Вісник Львівського університету. Серія філос.-політолог. студії. 2023. Випуск 50, с. 100–106
Visnyk of the Lviv University. Series Philos.-Political Studies. Issue 50, p. 100–106

UDC 165.194.3(324)
DOI https://doi.org/10.30970/PPS.2023.50.13

PARTICIPATION OF TACIT KNOWLEDGE IN SCIENTIFIC PROCESS

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Researchers of the phenomenon of tacit knowledge did not pay enough attention to the specifics of their participation in various stages of scientific research. Thoughts of the most outstanding scientists on this topic can be considered as meaningful sources of information of this question. Therefore, the purpose of the work is analysis of the role and functions of tacit knowledge in scientific research process based on the materials of self-observation and self-analysis of researchers-scientists of 20th century. The subject of the analysis was the first and the least researched stage of finding and formulating the research problem. Based on the reasoning of outstanding scientists of 20th century A. Einstein, A. Poincaré, J. Hadamard, we can be ensured that the deep prerequisites of theoretical choice have their origin in intuitively obvious ideas for a wide range of scientific community about the structure and characteristics of reality, which are "embedded" in the scientific theory. The most fundamental fragments of tacit knowledge take part in this process, which are equally determined by the cultural and historical environment, as well as by the personal characteristics and passions of a particular scientist. Such tacit knowledge forms the basis of "picture of the Universe" described by M. Polanyi in his work. It should be noted that the initial selection of the problem for research is carried out unconsciously from the material that is in an implicit form, so the choice can be influenced by displaced layers of tacit knowledge that are beyond the control of consciousness. Sometimes the displaced tacit knowledge becomes the cause of a negative choice, even rejection of one or another theoretical construction, as well as even "unfounded" forgetting of correctly posed problems. The analysis made it possible to come to the following conclusions. Acquaintance with the works of published scientists of the 20th century. proved that tacit knowledge is included in scientific and cognitive activity at its very first stages. At the beginning of the research, the most active is the deep layer of tacit knowledge – prerequisite, worldview, and others that are part of the general picture of the Universe. Their functioning in conjunction with purposeful logical thinking stimulates the activation of new, diverse types of tacit knowledge. The scientific novelty of the work lies in the fact that significant material was collected from the works of outstanding scientists, which not only confirms the active participation of tacit knowledge in research activities, but also allows us to analyse the specifics of this participation at various stages of the realization of knowledge.

Key words: scientific research process, stages of scientific research, cognitive system, tacit knowledge, implicit knowledge, self-analysis and self-observation of outstanding scientists.

Introduction. As is known, the term "tacit knowledge" was introduced into scientific use by M. Polanyi in his work "Personal Knowledge: Towards a Post-Critical Philosophy" [1]. But long before the 20th century, the most outstanding philosophers and scientists of the past paid attention to the unconscious components of cognition. However, Plato's "remembering", R. Descartes'

innate ideas, B. Pascal's "presuppositions", and I. Kant's a priori forms of knowledge, thanks to their formulation, allegedly "removed" these specific forms of knowledge from the "power" and control of the individual mind, that is, they had considered them as factors external to subjective human cognition. Polanyi's merit lies precisely in the fact that he was not only summarized the results of the thoughts of his predecessors, in particular, scientists, natural scientists, about the important role of tacit knowledge in scientific cognition, but also for the first time in the history of philosophy declared the existence of implicit cognitive components that is an integral part of the personal cognitive sphere of the subject of knowledge. It should be noted that Polanyi used the term "tacit knowledge", while in modern studies the concept "implicit knowledge" is quite commonly used, which is considered as a synonym.

