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**SCIENTIFIC-TECHNICAL CREATIVITY IN STRUCTURE OF  
PEDAGOGICAL KNOWLEDGE**

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*Abstract*

The paper is devoted to the study of scientific and technical creativity, its role and place in the structure of pedagogical knowledge. In theory and practice of pedagogy the question of equal rights, the range or hierarchical dependence of some forms of knowledge in comparison with others is inevitably raised. The solution of this issue is necessary in creation of a new education methodology in the modern reality, because in the modern world there are growing demands for the creative abilities of specialists who form new knowledge or create new technical tools and technologies. The article analyzes some approaches in understanding the essence of scientific and technical creativity, provides a comparative analysis of existing approaches to the study of creativity in modern science, activity and amateur activities, identifies the essential aspects of the socio-cultural conditionality of the activity of human itself as a subject of creativity. This approach makes it possible to organically derive such predicative characteristics of an activity as its content, form, and character. The paper shows the characteristic features of the modern stage of development of scientific and technical creativity, which allows one at the theoretical and practical levels to develop a foundation for solving multidimensional problems faced today by science, technology and pedagogy.

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**Keywords:** scientific technical creativity, activity, development, culture



## 1. Introduction

The rapid development of science and technology significantly changes not only the nature of society's life, but also the nature of man himself, his way of thinking and feeling, his physicality and ways of existence. The essence of science and technology, laws, the stages of their development, the complex and controversial nature of the consequences of scientific and technical activities – all this becomes the object of research in the twenty first century in such areas as philosophy of science and philosophy of technology. Modernity is characterized by a significant transformation of scientific rationality, the emergence of a fundamentally new transdisciplinary methodology of knowledge, an unprecedented increase in the technical capabilities of humanity. Transdisciplinarity entered the practice of science and is particularly relevant in connection with techno-science and convergent technologies. Transdisciplinary research, compared with interdisciplinary one, distinguishes the way out in the practice of life, is a socially distributed production of knowledge (Chernikova & Chernikova, 2017). In this regard, the nature of engineering and research activities is changing, requirements for methodological and ethical culture, and especially for the creative abilities of specialists who form new knowledge or create technical tools and technologies, are increasing (Kirillov, Leontyeva, & Moiseenko, 2015; Maksimova & Zeremskaya, 2015). First of all, one need to understand all aspects of the system connections or the constructed object under study, including social, ethical, economic and environmental ones, to be able to calculate the potential impact of new knowledge or new technology (Belov, 2001). A scientist or engineer of the twenty first century must be ready for creative rearrangement of his/her own world, and thus he/she should understand its origins and foundation, while the occupational career in science and technology in terms of changes of its models should be based on ideas and principles of sustainable development aimed at long-term and humanistic goals (Popova, 2017). In modern pedagogy, a lot of attention is paid to issues related to the development of creativity in students (Karpov, 2018; López, 2015; AichouniTouahmia, Al-Ghamdi, Ait-Messaoudene, & Al-Badawi 2015; Pecheanu & Tudorie, 2015). It should be considered that despite the level of trust in scientific knowledge, one should not lose sight of its historical and social nature, should not be tempted to mythologize creativity, science and technical progress. Knowledge of the history of the development of scientific concepts, principles, understanding of the basic methods of knowledge, understanding the nature of technology and the essence of scientific and technical creativity will allow one to work effectively with a mindset that is based on the scientific picture of the world.

## 2. Problem Statement

Modern researchers interpret scientific and technical creativity in different ways. Thus, in the humanitarian tradition of the philosophy of science and technology, the idea of freeing man from the power of nature through technology is being reinterpreted. German and American philosopher, cultural scientist, sociologist H. Marcuse, for example, argues that nature should not be controlled by means of science and technology. He believes that in order to become guides of freedom, science and technology must be rebuilt in accordance with the new perception of the world – with the requirements of life instincts. Science and technology must be qualitatively transformed on the basis of a new non-repressive (no longer following the path of conquest, the conquest of nature) mind. In essence, a program is formulated for humanizing and humanitarization of the mindset as an expression of human essence.

Representatives of the Frankfurt School T. Adorno and M. Horkheimer treat “technological reality” as the realization of a western (masculine) type of culture, which is characterized by instrumental rationality towards formalization. Emotional, reflexive, playful components are eliminated from human consciousness, and creative activity is removed from human activity. This leads to the domination of mass and consumer culture, the regress of moral principles.

