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Generative Learning in Research Education for the Knowledge Society

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ABSTRACT

Education is the main cultural and socioeconomic institution of the knowledge society construction. The connection of education with research is defined as a strategic factor of a new society development. The purpose of the article is to analyze and give a description of generative learning in research education in the context of the development towards the knowledge society. The methodology involves the socio-cultural analysis of education reality, epistemic and didactic analysis of pedagogic relationships, the structural-functional analysis of the 25-years' experience of the Russian scientific and educational programme for young people and schoolchildren "The Step into the Future". The article substantiates the ontologically key role of research education in the genesis of the knowledge society. The role of generative didactics in nurturing a personality, capable of creating a new knowledge, its technologization and integrating into the socio-economic turnover is shown. The conception of "dynamic competence" is studied. The levels of organization of research education are considered – the institutional, environmental and educational ones. The research education stages are described - the involvement, the construction of a problem-cognitive program, incorporating the achievements of the student in the society activities; examples are provided.

KEYWORDS
Didactics, research, learning, knowledge society

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Introduction

The cognitive basis of modern education is based on an open and evolving picture of the world, which corresponds to the innovative nature of the society. Educational activities nowadays should take into account the sociocultural complexity of the world caused by human actions and artificial systems, the dynamics of the knowledge growth and technology development in conditions of uncertainty of prospects. Such an approach is incompatible with the traditional work with knowledge in the classroom using textbooks providing scientific facts. The new educational paradigm is underlain with a generative learning method that uses research methods of cognition, context-situational learning in an

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interdisciplinary subject field, and cognitive specialization in small profiled groups under the guidance of a professional mentor. In the contemporary culture of knowledge, a scientific study gains a high didactic and educational potential.

At the end of the 19th century, scientific facts and theories were regarded as an absolute truth substantiated by reputable people. Their critical comprehension in pedagogic practice was precluded. The «scientific» character of education was provided with formal calculations and learning by heart, which prepared people for maintenance of machines. Until the end of the 20th century, the mass education had been dominated by the unrealistic idea of science as a method of cognition, an objective, free from value judgements and indisputable method, which actually does not exist in reality (Mackenzie, 1998).

From the well-known concept of scientific management of labor developed by F.W. Taylor (1911), school adopts a linear and closed educational system based on a thoroughly timed curriculum oriented at results. School Taylorism of the 20th century is oriented only at those objectives that can be clearly differentiated, eliminating cognitive initiative, which adds uncertainties. Traditional school, having adopted the assembly line model, establishes mechanization of thinking in a standardized knowledge environment as a fundamental pedagogical principle. “A good pupil, as well as a good worker, is trained on the basis of four postulates – consistency, punctuality, silence and diligence”, as said W.T. Harris, the United States Commissioner of Education in 1891 (Harris, 1891). E.P. Cubberley (1916) in the «Public school administration» published in 1916, says, «Our schools are, in a sense, factories in which the raw products (children) are to be shaped and fashioned into products to meet the various demand of life».

The Report to the Club of Rome “No limits to Learning” made by J.W. Botkin, M. Elmandjra and M. Malitza in1979 became an indicator of the approaching changes. In the Report, learning is treated from generative positions that are focused on the active role of a per-son in his attitude towards knowledge and society. The authors insist that the new conception of learning should be realized, they called this “innovation learning” in contrast to the traditional forms of learning – supporting (adaptive) and shock ones. The educational function of the society must acquire the properties of forecasting (advanced learning), interdisciplinary, context openness as well as provide the combining of creative involvement with specialization, personal individuality with integration in culture, initiatives with responsibilities. As a result, the person should go on the higher level of abilities that will allow him to act in new situations, devise and create new alternatives (Botkin et. al., 1999).

Literature Review

At the turn of the century, estimating the European educational prospects, W E. Doll thinks it necessary to create a new conception of cognition relying upon cognitive uniqueness, self-organization, and the ability to work in the conditions of uncertainty. It should be focused on the creation of knowledge rather than on its discussion and verification (Doll, 1993). V.V. Krajewski (2009) believes that one of the challenges of pedagogy is the development of a new content of education and appropriate methods. He writes that acquisition of knowledge on treasures of human culture by a student is a factor of sustainable development of the society.

