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PROBLEM-COGNITIVE PROGRAM OF THE STUDENTS-RESEARCHERS IN THE KNOWLEDGE SOCIETY CULTURAL REALITY

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Abstract

The author develops a fundamental concept of the research education theory – the problem-cognitive program, which is a model of socio-cognitive self-making and a type of implementation of cognitive interests both for an individual student-researcher and for research community. The challenge is to study a scientific-type investigative behaviour as a decisive factor in evolution of cultural reality of knowledge society. Objectives of the study: 1) research and generalization of experience in finding scientific and educational paths for students-researchers; 2) conceptualization of a socio-cognitive type of student development through scientific research methods in obtaining knowledge. The study uses methods of pedagogical experiments, generalization of social and pedagogical work with creative students, a structural-functional and cognitive analysis of educational activities, and educational and cognitive practices. The methodology is based on 25-year experience in the Russian "Step into the Future" programme for scientific training of young researchers (schoolchildren and students), which currently involves more than150 thousand participants. As shown, the problem-cognitive program articulates the logic of spiritual values of personal growth. It diagnoses the cognitive vocation in cultural reality of knowledge society. The last is ethically predisposed to social distribution of people depending on their abilities to operate with knowledge. Methodological principles of drawing up a problem-cognitive program are formulated; components of cognitive capacities are defined; examples from teaching practice are presented. Research methods in obtaining knowledge give learners and teachers an effective tool for practical application of discipline knowledge and linking them with specific professional areas, achievement of cognitive outcomes having social values.

Keywords: Education, science, research, knowledge, personality, development.

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Corresponding Author: Alexander O. Karpov
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1. Introduction

Knowledge society is a specific socio-economic and cultural domain within the modern society. It establishes scientific thinking as a key force of production and development of the society as a whole. It makes the science a dominating source of additional knowledge, and knowledge positions itself as a new axial principle of the society (Bell, 2008; Stehr, 1994, p. 92). Education plays the role of producing cultural foundation of the knowledge society which educates young people who are gifted in research activities, i.e. research education (Etzkowitz, 2008, p. 35; Thursby & Kemp, 2002, p. 110; Karpov, 2015c, p. 453, 454).

In the middle of the XX c., a new system of labor division which is typical for the knowledge society, an innovation system containing science as well as the society which is based on education took their origin (Druker, 1996, p. 114, 129). Multilayer systems of innovative networks and fractal-type clusters are developed for knowledge production. They distribute new global culture, where a creative knowledge worker becomes a key player (Carayannis & Campbell, 2011, pp. 336-338; Davenport, 2013, pp. 10-12; Peters & Besley, 2013, p. 1).

I indentify four historical stages in the formation of the research model of cognitive attitudes in the higher education: (1) education as acquisition of truth, (2) relationship between research and teaching, (3) relationship between research and education, (4) education through scientific research activities (Karpov, 2015a, pp. 441-443).

I. Kant (1798) sees the university as a learned community, whose mission is discover and "public presentation of truth" (1979, p. 23, 45, 55). Von Humboldt German University (1810) cultivates the relation between research and teaching (Von Humboldt, 2000, pp. 68, 78). For a university in the industrial age K. Jaspers (1946) claims the combination of research and teaching as the highest principle (Jaspers, 1959, pp. 45, 46). The research is included as a component in the teaching process, but it can't define its content and structure as a whole. By the end of the XX century, the research education sector was developed, where education was implemented *through* scientific research activities. They began to shape a teaching process as well as a cognitive function of thinking (Simons, 2006, p. 36). At the beginning of the XXI century, universities positioned themselves as a key element in building the knowledge society (The Role of the Universities..., 2003).

Research education for school is a recent acquisition. According to Kant (1900) , "scholastic culture constitutes *work* for the child" (pp. 70, 67). Humboldt states that the school should "always and clearly" be separated from the university (Von Humboldt, 2000, p. 70, 69). In the industrial age, *mechanization* of brainwork in the environment of *standardized* knowledge should be a pedagogical principle. The creative approach in school education became the subject of political attention of the US government in late 1950s – early 1960s, which was due to the Soviet achievements in military and space technologies (Trow, 1968, pp.133-134). In 1980s, the EU Commission made research activities at school a part of the human evolution policy. In Russia, design and research education emerged in mid-1990s as a result of activities under the "Step into the Future" programme (Karpov, 2012, pp. 725-731).