Research by Polanyi's successors – M. Mulkay [2], G. Gilbert, T. Kuhn [3], J. Watkins, S. Papert and M. Minsky [4] – proved that tacit knowledge takes part in any cognitive actions of a person. In our opinion, particular importance for the theory of cognition is the analysis of the participation of tacit knowledge in the most rational and maximally conscious type of cognition – scientific cognition. Over the past half-century, this direction has received some (although, in our opinion, not enough) attention. We can mention, for example, the works of M. Melnychuk [5], in which tacit knowledge was the subject of analysis, analogous to the subject of any scientific research, that is, certain facts, data, etc. were investigated and rationally considered. We propose to approach this problem from a slightly different angle – to analyze how the participation of tacit knowledge in scientific research is perceived by the participating scientists themselves. It should be said that in the 20th century a significant number of scientists were interested in this issue, so we have enough material to analyse what role, according to scientists, tacit knowledge plays at various stages of scientific research.

Purpose and subject of research. So, the goal of our research can be formulated as follows: analysis of the role and functions of tacit knowledge at various stages of scientific research process, based on the materials of self-observation and self-analysis of researchers-scientists who took a direct part in scientific and cognitive activities. Accordingly, various types of tacit knowledge, which, depending on their characteristics, take part in the cognitive activity of scientists at various stages of their research work became **the subject of research**. It is necessary to remind that scientific research includes certain stages: search and formulation of the research problem, selection and implementation of empirical methods of obtaining data, interpretation of the received information, analysis, formula and mathematical processing of it, finding new, previously unknown regularities or characteristics of the object under study. But the volume of our work does not allow us to consider all of them in detail, so in this work we will focus on the analysis of the role of tacit knowledge at the first stage of scientific research, which has not yet attracted enough attention of researchers – the stage of problem selection.

Sources. In accordance with the set goal, we turned directly to the works of scientists – predecessors and contemporaries of M. Polanyi, who paid attention or even tried to analyse the place and participation of tacit knowledge in their scientific and professional activities. In our opinion, the important role in this topic has thoughts of A. Poincaré, who also Like I. Kant in his time, became interested in the question of how a scientist discovers something new, how researchers arrive at unexpected answers, how the process of scientific creativity takes place in general. He was not only independently reflected on these questions, he corresponded on this topic with many outstanding contemporaries, representatives of science of that time – A. Einstein [6], P. Dirac, M. Planck and others. The results of these reflections were embodied in several articles and essays by Poincaré [7]. An important contribution to the development of this issue was also made by the works of outstanding scientist of those times, J. Hadamard, who meticulously

analysed the process of scientific activity, particularly, and its creative component. Therefore, his works provide many materials for conclusions about the role of unconscious components at various stages of scientific research [8]. The particular interest are individual statements on this matter by such outstanding scientists as A. Einstein, P. Feyerabend [9], T. Kuhn [3], who, in one way or another, paid attention to the process of their own cognition and, particularly, on participation of unconscious components in it.

Main material and results. Based on self-analysis of creative process of famous scientists of their time (A. Poincaré, A. Einstein, J. Hadamard, G. Helmholtz, etc.), H. Wallace once proposed a scheme of scientific creative process, which remains acceptable to this day. This scheme includes four stages: the stage of preparing a scientific discovery; the stage of its "ripening"; a moment of sudden enlightenment; stage of the next inspection.

Most researchers associate the greatest subjective and psychological stress not with the initial stages, but with the moment of enlightenment, insight, the point of "emergence from nonexistence" of new knowledge [10]. However, the first stages of scientific research work should be considered no less important and no less "loaded" with unconscious components, particularly, searching for research problem, its more or less clear formulation, and associated identification of possible ways and directions for solving this problem. Identifying and posing a problem reveals the incompleteness of previous knowledge and thus is a necessary moment in transition to a new knowledge.

Problems not only separate one science from another in terms of content, but the problem also provides scientific research with a creative character. The choice of the problem coincides with the choice of research direction, which consists of solution efforts of the problem. That is why representatives of modern epistemology agree with the opinion of A. Poincaré that creativity and invention are, first of all, the ability to choose [7]. As a rule, the implementation of this choice begins with the orientation of the scientist in the problem space of his science and the subsequent determination of boundaries of a narrower problem area. It is necessary to emphasize that the initial orientation in the problem field of science directly depends on the unconscious fundamental theoretical ideas that each scientist has, which is the basis of any cognitive actions. The choice that a scientist makes at the first stage determines the entire course of his further work. In fact, this choice determines not only the direction or a specific problem, as a result, methods, ascending basic concepts/theories, mathematical apparatus, etc. are also "automatically" selected.

