

Scientific Creativity Triple Determination Patterns

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Abstract—Three main factors are identified that determine the appearance of discoveries and inventions in science and technology: intra-scientific (logical and empirical); extra-scientific (sociocultural) and personal (mental). Their relationship and interaction are considered. It is shown that the first factor is studied in detail in the framework of internalism, the second in the framework of externalism, and the personality factor is experiencing a shortage of analysis. The category of mentality is proposed to use for studying the role of the individual in the scientific and technical progress. The purpose of the paper is to substantiate the principles of the new concept — the concept of triple determination of the creative process: the sociocultural factor provides an order for discovery, intra-scientific — gives a historically formed cognitive basis for solving the problem, and in the personality factor — the creator's mentality — the original superposition (superposition) of intra-scientific and sociocultural parameters is implemented uniquely transformed by a subject based on knowledge, intuition, faith, will, which leads to innovative scientific and technical progress. The connection of the three determinants noted can be called the law of the triple determination of scientific and technical work.

Keywords—the dynamics of scientific knowledge; mentality (set of mind); internalism; externalism; simultaneous inventions; premature inventions; the law of triple determination of scientific creativity

I. INTRODUCTION

With the increase in the proportion in modern culture of such a form of spiritual production, like science, the importance of comprehending the laws of scientific creativity also increases. When analyzing the process of discovery in science and inventions in engineering, the following main factors can be distinguished: 1) intra-scientific — new empirical data, immanent logic of the development of scientific knowledge and the general level of development of science and technology at the moment, prepared by the entire course of their history; 2) non-scientific - social and cultural conditions, including the “social order” from the society; 3) personal - the creative personality of a scientist or inventor, among the mental features of which an important place is occupied by the

ability to grasp the social need for a particular discovery, invention and effectively satisfy it. The significance and interaction of these three factors may change at different times, but as a result of the acceleration of changes in nature and society and the shortening of periods between phase transitions, in this case between scientific revolutions, the role of the scientist's personality sharply increases, which makes its study particularly relevant [1].

If the first factor of the development of science — the immanent logic of the development of scientific knowledge — is studied in sufficient detail in the framework of *internalism*, the second factor — sociocultural conditions — in the framework of *externalism*, the third factor (containing a kind of creative overlapping of intra-scientific and extra-scientific parameters) — the identity of the creator — incurs a deficit of analysis. Therefore, the processes of interaction of external and internal factors in the generation of new knowledge are also insufficiently disclosed. In our opinion, the category of mentality (or mentality) may have a heuristic value for comprehending the essence of creativity, since the socio-psychological characteristics that make up the mental content of the subject of science create a unique “interference pattern” of overlapping intra-scientific and extra-scientific factors transformed by the subject [2].

II. ROLE OF MENTALITY IN SCIENTIFIC CREATIVITY

The scientist, in accordance with his mentality, produces a creative interpretation of new empirical data and, in its relation, develops only certain possibilities from the inner potential of the existing knowledge. The scientist also perceives the social needs that give rise to a scientific problem, correlates the cognitive possibilities that he has discovered, selectively uses the available material and cultural resources, and ultimately solves the problem that has arisen.

Among the post-positivists there is a different understanding of the structure of scientific knowledge and the following result is the separation of the various components of culture into internal and external in relation to science. Thus, according to K. Popper, the process of

discovery of scientific laws is an external factor for the dynamics of science, and for M. Malkei and J. Gilbert - an internal one. According to the majority of post-positivists, psychological and social determinants belong to the external history of science, whereas T. Kuhn, M. Polani, and P. Feyerabend partially include them in the "internal history" of science [3]. Therefore, the role of the individual in science is difficult to adequately describe, being only in the framework of an internalist or externalistic model of the dynamics of scientific knowledge: some components of the problem will not be taken into account, and there will be some discussion about their identification as internal or external. Therefore, it is advisable to consider all three factors in each scientific event and especially carefully select the third factor as an independent one - the personal one. It seems to us that the category of mentality will be useful for the successful achievement of the latter goal. It is the mentality in the composition of the spiritual world of the subject (consciousness and unconscious) that determines the direction, originality and novelty of any activity. We give a brief description of the intra-scientific and extra-scientific factors and demonstrate how the original superposition (overlapping) is carried out in the mentality of the creator, leading to an innovative scientific and technical result.

