Noospheric Way of Organizing Knowledge in the Knowledge Bases of Innovate Importance

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Abstract: A major part of the flow of new knowledge is knowledge about facts. Its value is inversely proportional to the increasing amount. It can be enhanced by the way of conceptualization of knowledge, developing and applying the innovative ways of its organization. It is suggested to use the way of organizing knowledge based on the model of cognition of objects as spheres of phenomena; convergence of the sphere of natural and conscious phenomena, models of phylogenesis (Paradigm Innovative Development) and ontogenesis (Vertical Integration and Parabola of Knowledge) of knowledge as well as based on the paradigm of the ontology of sign constructions. The above-listed tools have been obtained as a result of studies of M.V. Polyakov's scientific school, and they have been adapted by the author of the paper to develop architecture of the knowledge bases functioning as a part of innovative systems of venture enterprises.

1 INTRODUCTION

Any conscious activity bears information nature. The economy is not an exception. Information is an ambiguous term. One of its meanings is measure of the impact of message on its recipient. Besides, information is synonym of message. Messages consist of signs; therefore, we will speak of fundamentally sign nature of conscious activity.

Signs are the form of existence of knowledge. Knowledge can be old or new. It also can be genuine or false. It depends on criteria of genuineness and is determined in practice. Therefore, almost any conscious activity is cognitive, even if the subject does not strive to it. The subject either reinforces old stereotypes, or gains new experience.

Cognition is inseparable from economy, whether the subject wishes it or not. Although, in terms of innovations, it can take place with zero result. Depending on the object and phase of development, cognition merges with economy or stands apart of it.

Similar points were raised by Friedrich August von Hayek in his paper "Individualism and Economic Order" (1958).

1.1 Some Related Work and Relationship with Knowledge Management Area

Many books and articles on knowledge management begin with definitions of their essence (Nonaka and Takeuchi, 1995), (Lundvall, 2007). The diversity of various definitions of knowledge suggests that they have failed so far. Most definitions concern not so much with the essence, but with the origin, purpose and application of knowledge. Such works as "Ontology and knowledge economy" (Polyakov, 2015) may be an exception, because it concerns with the ontology of knowledge that is reduced to the ontology of signs. Such "knowledge about knowledge" is necessary, first of all, to optimize the structure of the denoting part of knowledge, called the knowledge base. For innovation activity, it is much more important to be able to recognize the knowledge necessary and sufficient to solve the innovation task. Traditionally, there are researches devoted to this problem which are related to librarianship. The results are well-known library classification systems (UDC, educational standards, nomenclature of subjects for which academic degrees are awarded, etc.). However, they describe a well-established

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picture (more precisely, a map) of knowledge, and today it is a stream of changes, especially in the infosphere. Especially when it comes to computer knowledge base, with its ability to update the structure and content. This disadvantage is partly compensated by the efforts of educational organizations, virtual research networks, organizers of scientific communications, publishing houses of specialized literature, etc., institutes, such as INSTICC, Common Ground, Global Science and Technology Forum (GSTF) and others. They react to the facts of changes in science and technology promptly, but the reactions do not always coincide and do not always fit into the traditional framework. It takes time to comprehend and systematize them.

It is worth mentioning researches of S.Ranganathan (1957) or Karin Karlics (2013). However, in terms of the connection with ontology and coverage of the variety of objects and aspects of knowledge in their relations in this research, we focused on the works of M.V. Polyakov and his co-authors (Polyakov, 2017; 2018).

The originality of our research lies primarily in its conceptual character. It consists in a completely non-obvious interpretation of the results of the development of the noospheric approach to cognition and its transfer to the problem of knowledge, its essence and properties, with application to the development of Knowledge Bases that are part of innovative systems.

1.2 Structure of the Paper

Section 2 discusses the basic concepts and includes: General requirements to Knowledge Bases; Object structure of cognition process and knowledge; Genesis of cognition and economy in the spheres of phenomena, Vertical integrated units of knowledge and their genesis.