The deep prerequisites of the theoretical choice have their origin in the ideas of structure and characteristics of reality that are intuitively obvious to a wide range of scientific community, which are supposedly "embedded" in the scientific theory. Therefore, the implicit justification for theoretical preferences is the idea of the world and ways of knowing it, that is, a certain picture of the world, deeply rooted in the consciousness of people, including scientists of a certain era. It was this kind of prerequisites that complicated the relationship between traditional, classical and innovative, relativistic concepts at the beginning of the 20th century, when scientists had to choose between Newton's theory of gravitation and A. Einstein's general theory of relativity. According to him, this was a turning point that led to doubts in the ideas that were common among scientists at that time, in particular, the confidence that fundamental concepts and laws can be deduced from experiments by abstraction [6].

Both generally accepted, traditional concepts and those that replaced them can be classified as paradigmatic, in T. Kuhn's terminology, knowledge that is common to all members of scientific community. However, researchers often forget about the subjective "carrier" of the theory, its creator and interpreter, about specific scientist who makes a choice in favor of a certain theoretical construction. So, the choice between paradigms and theories is determined

not only by logic and experiment. Along with social and scientific-cognitive reasons, one can always find deep-personal motives, which quite often determine the final choice of theoretical basis for further research. In fact, the individual subject is the bearer of these "paradigmatic attitudes" and considers them through his own subjectivity. Kuhn also wrote that: "Each will have learned to translate the other's theory and its consequences into his own language and simultaneously to describe in his language the world to which that theory applies" [3, p. 202]. Thus, already at the stage of orientation in the general problem field of science, unconscious components and, tacit knowledge significantly influence the choice of a problem area for research and basic theoretical prerequisites. The most profound fragments of tacit knowledge take part in this process, which are equally determined by cultural and historical environment and personal characteristics and passions of a particular scientist. Such tacit knowledge forms basis of the "picture of the Universe", which M. Polanyi described in his work [1]. It can be assumed that this "picture" includes worldview, archetypal, prerequisite types of tacit knowledge. Therefore, it can be assumed that the role of the personal factor increases significantly at the moment of choosing a specific problem for research. Observing the activities of individual scientists, as well as their self-observation, makes it possible to assert that a conscious list and critical analysis of all possibilities is not only mandatory, but also impossible [8]. Modern researchers of scientific creativity agree with the statement that, in general, the selection of problems is mostly creative in nature, and this process requires intuition and experience rather than methodology. For example, J. Hadamard mentions a case when he studied one algebraic question (about determinants), guided only by the feeling that it deserves interest, but not seeing in its study a real benefit for science. Only seven years later, Fredholm's theory has appeared, for which the result obtained by Hadamard was quite significant [8].

Hadamard, by the way, was sure that, along with artistic or literary taste, talented researchers and inventors also have a scientific "taste". He agrees with Poincaré's opinion that in the process of choosing a problem, one of the important driving forces, a "guide" for a true scientist is "that invention is choice that this choice is imperatively governed by the sense of scientific beauty" [8, p. 31]. According to Poincaré, an intuitive sense of mathematical order, which allows us to guess harmony and hidden relationships, helps a scientist not only to feel the order in mathematical reasoning, but also to "see" the entire reasoning as a whole [7]. Sometimes this sense of beauty and perfection becomes a determining factor in choosing a problem for research.