M. Euth and E. du Bois-Reymond reflecting on the specifics of scientific and technical creativity, distinguish between invention as a mental event, similar to the artist’s inspiration, and a material artefact. M. Euth also emphasizes the difficulties of introducing a technical invention and offers a classification of types of inventions.

An extraordinary understanding of scientific and technical creativity is proposed in the concept of expertocrat. The latter is based on the idea of forming a “new class”, which is understood as a group of highly educated specialists. The income of this new class is not determined by the property, but is directly proportional to the intellectual and creative potential. The expert, a specialist, scientist, possess not only a high and in many respects universally-common cultural potential, but also a culture of critical discourse. In this case, discourse is the mean with which the new class of intellectuals (experts) seeks autonomy in society. The creative free idea of intellectuals, being socially oriented, dominates, which makes it possible to speak of an expertocracy.

In the framework of the concept of neotechnocracy, which emerged at the end of twentieth century, an attempt was made to synthesize technocracy and expertocracy. Here scientific and technical creativity is still conceived as one of the determining factors of the social process. However, this development needs evaluative and corrective controls and intervention of experts, and, moreover, not only a special technical, but also a broad humanitarian profile. Specialist in one of the fields of applied physics, entrepreneur, brilliant lecturer, neotomist philosopher F. Dessauer believed that the essence of technology should be sought in the act of technical creativity, where not only natural laws are combined (technology is created in accordance with the laws of nature) with human goals but also where certain area of “pre-given solutions of technical problems”.

### **3. Research Questions**

The philosophical aspect of scientific and technical creativity is distinguished by a number of features. Scientific and technical creativity is usually considered in the intellectual sphere, which can provide an understanding of this phenomenon at the level of rationality. In this case, often, attention is focused on significant, but secondary and derivative factors, means, conditions, results, and not on the ontological level of consideration of scientific and technical creativity. Correspondingly, the question arises about its determinants, about the factors of its sociocultural and subjective-personal conditionality. Creativity takes place in the ratio of such categories as "relationship", "activity" and "culture". Understanding a person as an "ensemble of social relations", as an "active being" and as a "subject of culture" allows one, in the first approximation, to consider the categories "relations - activity - culture" as genetically and meaningfully related. Activity is the process of producing and reproducing social relations, the process of translating natural interactions into artificial, social and cultural relationships. That is, those in which the goal-setting and purposeful dominants of culture are mediated by human needs, abilities,

interests and goals “freeze” in an objective form. These relationships, constantly evolving, are the resultant indicator that can be integrated as socialized. And the person is a personified carrier of socialization. Although the category of relationships in an implicit form contains its own dialectical contradiction, it does not yet reveal this dialectical contradiction in a theoretically mature form. Activity, as a category, has a broader methodological, ideological, heuristic potential, since it combines the subject, conditions, means, subject and purpose of the activity - that is, everything that allows us to speak of a theoretically concrete, enriched with logical definitions of the object mapping. This makes it possible to organically display such predicative characteristics of the activity as its content, form and character. The activity itself, while actualizing its potential, predetermines the conclusion that it is the essential and genetically direct basis from which creativity arises. Therefore, activity is common, and creativity is the universal way of humanity existence

#### **4. Purpose of the Study**

The paper aims to develop a theoretical and methodological basis for the study of scientific and technical creativity in education, contributing to the development of effective social adaptation and increase the level of individual vitality. To accomplish this, it is necessary to determine the place of scientific and technical creativity in the structure of pedagogical knowledge, identify the essential characteristics of activity and creativity, show the specifics of scientific and technical creativity and consider innovation as a system, as a way of mental actions contributing to the attainment of knowledge by subjects of scientific and technical problems associated creativity and ability of its utilizing for obtaining new knowledge.