Section 3 (Outcomes) discusses the concepts of Knowledge maps and Noospheric knowledge map, as well as multimaps, which underlie noospheric knowledge bases. Section 4 is Conlusions.

2 BASIC CONCEPTS

Knowledge, which is the result of activity of such fields as semantic technologies (Berners-Lee, 2001), organizational semiotics (Stamper, 2000), ERP-systems, theory and practice of business processes (Scheer, 1999), differs drastically from natural-science and humanitarian knowledge by content as well as by methods of obtaining and application.

This knowledge is related to infosphere, but relies on computers, representing the implemented knowledge of physical phenomena. As a rule, it is obtained by young people, often by students within small enterprises or informal groups. These structures have a chance (not always high one) to become successful startups. The above-mentioned people do not have theoretical background in the field of infosphere, as well-recognized theories just do not exist there, and it is not even sure whether they could exist. At the current stage, for the whole period of its development, infosphere demonstrates maximum degree of integration of cognition and economy. Here it is, in fact, two sides of the same coin. The same high degree of unawareness of what is going on should be noted, which is quite natural for pre-paradigm phase of development. This is particularly evidenced by the words of Grady Booch, who has acknowledged that "many years will pass and OOAD will become as usual as motherhood or apple pie, but no one will be able to explain what the Object Oriented Analysis and Design is" (Booch, 2004).

Having formulated the productivity paradox of IT in economy and business, Robert Solow actually pointed the signs of technological and financial bubble in the sphere of IT application in the global economy (Solow, 1987). A discussion took place in the scientific world, which, in our opinion, was not able to resolve the paradox, having maintained the status quo.

Kris Freeman and Carlota Perez have found the emergence of these bubbles at the stage of adaptation of innovate technologies to social and economic environment to be regularly recurring pattern (Freeman, 1982, Perez, 2011).

All innovations, which have taken place in the infosphere until today – are based on pure heuristics, experience (analogy, association) or modelling, when the abstraction of the deeper level is applied to simplify the existing practices. This series continues in future in the form of such trends as Big Data and Artificial Intelligence.

It is interesting that Peter Druker spoke of the failure of IT to become a tool for management of economy and business, like of something very obvious: "…all of us nonconformists agreed on one thing: The computer would, in short order, revolutionize the *work of top management.* We could not have been more wrong. The revolutionary impacts so far have been where none of us then anticipated them: on operations." (Drucker, 2001).

One more thing: "But they did not, as a rule, realize that what was needed was not more data, more technology, more speed. What was needed was to

define information; what was needed was *new concepts.*" (Drucker, 2001).

In our opinion, quasi-physical approach to conscious phenomena, and products created on this basis, in particular, knowledge bases, are of obvious interest in this respect.

2.1 General Requirements to Knowledge Bases

Knowledge, indeed, is diversified, and its development requires different innovative systems and methods for innovative management.

In this study, the knowledge, accumulated in the knowledge base, serves as the major resource for creation of innovative products, including description and the process of creation of the products themselves. However, there is also an inverse relationship. The experience in empirically heuristic cognition, being a result of economy, as well as the experience in application of scientific findings in economy, is a resource for development of paradigm and post-paradigm (scientific) cognition.

It is obvious that a skilled carpenter or joiner is obliged to excel in woodwork, metalworker – in metalwork, etc. Accordingly, an individual or collective Subject of Innovative Activity (SIA) at the enterprise has to know the ropes of knowledge.

Unlike the specialist or teacher, who works in a narrow sphere, he needs to be able to deal with an ample sphere of diverse knowledge. In order to be well-versed in a rapid stream of knowledge, it is necessary, first of all, to have an idea of architecture (in other words, structure) of the whole wide range of knowledge, accumulated by mankind and being relevant at the current state of cognition. It is critical to understand what is the state and trends in the development of knowledge system.

We can implement rational investment policy, build ideal innovate system, but what will be the benefit if, due to unawareness of what is going on, the goals and trends in the development turn to be risky, or even false and needless? In order to diminish these risks, Noospheric knowledge base should be not just a topogram, but also a sort of "roadmap" of the innovative development of infosphere. Dynamic properties of the models of PIDev and parabola of knowledge provide this opportunity.