The research education sector, comprising of schools, universities, corporate training programs for researchers and developers, is focused on formation of complicated high-level competences to be started at

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the stage of learning at school. The answer to this challenge should be a special education system ensuring a principle of scientific-cognitive continuity between a school and a university (Karpov, 2015b, pp. 531-534).

Research education gives for grown up person a dynamic competence that makes possible to predict in-deep cognitive transformations of a paradigmatic type (Karpov, 2016a, p. 9955). This person forms an antroposocial foundation of the knowledge society. Research education becomes a tool of research-type socialization, which trains young people for living in the knowledge society (Karpov, 2016c, pp. 3490-3492).

A model of sociocognitive self-making of learners engaged in research activities is studied in this work. I will call these schoolchildren and students as learners-researchers. Their cognitive growth is driven by scientific-type research behavior.

2. Problem Statement

The scientific-type research behavior is different in its essence from the innate psycho-biotic "curiosity", which has its roots in the primitive struggle for survival. The scientific-type research behavior is driven by a conscious search for truth, which is a professional component in scientific work with knowledge. The study of the scientific-type research behavior as a decisive factor for progress of cultural reality of the knowledge society has an important epistemic-didactic value.

3. Research Questions

The research behavior formation process can be judged by analyzing a time sequence of scientific and engineering challenges a learner solves at different stages of his/her socio-cognitive self-making. Key research questions I can identify as follows.

3.1. How, in practice, are cognitive preferences of learners progressing with time if even at school they are engaged in professional work due to their knowledge?

3.2. What is a theoretical object, conceptualizing a cognitive trajectory of learners-researchers engaged in professional work with scientific and engineering knowledge?

4. Purpose of the Study

Based on the research questions, the purpose of the study is divided into experimental and theoretical parts.

4.1. The purpose of the experimental part consists in the analysis and generalization the experience in construction the research-cognitive trajectories of learners-researchers.

4.2. The purpose of the theoretical part is conceptualization of the socio-cognitive type of learner self-making through scientific-research methods of obtaining knowledge.

5. Research Methods

The study uses methods of a pedagogical experiment, generalization of social and pedagogical works with active up-and-doing schoolchildren and students with creative thinking, and a structural-functional and cognitive analysis of educational and cognitive practices. The research methodology is based on 25-year experience in the Russian National Science Forum "Step into the Future" dedicated to scientific training of young researchers – schoolchildren and students, currently involving more than 150 thousand participants..

The "Step into the Future" programme was established by me a quarter of a century ago. To make a decision on propensity to research-type cognition and teaching for schoolchildren promising from this point of view, I developed a scientific research method. At the heart of this method is the construction of cognitive attitudes in educational societies on the basis of principles inherent in scientific research. Unlike the projects method coming from followers of John Dewey, here the solution to the research problem becomes not a private "project" episode, but it is included in the mainstream of research-cognitive trajectories of personality development.

In the course of implementation of the "Step into the Future" programme I completed quite a few observations over the process of socio-cognitive development of young people who demonstrated their talent in science and engineering. The target of the empirical study was not those who executed the projects as an integral part of education at school, but those who on their own initiative were keen on science and engineering, first independently and in specialized educational institutions, and then as members of adult teams professionally working with knowledge. I talked with learners-researchers in different cities and villages in Russia, studied the environment and circumstances of their scientific creativity, dynamics of cognitive interests, specific results of their activities in different periods of life.

During the study it was found that psychological tests that identify the personality development are not well informative for research-cognitive trajectories of learners-researchers. As a result, the vision of creative growth and success of learners was based on outcomes of their research activity. In other words, I applied the generative assessment as opposed to summarizing or competency-based approaches. Summarizing assessment uses a correlation between learner’s achievements (outcomes) and established standards. The competency-based assessment answers the question: "How does a learner operate with the knowledge?" The generative assessment is based on what a learner can do with received knowledge and what he/she is able to create independently. This assessment diagnoses the specialized creativity, and, in our case, the ability of a learner to produce new scientific-type knowledge.

6. Findings

6.1. Environment for Experimental Research.

The environment used for the experimental study is a scientific-cognitive space of the "Step into the Future" programme, which was founded in 1991 as a nongovernmental and non-profit organization. Today, the programme is a powerful and efficient research training system for children and youth interested in science and engineering. The European Commission and partners from 39 countries are collaborating with the programme.

I distinguish three key dimensions in the scientific-cognitive space of the "Step into the Future" programme: institutional, environmental, and epistemic-didactic.

