a way to stimulate a group of experts to exchange views.

Methods of cooperation between an expert and knowledge engineer include business games and oral protocols (recordings of expert statements). These methods require the activity of both roles: the expert and the knowledge engineer. A business game is a simulation of professional activity and involves the participation of several experts. Preparation of the project, scenario and the game itself is a time-consuming stage. The result, however, can be satisfying. A well-designed game activates the minds of experts and allows them to gain tacit knowledge

about decision-making processes. Expert games can be considered as a special case of learning through interaction – one of the three approaches to acquiring tacit knowledge (along with intelligence and inductive learning) described in the taxonomy of methods for acquiring knowledge proposed in the study (Parsaye, Chignell, 1988). In this approach, experts cooperate interactively with a computer program that helps to extract tacit knowledge (Michalik, 2014).

An oral protocol record means that the expert is asked to comment on their actions and decisions. An expert's statement can be recorded. The main disadvantage of this method is the difficulty in articulating the thinking process. Another problem is the reluctance of some experts to such a perfect disclosure ("from the backstage") of their workshop. Nevertheless, it is believed that this method, if it only manages to overcome these barriers, can bring satisfactory results in knowledge acquisition.

The choice of an appropriate method of knowledge acquisition should depend on the specific problem and situation. From the point of view of knowledge management, the choice of the method should depend on the type of acquired knowledge (tacit or explicit) and whether the given expert area concerns an individual person or a group. In addition, mixed forms should also be considered, i.e. the use of several different methods depending on the stage of knowledge acquisition. In the study (Kempa, 2015; Hrapkowicz et al., 2013), three approaches were used to acquire knowledge from the experts - cardiac surgeons. Initially, it was a lecture that allowed for the preliminary presentation of both the field and helpful materials for further work (written sources of knowledge, which in this case were medical guidelines). The interview dominated in further cooperation, and at the end, there was testing of the developed prototype of a knowledge base in the expert system. The last element of cooperation between a knowledge engineer and an expert (testing) may be of importance in the context of KM even when the development of a knowledge base for an expert system is not the main goal of knowledge acquisition, but only serves as an auxiliary. This aspect will be presented in the next chapter.

3.3. Verification and validation of knowledge

Acquired knowledge can be used for various business purposes. In this part of the article, the attention will be focused on a quite specific goal, which is the development of regulations, i.e. applicable (or recommended) rules, concerning both an organization and its environment. Examples of such documents are: university regulations, rules for accepting returns and complaints, rules for the processing of loan applications or medical guidelines. Knowledge based on which such regulations are created usually comes from experts using both their own experience and many other sources. For example, guidelines in medicine are established based on meta-analyses verified by groups of expert. Supporting this stage of work (creating formal records of knowledge in the enterprise) through techniques used during verification and validation of knowledge in knowledge engineering seems to be promising.

Research on the possibility of using knowledge engineering techniques to create legal regulations is not new. In the study (Niederliński, 2005), the subject of automation of legal reasoning was taken up. The author of the aforementioned work, the creator of the skeletal expert system, encourages his readers to imagine a world in which new laws will be issued in the form of knowledge bases. He also points out that "the essence [of law] is that the law is a text; while its practice consists in drawing conclusions from these texts by highly qualified experts with the appropriate specialist preparation." Two groups of advantages of this approach can be indicated. One group concerns access to knowledge and its use, e.g. in the form of legal advice. The other group of benefits is connected with the process of verification and validation of knowledge, which would allow to avoid contradictions, ambiguities and other anomalies at the stage of creating regulations.

The main difficulties in implementing such a bold concept include the lack of appropriate tools and the lack of adequate knowledge about the capabilities of knowledge engineering (Niederliński, 2005). However, these are not the only barriers. The others that can be mentioned were revealed during the creation of expert systems in this field. Leith in a paper on the rise and fall in popularity of the concept of legal expert systems indicates a number of difficulties (Leith, 2010). And as one of the most important, the lack of a proper bridge between knowledge engineers and lawyers. Knowledge engineers show lack of proper understanding of the nature of law, while lawyers have problems with proper understanding of the principles of formal logic. These are super-disciplinary problems related to the previous chapter of this article, i.e. knowledge acquisition. The second important problem of the formalization of legal knowledge raised by Leith is that the process is too static in relation to the dynamic nature of real law.

The author of this article analysed the possibility of using knowledge verification techniques in the area of creating medical guidelines. Creating guidelines for medical practice differs significantly from the legislative process in terms of the degree of formalization and centralization. Development of guidelines is decentralized and is based mainly on the initiatives of scientific societies and private publishing houses. The guidelines provide physicians with access to current medical knowledge and thus can contribute to improving the quality of healthcare.

When applying verification of a knowledge base, a formal apparatus can be used to detect any possible contradictions or deficiencies in the formulated recommendations. As an example of the usefulness of such an approach, one can provide results from work on verification of the knowledge base created on the basis of guidelines in the field of cardiac surgery (Kempa, 2015). During this work, only the rules that result directly from the guidelines were coded in the first place, and then the completeness was examined. This allowed for identifying the missing rules and, after an analysis made together with physicians, for establishing conclusions for the missing rules. The results obtained showed that incompleteness also occurs for the guidelines, i.e. cases were identified that have a real chance of occurrence, which were not included in the

guidelines, and according to physicians, they should. The analyses carried out during this work revealed some doubts and inaccuracies in the content of the guidelines. Working on a knowledge base enforces the analysis of many possible cases. Performing such tasks during the development of guidelines would undoubtedly be beneficial for this process and would improve the quality of the provisions in the guidelines (Kempa, 2017).

4. Conclusion

KM and KE use two separate workshops. For example, within the framework of KM, the roles, such as a knowledge manager or a knowledge broker, are distinguished, and in KE, there are two basic roles: a knowledge engineer and an expert. The distinction between management and engineering is justified and commonly known also from other disciplines. The knowledge manager determines the direction to be taken, and the knowledge engineer develops the means to achieve this direction. If the chosen direction is the codification of organizational knowledge, then KE has a significant role in the whole KM system, as it was presented on the example of formalization of knowledge about computer failures. However, KE may be useful for KM, regardless of whether the goal is to develop a knowledge base. The experiences of KE in applying techniques of acquiring knowledge from experts have a long history and it is worth using them in KM, which was also argued by the authors in the study quoted here (Gavrilova, Andreeva, 2012). The last prospect of cooperation between KM and KE presented here is connected with the author's experience gained during the formalization of medical guidelines. It should be noted that in this last case, the goal is not a comprehensive codification of knowledge. It is about supporting the creation of regulations in the natural language through KE techniques in the field of formalization and verification of logical correctness. Based on the work carried out by the author, it can be concluded that the use of KE techniques can improve the consistency of the text of guidelines (Kempa, 2017). The article discusses only selected possibilities of using KE in KM. This topic can be extended, among other things, with techniques and tools that can support a knowledge broker during the search of experts in a given field (Kempa, 2006) and solutions helpful in creating knowledge maps.

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