RESEARCH TRAINING FOR THE KNOWLEDGE SOCIETY: EXPERIENCE IN THE "STEP INTO THE FUTURE" PROGRAM

report of the Chairman of Central Council of "Step into the future" Program,
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Good afternoon, dear colleagues!

Research training is a key paradigm of education development in the knowledge society. Training of high-level research competencies takes long time, so it should begin in a secondary school years.

Research education of schoolchildren as an area of educational practice, and, in particular, theory, has emerged relatively recently. I mean not a project method of teaching, but a special form of organizing cognition based on methods that are used in science and engineering. What makes it special is the *many-year and continuous* involvement of a learner in problematics under study.

The theory of research training I will talk about was developed as a result of thorough comprehending the experience of the Russian "Step into the Future" program. This program was founded by me in nineteen ninety one. It is in progress as a non-formal system of research training for schoolchildren at the age from seven to eighteen. Today, there are more than one hundred fifty thousand participants in the program. The system of scientific-educational partnerships created by the program throughout the country gives a potential for talented schoolchildren to carry out their developments on the basis of research laboratories of universities and scientific institutes, engineering centers and workshops of high-tech companies.

The "Step into the Future" program takes its origin "intra muros" the Bauman Moscow State Technical University and inherits traditions of the Russian school of engineers' training. Its latest area of activity is innovative and scientific-entrepreneurial training of schoolchildren-researchers, which is supported by the Presidential Grants Foundation.

The need for a theoretical comprehension of activities under the program has become especially acute after first ten years of its implementation. In my report, I will present in brief a part of the theory that *directly* describes the practice of research training – its basic propositions and key concepts. An attempt will be also made not only to comprehend the present, but also outline the future.

As basic propositions, let us consider "research behavior", "generativity" and "scientific-cognitive continuity".

Research behavior is often interconnected with psychobiotic mechanisms arisen in primitive struggle for survival. Interest and curiosity inherent in the unconscious human nature are results of this fact.

However, research behavior distinctive for scientific cognition is, first of all, *a cultural* phenomenon. It stems from a *conscious* desire to discover a scientific truth that determines life values, professional occupations, standards of cognition and working with knowledge. This special cognitive way of action I call "*scientific-type research behavior*".

Scientific-type research behavior cannot occur in the communicative field of a classroom. It is not implementation of a canonical set of cognitive actions – it requires something more than organization of cognition by subjects and lessons.

The scientific-type research behavior is driven by a strategic cognitive interest of a person, and not by formal evaluations. It arises in conditions of problematic situations that occur in social life, in professional environments of science and technology.

The fundamental epistemic-didactic condition for research training feasibility is **generativity** of learning, learning environment, learner evaluation. By the term "generativity" I mean the ability to actively encourage cognitive thinking towards productive creative-type activities.

Generative learning develops a knack for creation of new knowledge and its transformation into a social or technical product.

Generative learning environment is an open-type educational system that is endowed with socially active cognitive components stimulating and guiding the creative function of thinking.

Generative evaluation in contrast to summative evaluation brings a focus on *what* a learner can do with acquired knowledge, and not on how well acquired knowledge corresponds to limits set by others.

Research training in the knowledge society interconnects a school and a university via **scientific cognitive continuity** operating at the level of a learning method, a cognition way, an environment, and a pedagogical subject. It is worth noting that in the industrial age, school and university are separated both epistemically and didactically.

Scientific researches in the knowledge society are used as teaching techniques. They form a teaching and learning process and a creative function of thinking. The learning environment becomes distributed in the network system of *institutional partnerships*. It connects the educational institution with organizations engaged in production, technologization, and social incorporation of

knowledge. A pedagogical subject represents a pedagogical couple connecting a teacher (professor) and a professional mentor – a scientist or a professional who has experience in working with scientific knowledge.

Next, I will talk about such key concepts as “method of research training”, “problem-cognitive program”, “learning environment”, “school of cognitive roles and socio-cultural experience”, “cognitive-cultural polymorphism”.