The institutional dimension is the system of cooperation between educational institutions with organizations engaged in creation of new knowledge, its technologisation and innovation activities. This partnership was named by me as "an integrated system of research education" (Karpov, 2015b, pp. 531-534).

The environmental dimension is an infrastructure of science, which is formed inside and around an educational institution through the institutional partnership. It includes study groups and scientific laboratories, techno-parks and design centers, school forestry and startup-companies. This structure I call as "educational and scientific innovation environment" (Karpov, 2002, pp. 1070-1072). It has a generative nature, i.e. stimulates and generates a creative function of thinking.

The e*pistemic-didactic dimension* includes generative didactics and methods of research education and cognition (Karpov, 2016b, pp. 1625, 1629). Falling into the episteme-didactic dimension, a three-level scheme for evolution the cognitive trajectories of learners-researchers will be discussed below.

6.2. Study of research-cognitive trajectories of learners-researchers.

Here are a few examples of research-cognitive trajectories of learners from the experience accumulated in the "Step into the Future" programme.

Anastasia Efimenko from Petrozavodsk in Karelia took a strong interest in mathematics and biology at the age of 12. When she was 14, she received her first results - mathematical models of Hardy-Weinberg genetic principle designed for different situational schemes. Wishing to check a heuristic potential of her models, Anastasia collected and processed numerous empirical data from hemotransfusion stations. At the age of 17, she received her first important scientific result – her study made it possible to estimate and predict a spread of a serious hereditary disease – phenylketonuria in Karelia. This disease was a cause of about a half of events of early infant mortality or disability from childhood. Anastasia found a relation between the disease and migration of people (Efimenko, 2000, p. 83). At this stage, her interest shifted to health care. In 2000, Anastasia Efimenko with her work "My challenge to children's mortality" was a winner at the Russian stage in the European Union Contest for Young Scientists. At the international level, getting in the final of the EU Contest, she won the right to represent European Young Scientists at the Nobel Prize ceremony.

From the first year of education at the Lomonosov Moscow State University, Anastasia was employed as an experimenter at the University Medical Center. Few years later, her interest shifted to fundamental medicine - she became involved in genetic research. In 2011, Anastasia defended her thesis devoted to the study of stem cells.

I call the model which fixes dynamics of cognitive interests and results of activities of learners-researchers as "the problem-cognitive program".

I outline a three-level scheme in evolution of cognitive trajectories of learners-researchers. At the first stage, learners get engaged in research activities through the basic system of initial cognitive practices. At the second stage, a problem-cognitive program begins to form. At the third stage, accumulated findings are tested and included in the system of scientific knowledge and in social activities.

The basic system of initial cognitive practices (Stage 1) is formed as a set of research-type scientific and educational tasks to be formulated by a learner independently or received from tutors as options to choose from. For example, at the age of 15, Anton Gureev from Samara used a laser beam in

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his school laboratory to test anomalies in vegetables (carrot, zucchini, cabbage, potatoes). From here he developed his interest in laser inspection of an organic material that made him attend classes at an anatomy theater. At the age of 18, he invented a laser detector that could be used for home identification of hidden subcutaneous tumors in humans (Gureev, 2001, p. 29).

The problem-cognitive program for Alexander Obuschenko from Krasnoyarsk proceeded in a professional scientific team (Stage 2). At the age of 12, he became interested in astronomy, and a year later he was involved in an 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 16, he received his first scientific results in the field of study of fractal nanostructures (Obuschenko, 2002, p. 30), 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 13, Valeria Gregorieva from Astrakhan attended classes with a group studying chemistry headed by a professor from a local university. At the age of 14, 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 17, Valeria developed a cost-effective method for production of washing solution for oil tankers from wastes, which aroused interest of Dutch and Russian companies (Gregorieva, 2000, p. 84). Becoming an university student, Valeria opened her own business (Stage 3).

6.3. Theoretical definition of the "problem-cognitive program" concept.

Searching methods of knowing in research education take a shape of a self-organizing and continuous stream of cognitive actions driven by initiatives of an individual, where a person solves the following existential questions: "Who am I?" and "Who will I become?" This form of cognitive becoming I identify by the "problem-cognitive program of an individual" concept.

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

The problem-cognitive program is one of fundamental concepts supporting various training methods (among them are a lesson, a training program, a project, etc.). It takes its origin from the basic system of initial cognitive practices diagnosing primary cognitive interests of a person.