In 2006, the European Universities Association (EUA) initiates the "Creativity in Higher Education" research project funded by the European

Commission under the "Socrates" program". The general task of the project is «to contribute to the progress of the European knowledge society». The report issued by the EUA on results of the research work (2007), states that creativity, and first and foremost, creativity in universities as centers of knowledge production, is a key factor for solution of intricate socio-economic problems and is the main driving force behind the knowledge society progress. Lateral thinking that is required to take into account all known factors is in close relationships with Creativity (Creativity in Higher Education, 2007).

In 2008, the UN report "Creative Economy" declares the fact of emergence of a new development paradigm, "which links the economy and culture, embracing economic, cultural, technological and social aspects of the development at both the macro and micro levels». The economic aspect of creativity promotes business activities, innovations and economic growth. It associates with creation of cultural products, scientific and technological innovations. The "creative economy" conception gives evidence of transition from conventional development models to an interdisciplinary model (Creative Economy Report, 2008).

A.P. Wierzbicki and E. Nakamori (2005) emphasize that «at the end of the 20th Century, together with the emergence of knowledge-based economy, the economic demand resulted in the need of a better understanding of creative processes, of micro-theories of knowledge and technology creation». J. Boys (2011) studies the creative domains of education from the perspective of creation the conceptual framework and methods that can help in mapping the social-oriented practices of education in universities and colleges. P. Bourdieu lays in the basis of the "non-Cartesian pedagogy", aimed at the transfer of skills understood as practical (and theoretically enriched) ways to say and to do, the creation of habits of inventiveness, creativity and freedom. He calls this concept a "research pedagogy". L.A. Mikeshina(2002) believes that at new century there exists the of re-thinking basic cognitive ideas of the theory of knowledge, among them, in particular, the influence of sociocultural factors on the knowledge content, methods and results of cognitive activity. Pedagogical theory and practice must concentrate on the "subject's comeback to education", on the development of a "living" individuality. This education-development reveals the fundamental relationship with finding, "getting" and constructing the personality.

Today, as never before, School is an essential component of education problems in universities, because learning performance in universities directly depends on cognitive readiness of students to operate with complex systems to gain professional knowledge. Experts notice the fact of a considerable disproportion between grade of intelligence and intellectual needs of students, on the one hand, and educational environment in schools and higher education institutions, on the other hand. Inactivity of students is caused by a model of educational institution as a translator of instructions; its overcoming is a key challenge of educational theory and practice worldwide. For example, according to one of mega-studies conducted in 26 States of the USA, about 40% of respondents believe that school subjects are not relevant to life, 45% - feel uncomfortable at school and only 2% say they are not getting bored at school (Yazzie-Mintz, 2007). D.B. Bogoyavlenskaya (2002), the leading Russian expert in the field of giftedness, comprehends creativity as the development of an activity on its subject's initiative, i.e. on the initiative of the child himself. She writes, "the set at the "result" existing in traditional school (to teach how to read, write, etc.)

determines the system of encouragement and thus forms a value orientation, which often negatively results in the children's aspiration to research activity". Longitudinal research made on the basis of her method of giftedness identification named "Creative field" showed that "the most interesting, original and profound inventions have been made by people whose inner aspiration for active search for new challenges and tasks and a high level of cognitive thirst were the main spur in their work". Hence, one of the main challenges of education is the need in scientific and educational continuity at schools and universities that requires a specific generative learning environment and scientific and research methods of obtaining knowledge (Karpov, 2015).

R. Godon (2004) writes that the challenge of education is to introduce children into learning through the real social world, while the challenge of pedagogy is the development of an adequate conception of teaching students through contexts that lead to this in the most optimal way. According to A. English, nowadays, to consider a pupil to be educated, his ability to provide correct answers in every sphere of knowledge that have been recognized appropriate for learning, is absolutely insufficient (English, 2009). The processes of transcendence of oneself into social medium underlie the process of a modern personality development, notes L.G. Hammershow (2009); with this, creativity is the unity of generative and assessed mode of intellectual apparatus operation.