2.2 Object Structure of Knowledge and Cognition Process

According to Noospheric thinking of V.I. Vernadsky, the world as an object of cognition (the signified part of sign) is divided into the spheres of phenomena, as follows: a) physical – physiosphere; b) biological– biosphere; c) conscious – noosphere.

Figure 2.1 shows the relationship between physiosphere, biosphere and noosphere within the universal sphere of phenomena.

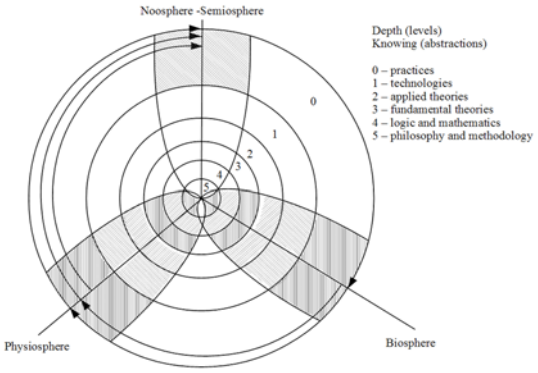

Figure 2.1: Object structure of knowledge.

Concentric circles symbolize the levels of abstraction, from zero (practical knowledge which can be implemented in bodies or be imitating the activity) to philosophy and methodology (depth 5).

A complete circle corresponds to noosphere, segment 240' – to biosphere, and 120' – to physiosphere. Each sphere of phenomena has a corresponding vertical and parabola of knowledge.

The object and subject structure of physiosphere and biosphere has been fundamentally developed within several centuries after scientific revolution of the 18th century. Scientific cognition of noosphere is at the beginning of its path. In the framework of the noosphere, we are, primarily, interested in the infosphere and economic sphere. Figure 2.2 shows their relationship.

Truncated cone symbolizes the infosphere. As far as information is an ambiguous term, denoting messages as well as the extent of their impact on the recipient, it is more preferable to use the term "sphere of sign phenomena".

The discovery of physiosphere (starting from geosphere) as well as biosphere and noosphere, scientific revolution in the information sphere, approaching owing to a wide use of data processing technologies being physical by their nature, have caused cessation of the traditional structure of scientific knowledge to correspond to the goals and objectives of further innovative development.

Thus, according to interpretation of Vernadsky's teaching, provided by M.V. Polyakov jointly with coauthors (Polyakov et al., 2018), the object of

integral cognitive and economic activity is the sphere of phenomena. The cognition of phenomena is concluded by implementation of its results in bodies and processes, needed by people (artefacts – artificial phenomena). As Niels Bohr said, "the objective of science is to make something incomprehensible to become trivial."

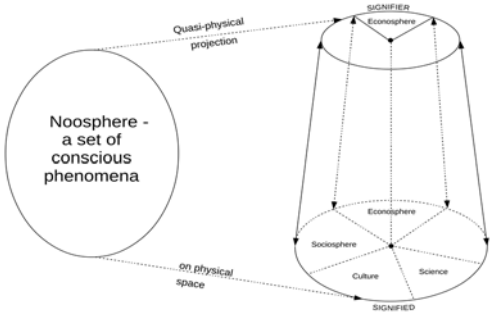

Figure 2.2: Object structure of knowledge. Noosphere.

In order to handle the arrays of phenomena, they have to be simplified. Vernadsky, in particular, suggested breaking down the array of world phenomena into the series of above-stated spheres, each with a certain entity (physical bodies, living organisms, sign bodies) behind phenomena. The phenomena, related to different sphered, are closely interrelated between each other, and in each of the artefacts, as a rule, knowledge about more than one kind of phenomena is closely intertwined between each other.

Therefore, if it is an innovative enterprise and its mission is "To cognize and manage!", the object of innovative activity and the respective knowledge base shall correspond to the structure, described above.