Research training is based on methods of cognition that are applied in production and “socialization” of knowledge. Among them are scientific, technological, innovative, scientific-entrepreneurial.

Theoretical insight into the experience in research training under the “Step into the Future” program resulted in the concept *of the method of scientific research* developed by me. The concept of method of scientific research is based on my vision of research training as *a continuous* research “project”.

The method divides research training into the following stages: *first stage* – engagement of learners via initial cognitive practices, *second stage* – development of a scientific-cognitive trajectory for a person, *third stage* – introduction of outcomes of research activities of learners into life of society.

The basic system of initial cognitive practices (Stage One) is arranged as a solution of research-type scientific and cognitive tasks to be formulated by a learner independently or received as options to choose from. For example, at the age of fifteen, Anton Gureev from the city of Samara used a laser beam in his school laboratory to test anomalies in vegetables (carrot, zucchini, cabbage, potatoes). From here his keen interest in laser inspection of an organic material aroused and made him attend classes at an anatomy theater. At the age of eighteen, he invented a laser detector that could be used for home identification of hidden subcutaneous tumors in humans.

Upgrowth of an individual scientific cognitive trajectory for Alexander Obuschenko from the Siberian city of Krasnoyarsk proceeded in a professional scientific team (Stage Two). At the age of twelve, he became interested in astronomy, and a year later he was involved in astrophysical research work in the Laboratory at the Institute of Physics, where he could use a top-of-the-line telescope. By the age of sixteen, he received his first scientific results in the field of study of fractal nanostructures, and two years later he, as a co-author, published an article in the “Physical Review” – one of prestigious scientific journals.

At the age of thirteen, Valeria Gregorieva from Astrakhan – the city on the Volga river – attended classes with a group studying chemistry headed by a professor from a local university. At

the age of fourteen, she became interested in the problem of recycling of wastes of a fish meal plant that had an adverse effect on ecological situation in the city. At the age of seventeen, Valeria developed a cost-effective method for production of washing solution for oil tankers from the waste, which aroused interest a Dutch and a Russian companies. Becoming a university student, Valeria opened her own business (this is Stage Three).

We can briefly summarize these examples.

Among the main objectives of the method of scientific research are the following: the *pedagogical* objective or upbringing of a researcher, the *epistemic objective* or cultivation of research competences, and the *ontological objective* or formation of scientific-type research behavior.

Starting from a certain time point in research training, a learner should get control over *cognitive initiative*, i.e. independently find tasks in line with own cognitive progress. The research attitude towards the world, that is peculiar to a scientific research, is able to turn this attitude towards oneself as a part of this world. It helps a learner to take first steps in the direction of understanding oneself, the world, and oneself in the world, or, in other words, cultivate own essence.

Therefore, I can define the *essence* of the method of scientific research as social and existential learning of becoming of a person involved in scientific-cognitive attitudes to the world.

The above-mentioned examples give an idea of a model of a learner's growth as a researcher. This model is called by me **the *problem-cognitive program*** for an individual. And here is a more detailed example.

Anastasia Efimenko from Petrozavodsk in Karelia took a strong interest in mathematics and then in biology at the age of twelve. When she was fourteen, she obtained her first independent results - mathematical models of Hardy-Weinberg genetic principle designed for different situational schemes. At the age of seventeen, Anastasia achieved a first important scientific result – her study made it possible to estimate and predict the spread of a serious hereditary disease – phenylketonuria (or Folling disease) in Karelia region. At this stage, her interest had already shifted to health care. In the first year of education at Lomonosov Moscow State University, Anastasia's interest shifted to fundamental medicine – she became involved in genetic research. In 2011, Anastasia defended her thesis devoted to the study of stem cells.

Let us give a definition of the problem-cognitive program.

The problem-cognitive-program for an individual is a long-lasting diversity of research-type cognitive activity, which, at a certain time point, acquires distinctive thematic directions, focuses on promising problematics and occupies an important status in socio-cognitive self-making of a person.