We preliminarily note that internalists regard scientific knowledge as a self-developing system, the content of which does not essentially depend on the characteristics of various subsystems of society — economics, politics, philosophy, religion, etc. Such a point of view was defended by A. Koyre, R. Hall, P. Rossi, G. Gerlak, K. Popper, I. Lakatos. Internalism has the following negative features: immanentism; the underestimation of the social and subjective nature of scientific knowledge; ignoring the cultural motivation of scientific activities; lack of understanding of the background nature of any theoretical constructs. Positive features are: underlining the qualitative specificity of scientific knowledge, continuity in science, the focus of scientific knowledge on objective truth. The main conclusion from the real history of science correlates with the position of internalism, which consists in the fact that the cognitive changes taking place in it have an evolutionary one, i.e. directional and irreversible [4]. So, the general Riemannian geometry could not appear earlier than Euclidean, and the theory of relativity and quantum mechanics - earlier or simultaneously with classical mechanics. Internalism easily explains such phenomena as simultaneous and independent discoveries. In science, many laws have a dual name: for example, the Boyle – Mariotte law or the Lomonosov – Lavoisier law [5] [6].

These and similar facts, from the internalism point of view, are a natural manifestation of the objective logic of the development of scientific knowledge, testify that the described discoveries were prepared by the whole previous course of the development of knowledge. The interactiveists are right in case the discoveries serve as a manifestation of the logic of the development of science. However, here you can also find a powerful manifestation of the personality factor. Of the three people who created mathematical manipulations (G. Lorenz, A. Poincaré, A. Einstein), only

one — Einstein became the creator of the theory of relativity and was able to produce an original physical interpretation of the resulting mathematical apparatus. The reason for this is the mental features of these scientists. Lorenz was too committed to classical physics and could not abandon traditional ideas about time and space. Poincaré was ready to abandon them and was not susceptible to dogmatism, but did not believe in the objective reality of space and time. In the mentality of Einstein, a kind of synthesis of Spinozian pantheism was made with the results of modern experimental natural science. The belief in the objective existence of physical reality, its knowability, the indispensable role of experience, a posteriori character of the concepts of space and time allowed Einstein to become the author of the theory of relativity [7].

Externalists believe that the main source of innovations in science and technology are the social needs and cultural resources of society, its material and spiritual potential. B. Gessen, J. Bernal, E. Zilsel, D. Nidam, T. Kuhn, P. Feyerabend, M. Malkei, M. Polani, L.A. Kosarev, G. Gachev and others were on the same page. The weak side of externalism is a clear underestimation of the relative independence and independence of science in relation to the socio-cultural infrastructure. When assessing the role of a person by some externalists, it is possible to underestimate it (the Marxist tradition), or to hypertrophy and slide it into the position of absolute relativism and subjectivism (P. Feyerabend). The role of the individual lies in the fact that it, having a high ability to capture social needs, manifests creative selectivity in relation to the existing cultural potential, choosing from it certain resources that she uses in processing relevant scientific knowledge, in our opinion, this is the correct solution of this problem. As a result of such processing, only certain specific possibilities unfold from the internal potential of existing scientific knowledge, which constitute the novelty and originality of the emerging theory [8]. As was mentioned above, Einstein did not use the entire philosophical legacy during the theory of relativity creation, but chose ideas that correlated with his mental attitudes and for which he saw the possibility of fruitful formulation of his theory, which crystallized as an innovative and original phenomenon from the entire array of cash scientific knowledge.

The strength of modern externalism is that only from its position "can adequately explain such facts from the history of science as qualitative leaps in the development of scientific knowledge, as the "unruly" behavior of scientists during scientific revolutions, as partial incompatibility of scientific eras and the change taking place fundamental theories in all areas of science, as a competition of hypotheses and programs, as a struggle for priorities in science, etc.?"[9] The influence of social conditions on the acceleration or deceleration of the appearance of discoveries, inventions is discernible in various fields of activity. This is especially discernible in military technology, where the social order dramatically activates the emergence of certain innovations. The important role of the formation of social welfare by the society, adequate to the growing rational knowledge, is noted N.N. Gubanov in his concept of calling

Apollo [10]. The authors of an adequate response to this challenge, which consists in designing a new social security that causes a positive increment of rational knowledge, are, as a rule, representatives of the spiritual and political-administrative, in particular, educational elite.

If such facts in the dynamics of scientific knowledge, as simultaneous discoveries, are well explained by the action of the intra-scientific factor, the acceleration and deceleration of discoveries - an extra-scientific (sociocultural) factor, then the best demonstration of the action of the personality factor are premature discoveries and inventions. Thus, the brilliant mathematician Euclid (3rd century BC), in his famous work, *The Beginning*, developed the foundations of mathematics: elementary geometry, theory of numbers, general theory of ratios, and the method of determining areas and volumes that include elements of the theory of limits. His pupil Apollonius (ca. 260 - ca. 170 BC) gave a full exposition of their theory, developing both analytical and projective methods. For explanation built the theory of epicycles. All the evidences of Apollonius were purely geometric. Geometric algebra in his works reached far ahead of the day results. And only in the 17th century, Apollon's reasoning was translated into algebraic language by the creators of analytic geometry, Descartes and Fermat. His theory of second-degree curves was also ahead of the day. In his works, Apollonius was far ahead of the day and is rightfully considered as a founder of analytical geometry. And there are many such examples in the history of science [11].