#### **5. Research Methods**

The methodological basis of the study consists of the general scientific principles of development, systemic integrity, determinism in the study of scientific and technical creative activity; culturally-historical, activity and anthropological approaches to the study of socio-pedagogical processes and engineering thinking (Cheshev, 2016a). This theoretically-methodological principle allows integrating in the study the elements of traditional socio-humanitarian branches of knowledge and pedagogy that are necessary for solving its specific tasks, heuristic potential, overcoming disciplinary barriers, taking into account the diversity of social practices objectively established around modern education. As a theoretically-methodological basis of the study we used: an activity approach, in which the category of subject activities was developed by M. Y. Bass, C. Rubinstein, A. H. Leontiev, V. V. Cheshev (Cheshev, 2016b); a dialectic method presented in papers Hegel (1972) and his followers; a philosophical anthropological concept of culture and creativity, which considers the essential equilibrium of human existence to be the dynamic equilibrium of individual collective life activity within a certain sociocultural model of development (Bazhutina & Bazhutina, 2014). The study also uses theoretical methods: critical analysis, comparative analysis, a hypothetical-deductive method.

#### **6. Findings**

In what way is the activity fundamentally different from creativity? The fact is that in the creativity human lives in the mode of constant going beyond the limits of existence, in the mode of transcendence,

transgression. Constantly transcending himself in existence, in scientific and technical creativity, a person can never outweigh himself in essence precisely because this essence is in creativity, in constant going beyond the limits of what has already been established, realized, acquired, created, cognized, learned. This is where the substantive rootedness of the objective foundations for the imperative "human - goal" is rooted. If an activity is a way of producing and reproducing a society, then creativity is a way of producing a humanistic public, a way of producing a fully socialized, or otherwise directly public person. In the activity, there is a deformed interaction of the goal-setting - goal-realization moments, that is, an interaction in which a unidirectional process dominates: the impact and its perception. In the activity there is an undeformed interaction of goal-setting and goal-realization, carried out as a dialectical contradiction. At the same time, excessive activity of individuals is fraught with a culture of loss of developmental stability; insufficient activity of members of culture leads to the elimination of the culture itself. If there is enough activity for the production of culture, then for the production of a humanitarian culture, a true culture the creativity is necessary. A culture that awakens to activity is syncretic. There are elements of humanistic culture, and its transformed forms - subculture, pseudo-culture, and anticulture. The culture that is brought to life by creativity is the existence of humanity in the global, humanistic dimension. The way of such existence is creativity. The practical universality of these cultures is formed as a practical universality of history and formed on the basis of prehistory, and on the basis of activity a practical universality of creativity is formed. Both a cultural (creative) person and a humanized (humanistic) person are completely socialized persons. The subject of history, creativity of history, creativity of freedom. Both the cultural society and the humanistic society are the true associations of true people, thanks to which the only possible, free, creative, amateur individual, creator. Thus, creativity is opposed to activity only as "creativity in general" - "activity in general." The special meaning of the latter for creativity is just as random and insignificant as the private and consumer-cultural value that creativity produces. Creativity is an activity in conditions where each person is practically carried out as a goal, limiting the imperativeness of real humanism only to the level of obligation.

Creativity as such (as well as matter, as development, activity) is not empirically manifested. Therefore, a unified theory of creativity is impossible. In each of the existing concepts under creativity is meant only the general case of a complex of certain social interactions and their results. Another thing is that psychological and aesthetic, ethical, pedagogical, heuristic, and any other theoretical and empirical studies of the problem of the same scale that are integratively defined by the notion "creativity" are something special that mediates the act of creativity as a unity and the process of creativity as a general. The ontologically individual and the general prepare the empirical and theoretical basis for the permanent development of the philosophical theory of creativity, and with the creation of the latter, they also find their public explanation, receive a reliable methodological and ideological basis.

Consciousness, understood as the highest form of reflection, tends to be relatively independent and thus not only capable of adequate, true reconstruction of the past, reproduction of the present, but also, due to the property of anticipation, is capable of scientific prediction of the future (Krymsky, 2003). At the same time, consciousness carries in itself the possibility of knowingly false and illusory (pre-, anti, and outside of scientific) speculative construction of reality in certain fragments and parts of it. And in the event that these are questions of a philosophical scale and order, then the construction of images of reality and