As a rule, the stage of engagement in scientific-research activities falls on the age of eleven – thirteen, when abstract thinking and abilities to analyze of a hypothetical situation by distraction from the context of perceived reality are developing. At the age of thirteen – fourteen, the individual's problem-cognitive program outlines a stable range of thematic areas for a research work, focuses on promising problematics playing the role of a beacon in socio-cognitive development of a personality.

The problem-cognitive program is one of fundamental didactic concepts and among them are a curriculum, a lesson, a subject, etc. The concept of the problem-cognitive program contains in its core the idea of *learning* of becoming. On this count it applies to other, non-research, modes of study both in secondary and higher education.

The problem-cognitive program of a learner develops in conditions of generative **learning environment** that goes far beyond the limits of an educational institution.

The concept of generative learning environment can be defined concretely by cognitive-constructive and process-environmental models.

Learning and scientific innovation environment that describes an object surrounding of the research training is relevant to the first model. It is an epistemic mega-constructor with components used in building its content. At the first level of organization there are such typical forms of cognitive activity as youth research groups, design bureaus, small business companies, business incubators. Meta-level includes integrating structures – students' scientific societies, development programs, methodological associations, techno-parks, generalized knowledge funds.

The process-environmental model of generative learning environment was developed by me as one of the forms of creative space, *directly* involved in cognitive development of a person. The completed classification of creative space concepts made it possible to identify three basic types: the first is a model of surrounding describing design, gadgets, furniture, the second is a model of cognitive processes, for example, environment for startups development, model of knowledge increment, the third is a model of cognitive system that integrates surrounding and work with knowledge, i.e. the process-environmental model. Within the scope of the last model, *the creative space* is defined by me as a cognitive-generative system that stimulates creativity on the basis of an emergent combination of generative-type cognitive practices with epistemically active environment.

The following two concepts can be viewed as a prediction of the future.

The knowledge society is objectively predisposed to the social distribution of people according to their abilities to operate with knowledge. In such a way, the concept of *cognitive rol*e arises, that is a way of mental functioning in the social structure of society. At a high level of generality, such types of cognitive roles as creative, instrumental, service, organizational can be identified. In turn, the creative type can be differentiated as knowledge-making, designing, technologizing, modifying, entrepreneurial, compiling.

Orientation of an educational institution to forms of social institutionalization of thinking in the knowledge society transforms it into a **school of cognitive roles**. It allows learners to "try on" a role of a researcher, a manager, a technologist, a designer, etc. in a disciplinary heterogeneous field, while a profiled school separates natural scientists, soft scientists and "techies". The cognitive role a learner has a try in is located *above* the subject area, because a researcher can work, for example, both in natural sciences and engineering fields just as constructivism that can be technical and social. This "non-disciplinarity" in the sense of deviation from the subject under study offers a possibility to form an interdisciplinary and transdisciplinary approach to a problematic situation.

The process of acquiring skills in the cognitive role takes place in conditions of *real* problematic situations. The problem context is what makes a school of cognitive roles **a school of socio-cultural experience.**

In the knowledge society, human thinking should act in cognitive conditions that provide its transformative role to the maximum extent. Cognitive potential of an individual is formed *not only* as a result of social acquisitions. It is influenced by inborn components – inherited features of thinking, character, and cultural background. Culturally diverse individuals can perform work with knowledge on the basis of different mental schemes. The problem of cognitive-cultural diversity of thinking leads to the concept of **cognitive-cultural polymorphism**.

Cognitive-cultural polymorphism in an educational institution is characterized by inclusion in educational process the following items: firstly, cultural material of social groups, including ethnic materials; secondly, training methods providing culturally comfortable cognitive actions; thirdly, creative activity in the sense of a culturally determinated phenomenon.

Development in this direction of cognitively cultural diversity of thinking opens the way *to real and effective* educational equality, as it makes the cognitive and sociocultural *identity* of learners productive.

Thank you for your kind attention!