On Knowledge, Knowledge Systems, and Knowledge Management

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Abstract: The article analyzes the structure and use of knowledge in human expert activities, and the role of IT technologies (those emerging in the fields of artificial and computational intelligence) and computing systems (expert or knowledge-based systems) in the process of knowledge preservation and exploitation. Related to these topics, the role of knowledge management is briefly specified, and a possibility of, and the first experiences with, preparing specialists for knowledge management is presented.

Keywords: artificial intelligence, computational intelligence, knowledge, knowledge-based systems, knowledge management

1 Introduction – On the Structure of Mastership

The craftsman's state of being a master in his profession, his *mastership*, is a phenomenon which has been very closely related with the human knowledge for several thousands of years of human civilization. However, it means something more then also then *to know* something only. Mastership can be divided into two equally important parts from the perspective of applying of knowledge (Drucker, 2007, Chapter 5): to *knowledge* and to craft *skills*. The third, for centuries hidden capacity of all masters and craftsmen, is their competency to organize the effective production and efficient sale of their goods. This activity is denoted by the 20th Century's economy by the word *management* (see Fig. 1).

This division is perhaps as old as the craftsmanship. Today, it is present probably in all fields of human professional activities. Such a division is also crucial for our point of view to the subject of present contribution. It provides a suitable structure enabling us to further separated study of the previously mentioned three equally important components of mastership.

In the next sections, we will analyze the structure of knowledge as well as that of the skill. We will concentrate to their mutual interrelations, as well as to the relation of both of them to computing, in particular to their functions in knowledge (of knowledge-based) systems.

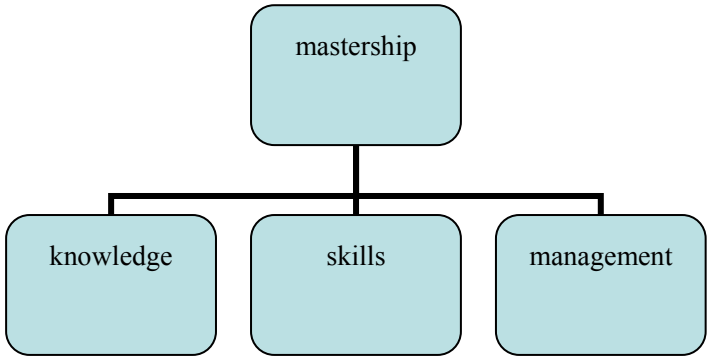

Figure 1
The structure of mastership

Moreover, we will show the way how the transfer of the knowledge processing to computerized *knowledge-based systems*, and the possibility to transfer (some of) skill to automated technological processes – to *robotic systems* in particular – prepare conditions for the growth of the role of managing knowledge – for *knowledge management*. Then, we focus to the university programs designed to prepare professional knowledge managers. We describe our experiences with several forms of their education and training at the College of Management in Bratislava including an intensive program sponsored by Erasmus.

2 The Structure of Knowledge and Skill

Expert's knowledge about some field of human activity – in other words any mastership – is internally complicated body of rules, taxonomies, uncertainties, conditionings, exclusions, etc. To become an expert in the particular field supposes to be well and deeply oriented in all of these aspects. To accelerate such a preparation requires dividing the general knowledge into the smaller and simpler parts, to some "nuggets" of knowledge, or, in other words, to (a finite number of) *pieces of knowledge*. Complicated (and just mentioned) relations between these pieces of knowledge form then the whole knowledge on the given field of expertise; see Fig. 2.

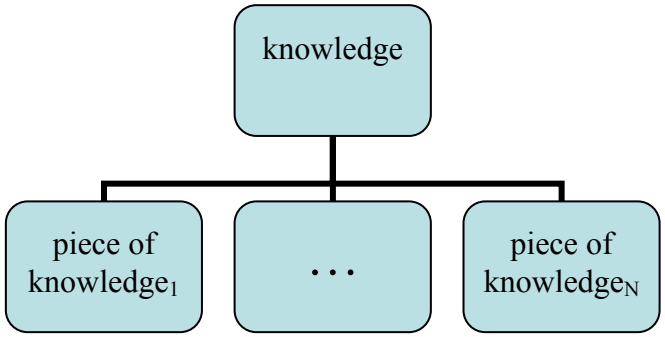

Figure 2
The structure of knowledge

The skill related to any mastership can be also divided into simpler elementary parts. We will call these parts of skill as *operations*, because they are the basic "building blocks" of any complicated modes of operations based and closely related with any master knowledge; see Fig. 3.