reality as such. The realization of the opportunity to practice this is the essence of the transformed forms of thinking, sensuality and practical action. Only from the standpoint of understanding creativity as a humanistic type of social form of the matter development, creativity as truth and the essence of activity, the development of society is understood as a philosophical problem. Just as the discovery of the law of unity opposites allowed us to understand development from its source as it really is, to understand it as self-development; in the same way, the understanding of the essence of the social form of the development of matter - activity can only be considered scientifically and philosophically understood when an activity is viewed as self-activity. In activity, a person is determined by the action of factors external to him and determinants. In self-activity, it is self-determined. A philosophical reflection of this state of affairs, respectively, emerges: the point of view of a person as a passive being, perceiving influence from the outside, as a means, reduced only to a certain function. At the same time, the category of "self-activity" will not show all its methodological, ideological and heuristic possibilities, unless it is dialectically distributed according to the type "I am different - everything". From the point of view of non-classical science, in the context of Boltzmann's determinism with inflexibility and the significance of distribution, it is a sociocultural form of the permanent process of removing limits, removing the actual limitations of human activity. Distribution is a social form of breakthrough, overcoming this limit, these boundaries. Consideration and understanding of creativity as the distribution of self-activities, that is, considering it as the realization of dialectical contradiction as a relationship of opposites of a single entity (remember Hegel: "in essence everything is relative") is a very promising and productive vector for further research on the problems of creativity.

Scientific and technical creativity, as well as activity, is a formative process. : the process of creating unnatural, artificial forms of nature itself - cultural forms. However, unlike activity, creativity in the form of practical universality is the creation, mastering and use of culture and presupposes the existence (in the form of practical universality) of humanism. Such creativity is a permanently carried out dialectic process, the twofold moments of which are the creativity of freedom and freedom of creativity. The objectivity of the creative process, as well as each of its acts, is determined by the fact that creativity, being a form-building process, always deals with objective content. It can be successfully carried out only under the indispensable condition that is consistent with the already truly scientifically known (or not yet known, but such that it is forced to reckon with) dependencies of reality. And from this point of view, objective dependencies act not as something that limits and creates the freedom of creative exploration of reality by the subject (man, people, society), but as the most important condition of creativity and freedom itself. On the other hand, absolutization of this moment is inadmissible. Absolutization is able to reduce all creativity, including its elusive ingredient as the sacrament of creativity, only to a certain kind of determinism or a simple teleological process; capable of giving this infinitely ambiguous, multidimensional and complex process a taste of fatalism, and as a result - not leaving room for its own creative work.

Human itself is no less valuable condition for existence of creativity. A person with his historically developed and permanently developing essential forces - inclinations, abilities, needs, knowledge, experience, responsibility, activity, beliefs, conscience, genes - can create. Create freely, create the story itself in line with the vector of progressive development of this story. A person, transforming the objective world (and thus the world of his own subjectivity), is able to act successfully only if he connects himself to

this world. The connection as a natural (objective) force, but such a force that is capable, considering its subjectivity, of shaping this world. First of all, of its normative transformation, of the generation of its new forms (potentially infinite and inexhaustible), of the translation of natural interactions into artificial, cultural, or - of transfer them into the form of social relations. Such a development (creativity) is always expedient, i.e. the nature of a harmoniously carried out two-way process: goal-setting - goal-realization, and meets well-defined - humanistic - definitions of axiological order. But in any manifestation, directly or indirectly, creativity is not isolated from natural and artificial realities, from the reality of existence. At the same time, it is necessary to proceed from the fact that an understanding of a person's historical freedom must necessarily include freedom both in relation to objective reality and in relation to his own social and personal nature. The first acts as an inexhaustible substrate of material, spiritual and sensual formative self-activity, and the second - the complex of developed reality, which is a social, cultural entity. And this last one is decisive, since in the "second nature" in the removed form the first one is present, and together they constitute the transcendental substrate of human. Such a substrate is to be transformed into the human world, which, in turn, is possible provided that the activity is transformed into creativity, and the need - into freedom.

Scientific and technical creativity is inexhaustible. Inexhaustibility is due to a dual objective-subjective factor. First, the objective world itself is inexhaustible. And therefore it is inexhaustible, infinite and objective dialectics. Secondly, the levels of expediency itself are inexhaustible and limitless, conditioned by human abilities, talents, needs, interests, experience, knowledge, etc., and they dynamically increase in the process of creativity. Consequently, only the point of view of scientific and technical creativity, as the limitless field of deployment (actualization) of the generic essence of man, allows us to overcome the traditional limitations. There must be a certain marginal, transitional period in the development of society (a person culture, history, freedom, humanism), which is characterized by its decisive, dominant indicator, namely the process of transformation of scientific and technical activities into scientific and technical creativity: it is no longer an activity, it is not yet creativity. And then what? The creative activity of scientific and technical society.

