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The metascientific foundations of nuclear knowledge management

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Abstract

It is noted that achievements by metascience are insufficiently used in the development of the theory of knowledge management including nuclear knowledge. The phenomenon of theory deserves paying special attention because knowledge means the theories mastered by people. There is no such knowledge about subjects and objects, processes or phenomena that would not be the representation of theories. That is why the main provisions of metascience are first disclosed by the author in the present paper and following this they are applied for characterization of 15 important problematic issues of the nuclear knowledge management theory.

Management of intratheoretical concepts, i.e. the principles, laws and variables, is implemented using four methods, namely, deduction, experiment, induction and correction of the original underlying principles. Management of theories is implemented by the use of three methods: problematization, innovation and interpretation. Multiplication of theory management cycles results in the generation of series of interpretative theories. Subject matter of each separate theory is exposed in the composition of the series from the viewpoint of the most well developed concept. Conclusion is made that series of interpretative theories constitute the basic element (unit) of knowledge.

Significant place is occupied in the characterization of outstanding problems of nuclear knowledge management by the correlation between the articulated and practical, as well as between tacit and explicit knowledge. Mechanism is examined for implementation of the discourse leading to the development of the group knowledge. Characteristic is given of the status of competence, skills and hands-on experience of carriers of nuclear knowledge. Approaches to the preservation and development of theories are discussed.

Keywords: Knowledge management; Methods of nuclear knowledge management; Metascience; Series of interpretative theories; Competences.

Introduction

Since 2002 management of nuclear knowledge or, which essentially means the same, administration of nuclear knowledge became one of the priority directions of activities by the International Atomic Energy Agency (IAEA) [1]. Different aspects of the above concept are examined in the series of monograph studies dedicated to the nuclear knowledge management concept (*nuclear knowledge management,* NKM) listed on the IAEA site [2–6] and, in particular, those the methodological aspects of which are of interest for us in the first place [5]. NKM glossary developed within the IAEA framework is opened with the following definition: "Knowledge Management itself is defined as an integrated, systematic approach to identifying, managing and sharing an organisation's knowledge, and enabling persons to create new knowledge collectively and thereby help achieve the objectives of that organisation. Knowledge Management helps an organization to gain insight and understanding from its own experience. Specific activities in knowledge management help the organization to better acquire, store and utilize knowledge" [6, p. 1]. This definition is forestalled with warning that all definitions used in the glossary refer to knowledge management. It is, however, noted that "The following definitions of terms apply specifically to the field of Knowledge Management. It should be noted that identical terms applied to, or used in, other fields may have somewhat different definitions" [Ibidem]. The included elucidation evidences the fact, that nuclear knowledge management is understood as an applied field of knowledge management. However, the well-known collision emerges with this respect. The point is that knowledge management was originally developed as applied to economics.

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All outstanding knowledge managers, in particular, Drucker et al. [7–9] are more inclined towards economic knowledge. Nevertheless, they presented their conclusions using the terminology neutral with respect to different fields of knowledge. As the result the impression is formed that they managed to develop the general theory of management which can be applied, for instance, to the specific field of nuclear technologies. One cannot but doubt the above, especially considering that, as it is demonstrated in [10], conceptual and methodological basis of management as a whole, including knowledge management, evidently requires further specification.

Thus, as of today, inflow of conceptual and methodological currents comes to nuclear knowledge management mainly from the side of general management. However, it can be approached as well from the side of theory underlying nuclear technologies. When experts in nuclear technologies discourse about knowledge management they to this or that extent necessarily take into consideration their special status. Unfortunately, even under such approach to nuclear knowledge management obviously insufficiently thoroughly developed conceptual and methodological foundations of in this case technical science (technicology) including nuclear science let themselves be known [11].

By definition fundamentals of a science constitute the subject of metascience. Thus, fundamentals of mathematics are studied by metamathematics, the founder of which was Gilbert. Unfortunately, as it was demonstrated in the whole series of our monograph studies, due attention is not paid to metascientific studies in each of a couple of dozen fields of science. Taking into consideration the above discussion we will first familiarize the reader in the thesis form with main conclusions of metascience [12] undertaking the commitment that they are applicable to nuclear technological theories. And only after that a number of important present day provisions of nuclear knowledge management will be addressed in the light of these theories.

In order to escape misunderstanding let us note that in the present paper we do not refer to the so-called philosophy of science. Contemporary philosophy of science constitutes part of philosophy represented, first of all, by analytical, hermeneutical and poststructuralist concepts. These concepts are not discussed in the present paper. Metascience, in contrast to philosophy, is not a special field of science.