So, the imparting of the generative character to learning is considered nowadays as one of the key challenges of modern education.

The purpose of this article is to analyze and provide a brief characteristic of generative learning in research education in the context of the development towards the knowledge society. In particular, we are to determine the role and place of research education in the modern culture of knowledge, to formulate the concept of generative didactics and explicit the main principles of generative learning, to provide practical information on the organization of research education.

Materials and Methods

The methods used are: sociocultural analysis of the education reality, epistemic and didactic analysis of the system of pedagogical relationships, structural and functional analysis of the 25 years' experience of the Russian scientific and social programme for youth and school-children "The Step into the Future". The latter methodical component provides the validity of the work theoretical results. It includes facts and analytical materials provided by the practice of one of the strongest and representative systems of research education in modern Russia. Today, more than 150 thousand young research workers, schoolchildren and students, are participating in the programme, as well as more than one hundred universities and research institutions, about five thousand schools. In the field of research training of young people, "The Step into the Future" Programme is cooperating with the EU Commission and organizations-partners from 46 countries, which allows accumulating the most progressive educational experience in its activities.

The results, published in the article, have been obtained in the framework of the implementation of the project part of the State order by the Ministry of education and science of Russia (grant No. 27.1560.2014/K).

Results

Research education and generative didactics

Research education requires the theory of its own. At the same time, it proceeds from the practice of science in its cognitive sets. Moreover, modern education can be considered and named scientific and research when it uses methods inherent in scientific searching. Thus, didactics of research education is a pedagogical theory interconnected with scientific practice. And in this respect it is safe to say that there is nothing more practical than a good theory.

Unlike traditional adaptive teaching conveying a fixed set of knowledge and methods for solution of well-known and repetitive tasks, the modern research education has to deal with a rapidly changing system of knowledge and understanding of the world. Research training forms an educational domain for those young people who intend to be professionally engaged in scientific production of knowledge. This applies to pure sciences, including social and humanitarian fields, as well as to application areas that require creativity to yield something new. The latter includes engineering, medicine, management, pedagogy, etc.

Separation of research education into a specific educational area is connected not only with its didactic specificity. The determining factor is the social role that research education plays in the progress of the present-day culture, which is positioning itself as a culture of productive knowledge. Both the society "running on knowledge" and the culture in which this society is developing rely on cognitive abilities of the creative personality. Professions of the cognitive type, with a large amount of creative work in science-related fields, are becoming the tools of the material and spiritual growth of the knowledge society. Education, which is nurturing young people with potential capabilities to scientific research, i.e., research education plays the role of a cultural productive basis of the knowledge society. These young people's education starts at school, continues in university and changes into the level of professional production of fundamental and applied knowledge.

Consequently, the research education is a fundamental component of the cognitive modern society structure – it covers decisive points of the knowledge culture growth. It takes into possession own methods, infrastructure and forms of institutionalization, becoming a specific component of the educational system, which is responsible for upbringing a group of technological progress.

Research education is underlain by the generative didactics. The term "generative" de-notes a process of learning, which creatively stimulates the production of a new knowledge. We propose the following short definition.

Generative didactics is a theory of research education which examines a method, environment, knowledge and cognition in terms of the process of education and upbringing a personality, capable of producing and technologizing knowledge (i.e., of transforming knowledge in technical and social facilities and technologies).

The generative nature of learning becomes apparent, for example, in the approach to the current short-term assessment of the learner, which is considered in opposition to the Cartesian-Newtonian paradigm of standard knowledge, which strictly separates winners from losers. The traditional assessment based on the

correlation of the learners' results and established standards does not measure to a proper extent what the learner has acquired by himself. The latter includes the products of the creative psyche that has absolute significance to humans of modern culture and to the society developing in this culture. In generative assessment, rather than in just summing assessment, the emphasis is made on what the learner can do with the received knowledge, rather than on how well the knowledge gained, match the frame established by others (Doll, 1993).