It is well known that the most difficult to learn are just marginal forms. The hierarchy of dispositions synthesizing the system of regulation of social behaviour is determined by the degree of inclusion of the individual in social relations. At the same time, in the early stages of ontogenesis (up to the "transitional state" in adolescence), the smaller the degree of inclusion, the higher the degree of creativity, the wider the scope of variability (variability) of behaviour that is not burdened with knowledge of reproduction. The complexity of the study of marginal forms, both for science and for pedagogy consists in the absence of its own basis of development, the fundamental dialectical contradiction, which motivates, determines and drives the development of the system and thereby ensures the possibility of its adequate cognition at the essence level. The very field of social and individual being was not sufficiently saturated with creativity in all its direct manifestations so that it was possible to make a reasonable conclusion about the persistent and irreversible, moreover, tirelessly growing tendency to find a form of practical universality. The question of why today it is possible and necessary to comprehensively develop the philosophy of creativity (creative philosophy) is not at all a theoretical question. In accordance with Hegel, everything is covered in the "readiness of the subject". Today, in the conditions of an avalanche-like growth of heterogeneous

information, creativity, its way is being, is beginning to clearly show a tendency to consolidate in the form of practical universality. Hegel thus characterized this the process of development theoretically - the universal: "knowledge moves from content to content. This forward movement determines itself primarily in such a way that it begins with simple determinations and that the determinations that follow them become richer and more concrete. For the result contains its beginning, and movement this beginning has enriched it with new certainty. The universal is the basis; therefore, the forward movement should not be taken as a process proceeding from something else to something else. In the absolute method, the concept is preserved in OEM otherness, universal in its isolation, in the judgment and reality, at every stage of the further definition of the universal elevates the entire mass of its previous content, and not only does not lose anything from its dialectical progress not only leaves nothing behind, but it carries with it everything acquired and enriches itself and thickens within itself."

An active beginning of scientific and technical creativity is innovation as a system, as an image of mental actions. This is the acquisition of knowledge by scientists and technicians and the acquisition of the ability to use it to acquire new knowledge. Scientific and technical innovation with its gnoseological and social properties can be viewed as a fractal of all science and technology, which models such invariant characteristics as dynamism, the rapid development of scientific and technical knowledge, its innovative orientation. All the typical features of the development of science and technology, in which there is a shift in the conceptual nature of knowledge, everything that fills this process is reflected in the mechanism of innovativeness from identifying deviations to the establishment of a paradigm. Philosophical and pedagogical Analysis of this problem from the perspective of social determination, cultural studies, economic, technical and other conditions conducive to the efficiency of innovative technologies makes it possible to the theoretical and practical levels, to develop a foundation for solving multidimensional problems of development of both the scientifically-technical creativity as well, and the entire pedagogical knowledge.

## **7. Conclusion**

Scientific and technical creativity is the most important direction for research in the field of philosophy, anthropology and proper pedagogy, since it was formed in connection with the necessity of reflecting nature in the social and anthropological transformations that have resulted and in the rapid development of science and technology in the nineteenth, twentieth centuries, continuing today. Modern creative activity in these areas, both theoretical and practical, based on the scientific picture of the world and high technology, which requires special methodological training and humanitarian culture from the pedagogy. The problem of the relationship among scientific, technical and other forms of knowledge is becoming key not only for modern philosophical thought, but also for social practice, above all - the strategy and tactics of education. The theory and practice of pedagogy inevitably raises the question of equal rights, a range or hierarchical dependence of some forms of knowledge in comparison with others. The solution to this issue is necessary to create a new methodology of education in modern reality. Methodologies that take into account the intensity of unsystematic and multidirectional information flows, the degree of their influence on the personality of students and educators, as well as the ability to structure and creatively transform knowledge into a single system. This is possible provided that the development of scientific and



technical creativity is conditioned by the transformation of non-classical scientific rationality and the formation of a new methodological apparatus of science; the need for a systematic and integrated understanding and prediction of changes determined by scientific and technical progress; a sharp increase in ethical responsibility for the results of research and engineering activities.

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