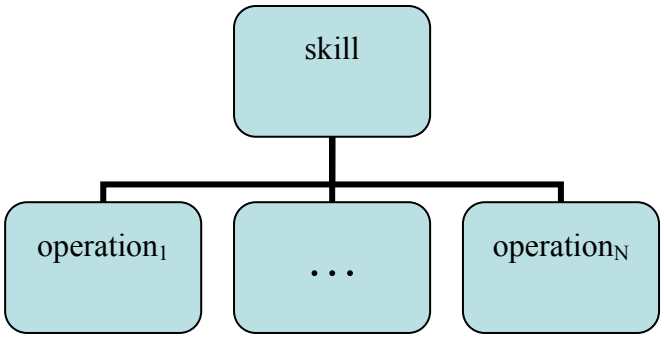

Figure 3
The structure of skill

3 Knowledge, Skills, and the GOFAI

In order to relate operations with pieces of knowledge, let us realize one among the basic moral form the traditional artificial intelligence research, one among the corner stones of the so called GOFAI (Good, Old Fashioned Artificial Intelligence) as presented in several university course books, e.g. in (Winston, 1977), the characterization of knowledge (as well as the pieces of knowledge) by three basic attributes; see Fig. 4.

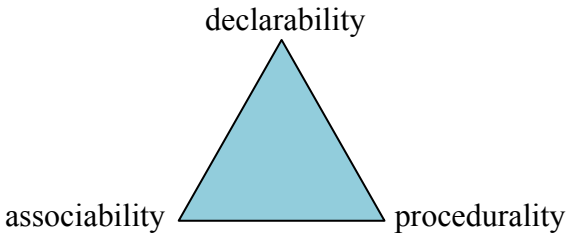

Figure 4
Attributes of (pieces of) knowledge

This specification of knowledge consist in relating each knowledge as well as each piece of knowledge with the attribute of it *declarability*, so with the property of any knowledge to be declared, exactly specified. It is the base for any *symbolic representation* of knowledge, for instance in computer memory structures.

Another attribute of knowledge is the *associability* – the ability of knowledge pieces be associatively interrelated with other such pieces in large nets in order to characterize the complexity of its real-world aspects. The term *associative* or *semantic nets* are usually used for denoting the resulting structures in artificial intelligence. In other words, the contextualization of each piece of knowledge in the space of all pieces of knowledge related to it.

Procedurability refers to the possibility to manipulate the pieces of knowledge. Such manipulations may transfer them into new object(s) – the new pieces of knowledge – with their new relations to their "origins" and, possibly, to other pieces of knowledge.

Because each piece of knowledge has to reflex all of the three inevitable attributes – its declarability, associability, and procedurality – it can also be associated with some basic elementary skill(s) of its use or application. For the same reason, *operation*(*s*) related to each piece of knowledge can be expressed by procedures dealing with this piece of knowledge. Note in this context that the equality between the number of pieces of knowledge (forming the general knowledge related to some mastership) and that of the operations (into which the expert skill is divided) is not accidental.

The emphasis put to one particular attribute leads to a particular type of knowledge representation structure. The *declarability* resulted in declarative representation schemes like rules successfully used perhaps first in the field of artificial intelligence by A. Newell and H. A. Simon (Newell, Simon, 1972) or formalisms and programming tools based on formal logic an automatic theorem proving, like the famous systems, in fact a declarative programming tool, PROLOG, etc., the *associability* – as we have mentioned already – to associative networks, the *procedurality* to different types of procedural representation schemes. The effort to integrate the positive sides of all previously mentioned

representation schemes, as well as to integrate them into a representational scheme of some other aspects of knowledge, like *uncertainties* (to the development of practically useful, and formalized enough methods of expressing formally and processing uncertainties the field of *computational intelligence* contributed significantly, e.g. by developing different fuzzy approaches) or *default values* (like different kinds of expectations usually related e.g. to stereotypical situations, and different types of commonsense knowledge) etc., led during the 70ties of the past century to different variations of schemes more or less similar to, but in basic principles almost identical with, the frame representation scheme as proposed in (Minsky, 1975), like scenarios, scripts, later objects, etc.