It should be noted that the initial selection of the problem for research is carried out unconsciously from the material that is in an implicit form, so the choice can be influenced by displaced layers of tacit knowledge that are beyond the control of consciousness. Sometimes the displaced tacit knowledge becomes the cause of a negative choice, even rejection of one or another theoretical construction, as well as even "unfounded" forgetting of correctly formulated problems. There are also cases when a scientist, relying on his own subjective inclinations, defines for himself a certain theory as unscientific, while the closest scientific community holds a different opinion. At the same time, negative reasoning can be pushed out of consciousness, but it is not completely lost, it turns into the form of tacit knowledge and exists in this form, "waiting" for the moment for its actualization. Poincaré found himself in a similar situation, who categorically denied the necessity of Riemann's or Lobachevsky's geometry. He could not find suitable mathematical arguments for simplification, he referred to the authority of Kant to prove the unity and universality of Euclidean geometry, since it is an a priori form of human perception of the world, and therefore unchanging [7]. Thus, the internal subjective rejection of non-Euclidean geometry turned out to be so strong that it "overwhelmed" even mathematical and logical proofs, and forced to look for arguments of a worldview, philosophical type. In a

situation of choosing from several theories, such negative information, which is embedded in tacit knowledge, can block memory processes at an unconscious level. As a result, the subject cannot remember a certain theory at all, although it may be part of the context of all existing theories of this or that branch of science.

Another important and fundamentally unaware element of scientific creativity at the beginning is intuition. A. Poincaré was the first who paid attention to its special role in the choice of research paths. In a work on the role of intuition and logic in mathematics, he wrote "Pure analysis puts at our disposal a multitude of procedures whose infallibility it guarantees; it opens to us a thousand different ways on which we can embark in all confidence; we are assured of meeting there no obstacles; but of all these ways, which will lead us most promptly to our goal? Who shall tell us which to choose? We need a faculty which makes us see the end from afar, and intuition is this faculty. It is necessary to the explorer for choosing his route; it is not less so to the one following his trail who wants to know why he chose it" [7, p. 218].

Observations of modern psychologists have proven that formulation that arose in an "insightful" way becomes personally closer and more valuable to the author than the one that was obtained in a logical, analytical and rational way. The subjective feeling of correctness is not always possible to substantiate rationally and logically, especially at the first stage of research. Nevertheless, the researcher himself agreed to changes in the formulation of the problem with great unwillingness and only under considerable pressure. This testifies significant role of unconscious cognitive elements that they play in this case. It can even be said that the scientist's attitude to the problem, that he independently formulated is based not only and even not so much on emotions, including "intellectual" ones, but also on those ascending personal tacit knowledge, which, in fact, ensure the emergence of such formulation. The only argument in such cases, scientists quite often use the already mentioned "feeling of inner perfection", "aesthetic harmony", etc., since all actual scientific, experimental or theoretical and logical proofs have to be obtained [6].

At the stage of clarifying the formulation of the problem, a choice is also made between specific "competing" options. The review and analysis of these options, their evaluation for maximum adequacy to the ascending prerequisites are carried out simultaneously on the conscious-reflexive and unconscious levels. In these considerations, one can refer to Poincaré, who assumed the presence of a so-called "filter" in the situation of choosing a problem. In his opinion, a similar role is played by the already mentioned sense of beauty, which, according to him, "commands the process of choice" [8]. Judging by his memories J. Hadamard was guided exclusively by the influence of such feeling when choosing the topic of his doctoral dissertation. He recalled that first, he could not logically justify his choice. Verbal argumentation arose much later, already in the process of direct research [8]. Based on one of the modern typologies of tacit knowledge [11], we can assume that in the composition of such "filter" a special role will be played by those types of tacit knowledge that have a predominantly extrapersonal source – this is objective and paradigmatic tacit knowledge, well-known, anti-paradigmatic. However, it must be emphasized that, next to them, for the final conceptualization of the problem, such types of tacit knowledge as systemic and contextual, which provide personal content to any conceptual fragment of human knowledge, have essential importance.

Conclusions. Therefore, the analysis of opinions of scientists of the 20th century about the role of unconscious components in their scientific activity made it possible more accurately and meaningfully consider the participation of tacit knowledge in the activity of scientist at the first stages of scientific knowledge. We see that tacit knowledge is actively functioning from the first moment of acquaintance with the problem, even from the moment of its search. Primary information "triggers" certain fragments of tacit knowledge, then other complexes of

tacit knowledge will be added to them gradually. At the beginning of the research, the most active is the deep layer of tacit knowledge – prerequisite, worldview, and others that are part of general picture of Universe. Their functioning in conjunction with purposeful logical thinking stimulates the activation of new, diverse types of tacit knowledge. In the process of processing fact information, one of the most important and very essential advantages for cognitive activity of tacit knowledge is realized – the possibility of simultaneously processing information at several levels of unconscious and using various types of tacit knowledge. It is quite likely to assume that representation/information about the same fragment of reality, which is contained in paradigmatic, common knowledge, hidden and another tacit knowledge, will always be different. Therefore, the results obtained in the process of unconscious analysis of these ideas can and will have certain differences.