Generative education creates a specific dynamic competence. This competence depends not only on the ability to gain knowledge and professional growth, but on ability to treat knowledge as an unforeseen event. Acquisition of knowledge in the generative education is not just an uptake of factual information with subsequent integration into activities, not just an up-dating, but the psycho-cultural assimilation of scientific innovations lying at its basis, which means the understanding of new principles of functioning of technologized types of knowledge, i.e. a work with epistemic changes of a paradigm nature. The willingness to accept profound paradigm-type changes is determined by a research style of the mind, which operates in a continuous processing the fundamentals of its activity caused by penetration into truly unknown. This unknown is characterized by such system unpredictability as inability to obtain a well-established knowledge configuration by a simple logical continuation. Consequently, the education that generates the dynamic competence didactically operates with a creative leap, which is an indispensable tool of research knowledge.

The dynamic competence relies on the ability to grasp the results of the segmentation process of professional knowledge and its progress. The latter directly relates to prediction of personal professional needs and, therefore, defines cognitive strategies that will dictate types of professional activities associated with technologization of knowledge. Therefore, the dynamic competence is not dealing with the problem of skill obsolescence, which has been solved within the framework of well-established forms of training and retraining, it relies on the sense of individual foresight the directions of changes in the content of professional knowledge.

The main strategical issue to be solved by modern systems of scientific education is in establishing research learning as the main form of school and university education. Here we speak not about all young people in general but about a certain group of promising youth from the standpoint of work with modern knowledge. The organizational process of research education involves: (1) the development of specific research curricula on the core subjects, these curricula including the content, methods and the environment; (2) the formation of a group of promising learners; (3) material and technical basis for research creative work; (4) the inclusion of approved programs of research learning into the academic processes of various grades of general and higher education (Karpov, 2012b).

The analysis of the issue "education through scientific research" made by the European expert group Strata-Etan showed that the process of research competencies formation should begin at the stage of incomplete higher or school education (Developing Foresight for the Development of Higher Education, 2002). This new task is a challenge for school. To solve it, it is necessary to establish educational partnerships of schools, universities and research institutions, which

will provide the construction of the "end-to-end" learning on the principles of scientific cognition.

The intensive inclusion into the pedagogical practice of the project method of learning, which began in the mid-90th, is largely due to the merit of "The Step into the Future" Programme (Karpov, 2012a). The active cooperation of the Programme with pedagogical authorities and the Committee on education and science of the State Duma of Russia has resulted in understanding the strategic role of research education on the administrative level. The directives that followed not always reflected the didactical positions upheld by the Programme. Nevertheless, the impact made by "The Step into the Future" Programme upon the Russian school opened the prospects of progress to the modern educational models of the research type. Generative learning cultivated by the Programme provides problem-cognitive progress of the learner together with a schoolteacher in the conditions of professional research environment. Thus the complex and joined development of fundamental and specific competencies in educational networks of the research type is being accomplished.

Principles of generative learning

Research education relies upon basic principles of generative learning – cognitive flexibility, cognitive generativeness and sociocultural interaction. These principles identify the learning complex that is responsible for the knowledge productivity and creative abilities of the learner (Karpov, 2010).

Cognitive flexibility of learning is its ability to cognitive adjustment, both individual and collective, i.e. to didactic focusing of content and methods of learning on the special in the learner's cognitive activity. In contrast to the variability of learning, offering a cognitive menu formed by an outside agent, cognitive flexibility presupposes the internal possibilities of the curriculum to response to the cognitive preferences of the growing person, this person acting both in the learning circle and individually. From this standpoint, cognitive flexibility determines degrees of didactic freedom in human education.