4 Knowledge Systems

As we have already mentioned, some of the pieces of knowledge can be represented more straightforwardly in different representational formalism. Perhaps the most usual in the computerized *knowledge system* (*knowledge-based* or *expert* systems are expressions for denoting the same) are production rules. This representational scheme is usually considered as declarative one. An important consequence of the decision to use declarative representational schemes is the necessity to generalize the procedural parts of the represented knowledge, end include them in their universal form into the general computational procedures forming the so called *inference engines* (a kind of interpreters of represented knowledge) of the knowledge systems. In the case of using more sophisticated representational schemes, however, for instance Minsky's frames, considerable part of the procedural knowledge can be expressed as part of the representation of the pieces of knowledge in frame systems, forming the representation of the whole general expert knowledge.

In any case, we are in present days faced with a situation when we have at hand sufficient representational schemes to represent (almost) all attributes of the required knowledge, and the knowledge systems are able to solve particular expert problems in the acceptable level of expertise; for more detail see e.g. (Stefik, 1995).

Looking back to the Fig. 1 we realize that the knowledge representation as well as the exploitation of the knowledge – the use of necessary skill providing successful problem solving on the base of represented knowledge and using suitable inference engines – are activities executable using well programmed computers with a working *inference engine* and "stuffed" with a suitable amount and quality of input data (by *base of facts* describing the particular problem, and a *knowledge base* enable to knowledge systems to solve it). These activities are usually covered by the term *knowledge engineering*; for details and relations with knowledge management see e.g. (Schreiber et al., 2000).

The only remaining part of mastership we have not mentioned it up to now is this of *management*. We will continue with it in the following Section.

5 Knowledge Management

The rapid progress in developing and application of information technology, esp. the progress in the fields like information systems development, and the growing field of application of knowledge-based systems in different areas of the research, industry and administration caused that the problems concerning the right management of knowledge becomes perhaps equally (but might be in some branches of professional activities more) important topic as the knowledge acquisition and knowledge-based problem-solving. The reason is obvious. Despite the enormous size and number of applications exploiting computerized knowledge, there is a wide area of knowledge that cannot be so easily captured and expressed in the form of pieces showing features of declarability, associability or procedurability to the degree that would allowed their (fully- or semi-) automated manipulation.

Knowledge management means in our context – similarly to (McElroy, 2003) – the large spectrum of activities connected with management of company's shared knowledge in the meaning of corporate knowledge decomposition, distribution, innovation, acquisition, accessibility, preservation, etc. The activities connected with satisfying of such requirements form the relatively traditional meaning of knowledge management. They are performed perhaps in all of the enterprises as the corporate knowledge is an important part of their function.

The direct use of the knowledge is often, as we emphasize already in the previous parts of this contribution, shifted to IT support, to knowledge-based systems. However, in connection with the use of knowledge-based systems some new kind of problems appears the solution of which also requires some specific management knowledge and skills. It is necessary to organize the right organizational conditions for effective and high quality knowledge acquisition process during the development of knowledge-bases of knowledge systems. It is necessary to organize the work of knowledge systems in the right way with respect to the requirements of users in different positions in the organization (often from the top management up to the product o technology engineers or technical support staff). This is the second meaning of the knowledge management, specific for the enterprises which exploit knowledge systems support. Informally these two views to knowledge management are referred to as "hard" (i.e. computer-oriented, more formal) and "soft" one. Soft knowledge management concentrates on tacit knowledge, i.e. to the foggy-specified pieces of knowledge in human brains which are not (yet?) transferrable into their explicit counterparts processable by information technology.

Because of the growing role of the knowledge management in the enterprises functioning, and the amount of specific knowledge and skills required from knowledge managers, it seems to be effective their specialized university level education, which provide not only the basics of the management in general, but complete their professional profile by knowledge and skills specific for the activities connected with managing knowledge in specific social and economic conditions of the *information* and *knowledge society*; for economic aspects of both see e.g. (Foray, 2004). The next Section shows an approach to developing a specific study program for preparation of knowledge managers in the bachelor and master levels of university studies.

6 Knowledge Management Study Programs: Their Concepts and Forms

VSM College of Management in Bratislava, Slovakia, opened its bachelor and master study programs in knowledge management in 2005 as a reaction to the so called *Lisbon Strategy* of development in the EU.