Acquaintance with the works of J. Hadamard and A. Poincaré demonstrated that scientist not always aware of the role of these tacit components in his work. Sometimes he guesses about their participation in the creative search only after its completion. However, thanks to the given examples of self-analysis of outstanding scientists, we have the opportunity to accurately and fully imagine the principles of action of tacit knowledge, variety of their participation in scientific research process, etc. It should be emphasized that with all the variety of tacit knowledge that takes part in one or another cognitive action, they do not function in a chaotic manner. Tacit knowledge is structured in a certain way, depending on the content of the problem that the scientist solves/researches, while at each stage of cognitive process, a specific structure is created to solve a specific narrow problem. Thus, it can be concluded that further analysis of works of famous scientists, which in one way or another relate to the process of obtaining new knowledge, will provide an opportunity to investigate the problem of tacit knowledge more thoroughly as an element of unconscious cognitive system of a person.

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УЧАСТЬ НЕЯВНИХ ЗНАНЬ У НАУКОВОМУ ПРОЦЕСІ

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Дослідники феномену неявних знань не приділили достатньої уваги питанню про специфіку їх участі у різних етапах наукового дослідження. Одним із змістовних джерел інформації щодо цього питання можна вважати роздуми на цю тему самих видатних науковців. Тому метою роботи є аналіз ролі та функцій неявного знання у науково-дослідному процесі на основі матеріалів самоспостереження та самоаналізу дослідників-науковців XX ст. Предметом аналізу став найперший і найменш досліджений етап пошуку і формулювання проблеми дослідження. Спираючись на міркування видатних вчених XX ст. – А. Ейнштейна, А. Пуанкаре, Ж. Адамара, можна впевнитись у тому, що глибинні передумови теоретичного вибору беруть свій початок в інтуїтивно очевидних для широкого кола наукової спільноти уявлень про структуру і характеристики реальності, які «вбудовані» в наукову теорію. В цьому процесі приймають участь найбільш фундаментальні фрагменти неявних знань, які в однаковій мірі визначаються як культурно-історичним середовищем, так і особистісними особливостями й пристрастями конкретного вченого. Такі неявні знання складають основу «картини Універсуму», яку описав у своїй роботі М. Полані. Слід відмітити, що початковий вибір проблеми для дослідження здійснюється неусвідомлено з того матеріалу, який знаходиться у неявній формі, тому на вибір можуть впливати витіснені пласти неявних знань, які знаходяться поза контролем свідомості. Іноді витіснені неявні знання стають причиною негативного вибору, навіть відмови від тієї чи іншої теоретичної побудови, а також навіть «необґрунтоване» забування правильно поставлених проблем. Проведений аналіз дозволив прийти до наступних висновків. Знайомство з роботами виданих вчених XX ст. довело, що неявні знання включаються до науково-пізнавальної діяльності на самих перших її етапах. На початку дослідження найбільш активним є глибинний шар неявних знань – передумовні, світоглядні й інші, що входять до загальної картини Універсуму. Їх функціонування сумісно з цілеспрямованим логічним мисленням стимулює активізацію нових, найрізноманітніших типів неявних знань. Наукова новизна роботи полягає у тому, що було зібрано значний матеріал з робіт видатних вчених, який не лише підтверджує активну участь неявних знань у науково-дослідній діяльності, але й дозволяє проаналізувати специфіку цієї участі на різних етапах здійснення пізнання.

Ключові слова: науково-дослідний процес, етапи наукового дослідження, когнітивна система, неявне знання, імпліцитне знання, самоаналіз та самоспостереження видатних вчених.