2.3 Genesis of Cognition and Economic in the Spheres of Phenomena

A human cognizes the essence of phenomena and implements it in the artefacts. The outcomes are represented by knowledge in sign and embodied form (artefacts). At the same time, the economic is inseparable from cognition. Theoretically, cognition can be suspended, but then the economic will cease to develop and start degrading. Actually, the economic is also the cognition. Their living connection can be broken due to specialization and alienation. This leads to breakaway of cognition from production, and the latter – from creativity.

Similar assumptions were made by many of outstanding thinkers, among which are Ferdinand de Saussure (2017), Friedrich August von Hayek (1958). Wide application of information technology in the sphere of conscious phenomena enabled Bertin Martens (2004) to compare the economy with an information machine for production of knowledge, including their embodied form, and Peter Brödner (2005) compared the organization with a computer program. The process of cognition is spread over time, and in diverse time segments, it behaves differently. Accordingly, it requires a diachronic, in other words, historical approach.

Polyakov's work shows an example of the application of diachronic model of Paradigm Innovative Development (PIDev) of cognition and economy (Polyakov et al., 2017).

Being a single whole, every sphere, driven by innovations, undergoes a number of phases in its development, as follows: 1) empirically heuristic (before paradigm); 2) paradigm; 3) scientific (post-paradigm).

The objects of changes are represented by the innovative products, i.e. knowledge in symbolical or embodied form.

Computers emerged as physical technology of data processing. At that time, the infosphere was and it is now in the empirical and heuristic phase of development. It means that innovations take place there at the level of practices (zero depth), do not affecting the level of constructions and technologies, not to mention the deeper levels of abstraction. Computers have accelerated the development of infosphere, thereby exposing the problems, and approached the transfer to paradigm phase.

As far as the spheres of phenomena have multilayer structure, there can be relict layers, along with the advanced ones. For instance, physics of a solid body, liquids and gases, optics, atomic and quantum physics and other branches of physics developed asynchronously. Nevertheless, multiple principal tenets combined them into the physiosphere.

By analogy with Darwin's theory of evolution, we can say that PIDev model, which determines historical development of the whole sphere of phenomena, is phylogenesis. In this case, innovations act as analogues of specific bodies, and innovative cycles within the framework of parabolas can be considered ontogenesis.

Macrogenetic or phylogenetic characteristic of knowledge stems from PIDev model.

2.4 Structural Units of Knowledge and Their Genesis

It is difficult for an individual human to acquire knowledge of all phenomena at once, even in the amount of a single sphere, and even more so for the

universal scale. That is why we have to fragment knowledge.

Although, it is only holistic and completed knowledge that can be quite understandable and, therefore, productive and constructive. Figure 2.3 shows decomposition, and, respectively, integration of knowledge about a particular sphere of phenomena (or its parts) "vertically" (by levels of abstraction).

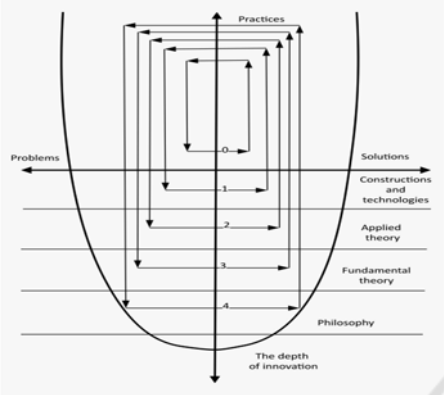

Figure 2.3: Ontogenesis of knowledge (Polyakov et al., 2017).

The right branch of the parabola describes rising from the abstract and simple (paradigm) to the concrete and complex (practice). The abstract corresponds to the set, and the concrete – to the individual. In case of rising, every level of abstraction (depth of innovation) also denotes a step. When the steps are skipped during immersion and rising, it means that the method of modelling is applied. For example, we can see a certain and poorly understandable correspondence between practical results and mathematical apparatus.