Main provisions of general metascience

1. Knowledge means the theories understood and accepted by people and nothing else. Notwithstanding in which form knowledge is manifested, for example, in mental or in lingual form, it constitutes representation of a theory.
2. Theory consists of concepts and methods for their management. These concepts include principles, laws and variables. They are necessary for developing conceptual images of subjects, i.e. people possessing knowledge, and objects. Humans are the subjects of nuclear power generation, while objects are, for instance, power generation installations and their equipment. Fundamentals of theories of nuclear technologies are represented, in the first place, by safety, efficiency, reliability, failure-free operation, lifetime, durability, maintainability and serviceability principles. The variables are the measured characteristics of objects and subjects. The laws are the relations between variables expressed in the form of equations or inequations. Thus, for instance, dependence of thermal efficiency factor for power generating installation versus temperature and coolant pressure is the law. In contrast to variables laws and principles are not measurable.
3. Management of principles, laws and variables is implemented by the following four methods: deduction, experiment, induction (data processing) and correction of originally formulated principles. Operations of abstraction and idealization are often used in concept management. These operations are the simplification techniques and usually they are disposed of as the result of the undeviating ascension from more simplified to less simplified description.
4. Theories are managed by the following three methods: problematization (revealing certain obstructions in the old concept), innovation (invention of new theory) and interpretation (old theory through new concept). The developed theory is the key to understanding the theory part of which becomes obsolete. Less developed theory does not allow expressing the full scope of the richer concept. The following two sets of theories are formed in the process of multiple repetition of the cycle of theory management: originally problematic theories followed by interpreted theories, i.e. theories harmonized under the aegis of the most developed theory.

Problematic set of theories is following: $T_1(p_1) \rightarrow T_2(p_2) \rightarrow T_3(p_3)$, where T_i is the denominator of the theory and p_i is the denominator of the problem.

Interpretation set of theories is following: $T_3 \rightarrow T_2\{T_3\} \rightarrow T_1\{T_3\}$, where $\{\}$ is the denominator of the interpretation. Record $T_2\{T_3\}$ means that the scope of theory T_2 is interpreted from the viewpoint of theory T_3.

Knowledge is decisively harmonized using series of interpretative theories. Let us illustrate the above using the example of electrodynamics, where in succession theories initially by Maxwell, and then by Einstein and Dirac form the series of problematic theories. Dirac's theory allows correcting the scope of theories by both Einstein and, as well, by Maxwell. As the final result the series of interpretative theories, namely, the Dirac-Einstein-Maxwell electrodynamics, appears.

Obviously, harmonization of knowledge takes place, as well, in the field of nuclear technicologies. Let us assume that theories of light-water, as well as alkali and heavy liquid-metal coolants are examined. It is clear that one will have to do with a relay of three types of theories, in particular, theories related to sodium–potassium or to lead–bismuth coolant. Pace of problematic theories allows revealing and explaining shortcomings of original theories. As the final result

thoughtful investigator singles out without fail the series of interpretative theories.

5. Interdisciplinary connections are realized by way of management of series of interpretative theories. It is achieved again through problematization, innovation and interpretation. However, here, for instance, technological theory appears not in its primeval purity, but, instead, with appendage in the form of auxiliary and, in this context, donor theory. As applied to technological theory the donor theory can be, for instance, a mathematical, computer, physical or medical concept.

Important present-day aspects of the concept of nuclear knowledge management in the light of metascience

The format of paper in scientific journal does not allow undertaking revision of all problematic aspects of the concept of nuclear knowledge management and still, however, some of them deserve at least brief exposure.

On the conceptual and methodological basis of the concept of nuclear knowledge management advocated by the IAEA. It is difficult to judge this concept insofar as it is not sufficiently well defined in its fundamentals. Identification of knowledge, its inclusion in the systems of tacit, implicit and explicit knowledge with subsequent processing of knowledge, its storage and transfer to interested organizations and individuals is declared in the methodological section of the fundamental document [5, pp. 17–24]. These conclusions may well be agreed with, but, however, they lack scientific consistency, because the key concepts and methods, as well as the principal nuclear knowledge management units are not defined. This unit is the series of interpretative nuclear technical theories. In 102-page document the term "theory" is used only four times in random context without any connection with characteristic of the methodology of nuclear knowledge management. As to the above discussed seven methods of knowledge management, they are not mentioned at all.

On the nature of knowledge including nuclear knowledge. Knowledge is the series of theories mastered by people and relations between them, or, in more detailed form, the concepts and methods of their management, namely, deduction, experiment, induction, correction of originally formulated principles, problematization, innovation and interpretation. It is not enough to declare the necessity of knowledge management. It is necessary to define the fertile soil, or the basis of knowledge. Acceptable definition of knowledge is missing in literally all fundamental IAEA documents. And this is not a mere accident. It is impossible to understand the nature of knowledge disregarding the concept of theory. And the latter, as it was noted in the preceding paragraph, is not addressed in the documents.