III. IMPORTANT COMPONENTS OF SCIENTIFIC MENTALITY

As noted, when studying the personal factor in science, the category of mentality has the greatest heuristic potential. The mentality, representing a set of socio-psychological characteristics of the subject, determines its specific perception of the world and the special, original character of its activity. Since the external forms of manifestation of personal internalities, consciousness and the whole psyche of a person are speech, behavior and activity with its objective results, the study of mentality requires the establishment of appropriate verbal, behavioral, activity and subject indicators. The results of the activities serve as forms of objectification of the mentality. The main sources for the study of scientific mentality are the technical devices created by scientists, scientific and philosophical texts, the memoirs of the authors themselves and their contemporaries, correspondence with other scientists, facts of biography, etc. The category of mentality allows us to deal with the matters about why this discovery was made by this scientist and not by another, who had the same cognitive basis, and also why the scientific community easily accepts one new idea and does not accept another for a long time.

The following features of the scientific mentality are usually noted: love to truth and intellectual honesty as a result, imagination and criticism, independent thinking, the ability to grasp social needs, courage and perseverance in achieving the goal, faith in yourself and the capabilities of science, the desire to improve people's lives, depth of knowledge in professional field, breadth of vision and good general erudition. It is worth noting that a productive

measure requires a reasonable measure in the intensities of these and other characteristics. Science makes conflicting demands on the scientist: on the one hand, he must be free from stereotypes and strive for the new, and on the other, he must defend fundamental scientific principles in order not to slip into pseudoscience [12]. Therefore, a very important mental feature of a scientist is a combination of the feeling of the new with reasonable skepticism and extreme caution. Deviation to or from here can lead either to dogmatism and stagnation, or to pseudoscience.

Let's turn our attention to such an important mental feature of the scientist as cognitive will. Thanks to it, "endless regression is terminated in the empirical and theoretical substantiation of the scientific concept, and the partial underdetermination of any piece of knowledge that always takes place is overcome. Cognitive will lie at the basis of the subject's acceptance of the decision about the truth of a fragment of scientific knowledge" [13]. Every will has its inevitable companions certain courage. Bruno, Copernicus, Lobachevsky, Cantor, Einstein, Pavlov, Landau and their cognitive behavior are the most vivid examples of the demonstration of this crucial component of the scientific mentality. In this context, Einstein's famous statement that Dostoevsky has given him as a scientist more than Gauss has become clear. What could the works of the Russian writer give the genius physicist more than the works of the recognized king of mathematics of the 19th century? In our opinion, awareness of freedom and responsibility is the generic properties of a person as a knowing subject. Therefore, the young Einstein was able to throw the most decisive challenge to classical mechanics. But F. Gauss did not become the creator of non-Euclidean geometries because he was afraid of the public opinion of mathematicians. N. Lobachevsky and Y. Boyai decided to take this step, but the mathematical community gave them a powerful obstruction, and its creators died without experiencing the joy of recognizing their accomplishment.

IV. CONCLUSION

In scientific creativity, both objective and subjective moments are important. Objective non-scientific factors are social needs and cultural potential. In the mentality of the creator, these objective parameters are refracted into subjective moments derived from them - the subject catches any need, he has the motivation to solve it, and he chooses some specific resources from the present cultural potential for processing and transforming the actual scientific knowledge [14]. Objective intra-scientific factors are new empirical data and immanent logic of the development of scientific knowledge. The subjective components derived from them are the creative interpretation by the subject of new empirical data and the selection from the existing potential of scientific knowledge only some meanings for realization and theoretical unfolding. Thus, in the mentality of the creator, there is first a subjective transformation of extra-scientific and intra-scientific parameters, and then a unique imposition of the received transformations. This explains the uniqueness of the creative result in which the role of the individual in scientific knowledge is maximally

manifested. There is a pattern of the increasing role of the personality factor in science over time, which makes the study of the mental determinants of scientific creativity a very relevant and promising research direction. As a hypothetical assumption, we assume that the study of the mentality of a scientist can have a practical application in the classroom with graduate students - for the formation of our future scientific elite.

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