Further, lacking full understanding, we can risk applying this apparatus for improvement and regularization of practical results. At the same time, the obtained model will require subjective interpretation, results of which, with a certain probability, can be useful, useless or even harmful. The application of abstractions of the high level to practical results, bypassing the steps of the vertical of knowledge, is called the modelling of conscious phenomena (Fig. 2.4).

The term "modelling", similarly to many other terms in the sphere of conscious phenomena, got the meaning, different from the traditional one. In the sphere of natural phenomena, it means simplification of real-life understandable object, while in the sphere of conscious phenomena it is a hypothetical understanding of still not understandable phenomena and their effects.

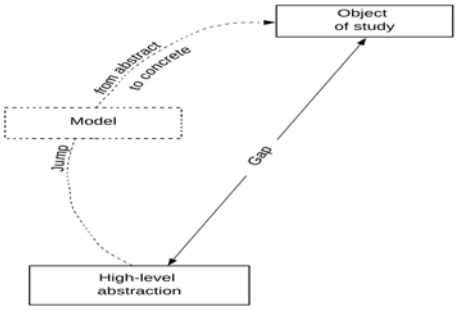

Figure 2.4: Modelling of conscious phenomena.

The parabola of knowledge determines the structure of knowledge units as well as their place and role in the innovative processes. These properties should find reflection in the structure of the knowledge base being developed.

Therefore, this paper formulates a methodological and theoretical background for development of the architecture of knowledge bases, focused on identifying, setting and addressing the crucial innovative challenges in the sphere of conscious phenomena, first of all related to information and economy. It also serves as a methodological basis for analysis of the existing solutions in the field of knowledge organization in the form of knowledge base as well as for evaluation of an impact of the created knowledge base on the economic efficiency of enterprise's performance.

3 OUTCOMES

3.1 Knowledge Maps

It is convenient to use the term "Knowledge Map" (KM) to denote graphical or text representation of the architecture of knowledge. Its synonyms can be represented by "topography (topogramma) of knowledge" (ToK).

The genesis of knowledge is represented by PIDev and VIK motels. PIDev reflects the development of the sphere of phenomena, being not differentiated by innovative products or levels of abstraction, and, by analogy with biology, it can be called as phylogenesis of knowledge. Knowledge maps, PIDev and VIK models are not only mandatory tools for innovations. It is also the means for development of the innovators' holistic world view, being one of the most critical factors which have impact on productivity of innovative activity.

The knowledge map should expose the real significance and trends in development of cognition

and economy, confirming or denying the appropriateness of the existing trends, or facilitating the emergence of the new ones.

3.2 Noospheric Knowledge Map

Knowledge base, the concept of which is a practical outcome of this study, is called noospheric.

Noospheric Knowledge Map (NKM) has a leading role among the knowledge maps, being a part of the multimap. Every Structural Unit of Knowledge – SUK (text, audio, video, and hypertext) should be characterized by a number of properties, determined by the acknowledgement of the fact of noosphere as an objective reality. Table 1 shows the specification of noospheric properties of NKM and the values taken by them.

Imposition of the vertical of knowledge on the infosphere demonstrates the vacancy of the key box, corresponding to fundamental (ontological) theory of information (to be more precise, sign) phenomena. This gap does not allow developing the applied theories and technologies. It enforces resorting to modelling, which, in terms of the parabola of knowledge, looks like the attempts to jump from the deep philosophical (ontology, object, universal sign) and mathematical abstractions over the levels of fundamental and applied theories as well as technologies to practices. As practice shows, in such cases, a risk of falling considerably exceeds a probability of success.

NKM does not assume that we should not deal with the empirical and heuristic innovations or use modelling for this purpose. It emphasizes the necessity in these cases to carefully consider the risks and use emerging opportunities for paradigm innovations, which, addressing business challenges, simultaneously build a ladder for scientifically grounded innovations, characterized by law probabilities of continuously recurrent success.