On the object of management in nuclear knowledge management. Knowledge means theories mastered by people and, therefore, these are specifically the theories which must be managed. It is not permissible to wish to manage knowledge disregarding the theories.

On the nature of nuclear knowledge. Nuclear knowledge is the series of theories and relations between them developed in connection with development of nuclear technologies.

On the necessity of nuclear knowledge management. First of all this concept is determined not by the successes of modern science and not by the special status of nuclear technologies, but by the human nature. Humans according to their nature are the conceptual beings who, specifically because of their nature, are the ones conducting management of knowledge including nuclear knowledge. As the result human beings are constantly improving themselves. Already ancient Greeks, in particular, Aristotle, who used the concepts of deduction and induction, insisted on the management of knowledge. It is obvious that in our days the need to manage knowledge became important as it has never been before. It is specifically within this context that close attention must be paid to metascience.

On the preservation and development of nuclear knowledge. It is appropriate enough to raise the question about preservation of nuclear knowledge. Let us note, however, that the meaning of this preservation becomes clear specifically thanks to metascience. Preservation of knowledge in its original form results in the dead end because not only achievements but, as well, misapprehensions are concentrated in it. The latter must be subjected to criticism. Initial concepts are preserved in the modified form, namely, after being interpreted from the viewpoint of the best developed theory. Researchers should always start from the principle of present day importance of the mature knowledge according to which it is specifically the most thoroughly developed theory which serves as the key to understanding partially obsolete theories. Preservation of knowledge is the necessary phase of development of knowledge – the only antidote against all sorts of misapprehensions.

On the truthfulness of nuclear knowledge. Concept of truthfulness is not used in abundant treatises dedicated to nuclear knowledge management. And, meanwhile, being freed from misapprehensions nuclear knowledge becomes true knowledge. By definition it is the knowledge contained in the series of interpretative theories and in relations between them which is true, although not in absolute, but in relative sense.

On the contraposition of tacit, implicit and explicit knowledge in nuclear technologies. The above contraposition occupies central place in nuclear knowledge [5], but, as it will demonstrated later, without absolutely no grounds. The indicated concept was developed originally from general philosophical positions by Polanyi [13] and later, within the management concept, by Nonako and Takeuchi [9].

Half a century ago Polanyi developed apologetics of tacit knowledge. If knowledge is expressed in well-articulated forms acclaimed in science, then this knowledge is explicit. In opposite case knowledge is recognized as implicit, the extreme form of which is tacit, i.e. completely not expressed, knowledge. Examples of tacit knowledge are emotions, practical actions, for instance, riding a bicycle. In the opinion of Polanyi, tacit knowledge is realized, as a rule, automatically and is apprehended by experimental approach. In the Russian

translation tacit knowledge is regarded as inexplicit. In reality tacit knowledge is, in fact, demonstrated and, therefore, it is also explicit. At the same time tacit knowledge is demonstrated with a sequence of not words but, for instance, emotions or practical actions. Theater directors teach actors to express their conditions by the sequence of feelings or emotions, coaches equally persistently train sportsmen, for instance, athletes or swimmers, to perform the sequence of actions (movements). Polanyi is correct – we are capable to know more than just the words. However, the provision that humans cannot know more than it is incorporated in their theories completely escaped his attention. Metascience allows identifying Polanyi's error: it is wrong to contrapose to each other different understandings of the theory, in particular, lingual, emotional and objective-practical. Their senses are predetermined by one and the same theory. It is specifically because of this reason why researchers should concentrate their primary attention specifically on this theory. Polanyi failed to do this.

Theory by Polanyi was used by Nonako and Takeuchi who made an attempt to explain principal difference between the strategies of actions by Japanese and Western, first of all American, companies. Americans, they say, are alleged to place accent on explicit knowledge, while Japanese, in contrast to them, allegedly more thoroughly take into account the potential of tacit knowledge. Essentially, Nonako and Takeuchi repeat the mistake made by Polanyi attributing practical knowledge to mysterious inexplicitness.

Thus, the point is as follows. Knowledge exists in different forms, for instance, mental, lingual or objective-practical. At the same time any of these forms can be more or less articulated. It is wrong to consider practical knowledge to be not articulated. It is obvious that mental knowledge is intimate but, nevertheless, its articulation does not remain the sealed book. One can judge about it indirectly, namely, according to the degree of articulation of the lingual and practical knowledge.

Central place in nuclear knowledge management must be occupied not by the forms for representation of knowledge, but, instead, by its conceptual and methodological content.