Episodic cognitive actions organized into projects can be a local part of cognitive programs of an individual. However, a training project, even drawn up as a research work, is a product of a subject-structured education system, while research training is implemented as a continuous presence in the field of the research problem.

A team of learners can implement a common meta-cognitive program as a collective program. The collective cognitive program is defined by me as an ensemble of *coordinated* cognitive practices aiming at solution of a *complex* cognitive problem

A necessary condition for progress in the problem-cognitive program is focusing an individual research area on promising problematics formulated in one or another macroproblem. Hence, *key aspect* in construction a research-type training process is the exclusion (at a certain time point) of project and research types of education in those disciplinary areas and subject segments which are not associated with the cognitive problem to be solved by a learner.

The above-formulated condition shows a need for theoretical development of methodological approaches to construction of a problem-cognitive program.

6.4. Methodological principles and cognitive potential of the problem-cognitive program.

Construction of the problem-cognitive program is not just the task of a learner involved in scientific research, but also of a pedagogical person (a research tutor, a teacher or an educator). They should be able to develop and support the “unfolding” of cognitive scenarios, which, to some extent, take part in the socio-cognitive growth of a learner. I can formulate three methodological principles of "scenario"-based implementation of the problem-cognitive program.

The functional integrity principle of the knowledge complex of an individual stipulates that implementation process of the problem-cognitive program shall contain time points (or stages), where the knowledge complex of an individual acquires the capacity to solve an extended class of cognitive problems. In these "cognitive capability nodes” the individual cognitive system switches to a more complicated level and transforms into a new holistic cognitive 'organ'.

The functional completeness principle of the knowledge complex of an individual requests maximal cognitive functionality at those time points, when its functional integrity is reached. This principle is aimed at assessment a level of attained cognitive capability of a person in comparison with potentialities at this stage.

The socio-cognitive individualization principle of the cognitive trajectory suggests the relativity of an educational timescale that specifies stages of the knowledge complex growth of this or that individual. The absence of a direct correlation between the age and a possible level of socio-cognitive development necessitates co-education of different-age learners, but, at the same time, it requires a special flexibility of scientific and educational environment to adapt to individual cognitive needs.

The problem-cognitive program (both individual and collective) should be designed by a pedagogical person on the basis of a qualitative assessment system. I have proposed to characterize the problem-cognitive program by a complex cognitive potential which includes the following components: "a heuristic potential", "a cognitive-instrumental potential", "a creative potential", and “an innovative potential".

The heuristic potential of the program is determined by the extent of new knowledge (theoretical and empirical), which is open for learning in cognitive practices of the program. It describes everything that a cognizer can get as *knowledge* from the program. This is a representation of the scope of cognitive-assimilated phenomena of the world, which the program intakes by means of self-development.

The cognitive-instrumental potential of the program is the assessment of its ability to create and develop cognitive instruments of individual psyche that operate also with dynamically changing knowledge. It describes what *methods of obtaining knowledge (cognition methods)* a cognizer can get from the program. This is an image of operations expansion in the world that the program produces.

The creative potential of the program is a possible creative productivity latently contained in brainwork with knowledge included in the program contexts. It describes what *creative products* can be developed by a cognizer on the basis of knowledge and cognition methods the program delivers. This is a level of creative feasibility of heuristic and cognitive-instrumental potentials of the program.

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The fourth component of the program complex potential is associated with my "innovative knowledge" concept, which is a cultural need in the knowledge society (Karpov, 2010, pp. 134-137).

The innovative potential of the program is the demonstration of its resources to empower a person with producing knowledge, i.e. the knowledge that makes a person able to create objectively new knowledge or, in other words, innovative knowledge. It describes the *synergy* of knowledge, methods of cognition and creativity an individual mind can possess in the course of the program implementation. This is a volume correlate of knowledge-producing world that finds its place in the program.

7. Conclusion

Research methods of cognition give a learner and a teacher an effective tool for practical application of discipline knowledge, their association with specific professional fields and specialties and achievement of cognitive findings having a real value in life.

The problem-cognitive program articulating spiritual-valuable logic of development is becoming a tool of existential and socio-cognitive self-making of a creative person who thinks of him- or herself and about his or her vocation in the mainstream of the knowledge society culture. It is a way of establishing a paradigm of the personal being, and it functions as generative ontology determining the self-making of a person.

The concept of the problem-cognitive program has a more extended scope of application than the research education. This scope can be defined as “training in self-making”. It is directly related to the essence of education.

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