3.3 Application Area and Multimaps of Knowledge

The noospheric knowledge base is the most important component of the innovation systems of enterprises, primarily those that create IT, wherein the noospheric map should ensure the divergence of knowledge in relation to the kind of phenomena and the phases of phylogenesis and ontogenesis of knowledge, as well as methods of immersion and ascent between concrete and abstract, using the VIK. The noosphere map ensures the convergence of knowledge relating to different areas of phenomena and levels of abstraction. Distinguishing the phases of the phylogenesis of knowledge used as an innovation resource, it allows you to select the mode of the innovation system corresponding to the pre-paradigm, post-paradigm or paradigm state of the VIK used in solving a specific innovation task.

However, initial knowledge can enter the noospheric base as element of different structures (“maps”) of knowledge that do not fit with the noospheric structure. Their names, annotations and content may differ from the noospheric knowledge map. Therefore, the noospheric knowledge base provides the possibility of indexing knowledge fragments according to several “knowledge maps”, whatever they are called.

Table 1: Noospheric properties in NKM.

Name of SUK property	Property value	Remarks
1. Sphere of phenomena	Physiosphere, biosphere, noosphere	«Spheric» approach, V. I. Vernadskyi
2. Layer of phenomena	To be determined upon necessity. Unlimited number of layers and levels. For example, infosphere (semiosphere, sign sphere), econosphere, etc.	Layer is a part of sphere of phenomena and the higher layer
3. Innovation (product, process, service)	Sequence number of product	Product is a part of sphere or layer of phenomena
4. Phase of development (cognition) of the sphere of phenomena	Pre-paradigm, paradigm, post-paradigm (scientific)	See PIDev model
5. Level of abstraction	Practice, technologies and constructions, applied theories, fundamental theory, mathematics, methodology, philosophy	See VIK model
6. Method of cognition (knowledge gaining)	Heuristics (assumptions). Empirics (experience, analogies). Immersion from the concrete to the abstract, rising from the abstract to the concrete. Modelling	See parabola of knowledge
7. Depth of innovation	Levels: practices, technologies, applied theories, fundamental theory, mathematics, methodology, philosophy	See VIK model
8. Modality	Problem (left branch of parabola of knowledge), solution (right branch of parabola of knowledge)	See parabola of knowledge

The users-participants of innovation processes determine these “knowledge maps”, wherein the noospheric map performs not only the described special functions of divergence-convergence of knowledge, but also serves as a “common denominator” for many other maps.

4 CONCLUSIONS

This paper suggests the idea of conceptualizing the knowledge, accumulated in computerized knowledge base and used in the process of production.

At the present time, historically developed system of knowledge with its division into natural and humanitarian knowledge is intensively diffused by the flows of heterogeneous knowledge about individual artefacts.

Every flow has a corresponding division of knowledge into subjects – the knowledge map. Still it is not possible to tell what of the maps is more adequate to the reality. Information and software apparatus of the knowledge base should provide a user with an opportunity to work with a multitude of knowledge maps, giving preference to one or another, i.e., to work with the multimap.

At the same time, we need a special knowledge map, guiding the innovator in space of knowledge, warning him of risky challenges and prioritizing him in the direction where the vertical of knowledge is filled with content or near to be filled, and, therefore, the paradigm innovations are highly probable.

In order to manage such knowledge base, we should use a flexible metadata base, built on the grounds of noospheric concept (PIDev model, VIK and parabola of knowledge). Moreover, to develop a flexible infrastructure of data, we should use the knowledge about sign constructions, gained as a result of paradigm innovation.

This article defines the general architecture and semantics of the noospheric innovation knowledge base, which defines the semantic structure (architecture) of its designating part (syntax). It describes the architecture of the object (array of knowledge). In the process of creating a knowledge base, it is necessary to develop its pragmatics and, accordingly, a pragmatic syntax which describes the processes of processing (selection, input, structuring, remembering, searching, assembling, displaying, etc.) of data. In addition, it is necessary to determine the structure of the syntactic syntax that reflects the state of the object, to develop and implement the organizational and software of the noospheric knowledge base as an important component of the enterprise innovation system.

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