On the relation between knowledge and skills. Contraposition of knowledge and skills passes as the main postulate through all guiding documents dedicated to knowledge management (see, for example, Refs. [5, p. 6, 28, and 56], [3, p. 1, 3, and 10]). At the same time skills are the form of representation of knowledge. It is clear, therefore, that their contraposing to knowledge is untenable. The criticized contraposing is the indication that its protagonists unjustifiably restrict the potential of knowledge. In our opinion it is necessary to remember that erroneous restriction of actual importance of knowledge, any attempts to contrapose to it something different result in dangerously approaching uneducated ignorance.

On the competences. Status of competences is often determined on the basis of understanding about knowledge and skill. "Competency is defined as the appropriate level of knowledge and skills along with the correct professional attitude to perform work effectively and safely" [3, p. 1]. But the point here is that the mere availability of actual knowledge ensures both the appropriate level of knowledge, and the correct attitude to professional duties, as well as compliance with efficiency and safety requirements. Competences are the actual knowledge and nothing more. Let us note that Russian-speaking authors often try to elucidate the nature of competences by making indications to knowledge, skills and hands-on experience. Within the same context English-specking authors prefer referring to knowledge, attitudes and skills. Both underestimate actuality of the institution of knowledge [14].

On the general and specific competences. General and specific competences to be possessed by bachelor or master specialized in the field of nuclear knowledge are defined in [2, pp. 8–9, 11]. Such approach raises objections insofar that competences must be defined based on the subject matter of certain theories - mathematical, physical, chemical, technological, economic, etc. Dividing these theories into general and specific is hardly possible. But, even if this were possible, then it would be advisable to give clear definitions of the general and specific theories.

On the assessment and development of competences on a regular basis. This task is formulated in [4, p. 32]. At the same time no information from the field of metascience is provided. Correct formulation of the question about competences and, to even greater extent, about their development is hardly possible without involvement of metascience.

On the nature of group knowledge. Knowledge management always takes into consideration the status of not only individual but of the group knowledge as well. Understanding the process of its formation is extremely important. In the light of metascience it is realized in the following way. Each subject within the organization is guided by his own set of theories. If subject ***A*** calls attention of subject ***B*** to a certain statement, then the latter strives to incorporate it in his system of theories. If he is successful, he agrees with the statement. Otherwise subject ***B*** rejects the statement made by subject ***A*** either completely or partially. Similar actions are performed as well by subject ***A*** who one way or another reacts to the statements by subject ***B***. Each of the communicants, however many they are, realizes knowledge increase cycles.

Unity of the communicants does not mean uniformity of their sets of theories. Evidently, the discourse does not leave these theories in the original form. The more successfully the discourse is developing, the closer becomes the network of theories of the communicants and the larger is the number of common points and confluence points the theories have between them. As we can see, new unity emerges which the subject of the organization in question expresses through his own theories in the interrelation with representatives of other groups of people.

Let us note as well that experts in nuclear knowledge management did not so far turn their attention to the issues of status of group knowledge. There is no doubt that very soon this issue will also attract their attention. Then they will have to take into account two dominating approaches – hermeneutical and poststructuralist. Hermeneuts presume that in the course of the discourse agreement is reached between the

communicants [15]. Poststructuralists, on the contrary, assume that principal disagreement or dissention exists between them [16]. However, as it has been demonstrated above, partial agreement and partial disagreement take place.

On the main form for development of lingual competence. In our opinion such form is the interactive seminar. However, of utmost importance is specifically how such seminar is conducted. If the moderator insufficiently clearly understands the conceptual and methodological arrangement of knowledge then he fails to correctly direct the seminar.

On the knowledge-based nature of group practices. It has been noted above that it is wrong to contrapose practice and knowledge. It is clear in this connection that group practices are the forms of group knowledge. Each member of the collective uses a certain sequence of objective actions. This is once again the same theory expressed, however, not in the verbal, but in practical form. Members of the organization exchange their practical experience and skills but, however, not all the experience and skills but only those which they manage to successfully incorporate in the series of their own actions. The main form of development of practical competence is such practical exchange of working experience in the process of which attention is paid to theoretical meaning of the performed actions.

Conclusion

IAEA efforts on the development of nuclear knowledge management deserve all-round support. They are the proof of evident increase of interest to the conceptual and methodological potential of theories. Its investigation is the task for metascience which so far was not paid due attention. Interesting allusion emerges in this connection as relates to specialists in the field of nuclear knowledge management. They referred to metascience later than their colleagues in the field of knowledge management but, however, they have the possibility to take into consideration the achievements and misapprehensions of their predecessors. It is specifically in this connection that the main provisions of metascience directly facing the vital demands of nuclear knowledge management were offered to the readers' attention.

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