The bachelor level study program (preparing for the degree *Bc.*) is oriented generally to management (with some emphasis of knowledge management) and poses its accent to business administration. Its graduates are supposed to become managers in lower and middle managerial functions. For that reasons they must be also familiar with all general principles of management as micro- and macro-economics, finance, marketing, management information systems, mathematics, statistics, etc. In accordance to newest trends, "soft managerial skills" as communication and presentation skill, social responsibility and ethics are also stressed. Naturally, they are also getting familiar with the principles of knowledge management in the courses like *Information technologies for managers, Algoritmization and programming, Interpretation of statistics and data, Database management, Introduction to knowledge management, Decision processes and analyses, Information systems* and *Introduction into E-Commerce*. These guarantee a specific profile of the graduates and their much-higher-than-average orientation in the field.

Another specifics of VSM College of Management supports deepening of their knowledge and skills. VSM courses are performed for small students groups (at about 20 students each). The classes are practically-oriented; theory is frequently exemplified by case studies, discussions and consulations with professors. The student write several assignments during each course. The most of them has the form of overview or research papers from various corners of the studied area. This introduces the students to specific distant fields of the taught subject and forces them to process their collected material, analyze it, and compose their own view to it.

The research papers are usually presented to the rest of the class. In this way, the communication and presentation skills of students are developed and become their routine – so important one for their future performance of their managerial duties.

Compared to it, the master level study program (preparing for the degree *Mgr.*) is much more focused to Knowledge Management itself. There components of traditional management, too, but the stress is made on knowledge-management-oriented courses from both directions – hard and soft. Typical courses are: *Quantitative methods for managers, Databases and information systems, Management information systems, Knowledge systems, E-Commerce and E-Business, Knowledge engineering, Knowledge management, Data Ming*.

Again, the individual approach to each student and the close connection between theory and practice is accented.

During the three years of the application of the study programs, more than one hundred students graduated. They have easily found their positions and seem to be satisfied with their gained knowledge. The reactions of their employees to their qualification are also positive.

The news about our innovative study program has quickly spread over our Erasmus partners. They expressed their desire to give at least basic information on knowledge management to their students. As we felt honored by their request, we (with their support) started looking for an opportunity to organize a mutual activity. It has got the form of a two-week summer school. Its title was *Introduction to Knowledge Management* and was held from 22 June to 5 July 2008 in Trenčín, Slovakia. 22 students and 10 lecturers from 4 countries (Czech Republic, Finland, Lithuania and Slovakia) participated in it. The main objective of the summer school was to provide its target group of student with relevant information on the principles, concepts and methods of knowledge management. This aim has been fully achieved as proved by the quality of their group projects and by their ability to deliver 30-minute presentations in the last day of the summer school. The projects addressed their topics at highly satisfactory levels.

Another objective was to extend the participants' knowledge on business and management with practical experience and know-how of the invited experts from partner countries and demonstrate opportunities offered by knowledge management to the sustainable development of Europe. This has been achieved by introducing many real-life examples in the lectures, excursion to Chemosvit in the city Svit, and to Slovak Telecom in Bratislava, and discussions with the practitioners from the above mentioned enterprises.

Since 2006, VŠM has organized one-day workshop Knowledge Management. In this year, it was included as an integral part into the summer school. Organizers enriched its program by inviting experts and speakers from all four partner countries. In this way, all participants could appreciate different approaches to knowledge management across Europe, including a group of speakers from the

Corvinus University in Budapest, Hungary. Their participation gave us an idea to organize our summer school on even wider base. In future, we plan to accommodate students from countries beyond our original circle. This also holds for the next summer school that is planned for the period from 21 June to 4 July 2009.

Conclusions

Since the middle of the 20th Century, knowledge has become a subject of intensive study. Now we are reaching the stage, when we can start discussing meta-knowledge – knowledge about knowledge. Such meta-knowledge is crucial not only for a proper implementation of computerized knowledge-based systems but also for adopting proper and efficient methods of manipulating knowledge by humans. The aim is to teach people to understand its value as a source of wealth, prosperity and sustainable development. For years, we are training specialists for the area of "hard" knowledge management. As our paper shows, there is also demand for more intensive preparation in the field of "soft" knowledge management.

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