Cognitive flexibility builds the potential of individual thinking disclosure into micro- and macro-education and thus leads to the formation of cognitive diversity first in the learning circle and, in future, in the cognitively active section of the society. Cognitive diversity is determined by the set of actualized cognitive types of personality functioning in the society. The cognitive type of an individual relies on the complex of intellectual capabilities, which determine the inclination to specific forms of cognitive activity of the individual in various subject areas. Generally speaking, the cognitive type of an individual does not determine the individual cognitive uniqueness though it serves as a characteristic feature of the latter.

In relation to a teacher and a scientific mentor, cognitive flexibility is represented through a special kind of methodical and environmental richness of the curriculum. Such richness is not just a specific set of individual possibilities, from which one can borrow, but a functionally organized and structured transformative didactic system, which generates cognitively diverse learning through building didactic strategies. This system provides the provocative-generative quality in relation to cognition.

Cognitive generativeness of learning is its ability to foster thinking that opens the world, i.e. thinking, which is creatively operating with the searching,

constructivist, hermeneutic forms of human cognition. Cognitive generativeness relies on a cognitively rich epistemic structure of the curriculum, arising from its richness and endowed with complex configuration of ideas and levels of competing sense.

While cognitive flexibility of learning generates cognitive diversity of a group of learners, its cognitive generativeness bears responsibility for cognitive diversity of an individual. Creativity individualizes, taking the advantage of the curriculum's richness. The individual creativity thus reveals the range of its potential. Hence, the combination of cognitive flexibility and generativeness is the path to creative uniqueness of each individual.

The inclusion of generative cognition in the culture of learning, i.e. the cognition that leads to the creation of a new knowledge, new meanings and new comprehension, is the response to the challenge of social reality, which emphasizes the cognitive-active human nature. The ontological status of generative cognition in learning is defined as the creation of the integral but open system of individual knowledge capable of self-development. Its epistemological status is represented in heuristic practices and research procedures of obtaining knowledge, which cultivate the ability to questioning, to creating the learner's own mental schemes and subjective knowledge from direct experience, as opposed to the traditional approach when the learner only copies mental matrixes and cognitive experiences of the others.

The resolution is non-standard, unique and ill-defined problematic situations today, more than ever, is an ordinary social practice. Therefore, present-day training programmes act as transformative educational systems with open problems and are open to problems. Structuring the problematic situation with identification of problems and their interrelations assumes an ability to see problems and understand problems before their solutions. These abilities to interact with realities rely on an intuitive psyche function, acting differently from the discursive way of thinking which is cultivated by the traditional pedagogy.

Intuitive forms of cognition underlay the creation of a new knowledge; it is they that mediate the principle of transcendence of scientific cognition and represent one of the basic components of scientific competence, which can be taught by research education. Thus, L.A. Mikeshina (2002) writes: "Apparently, radical changes in the field of learning and education in general, forming a new intelligence are to a large extent, programs that develop techniques and operations of fundamental intuition transformation".

Sociocultural interaction of learning is the inclusion of spiritual and material perspectives and the experience of public life in the practices of knowledge acquisition. It acts as a tool for the establishment and functioning of effective educational environments and thereby determines the order and intensity of reality, permissible in educational activity. The main thrust of modern pedagogy in the field of sociocultural interaction is forward-looking education.

Sociocultural interaction is acquiring today a genetic educational status and acts as a mediator between didactics and cognitive competence. It has a primary regulatory function in modern education, which determines cognitive objectives, limits and opportunities. Today, as opposed to the educational past, the external interaction is institutionalized as a system of flexible and dynamic cognitive relationships with the socio-cultural context, motif-based on the strategy of

advanced learning. Hence, modern education is functioning as a continuously evolving and self-transforming cognitive system.

No doubt, cognitive flexibility and generativeness of learning are the necessary conditions for "learning for the future". However, the development towards the knowledge society is able to enter into educational practices only in the conditions of the open didactic connecting knowledge with problems of social prospects in their scientific and technological prospects. Academic, professional and cultural institutions of the society are being included in educational institution contours. Here the teaching methods get a joint basis not only in the form of resources and knowledge, but also in the form of the professionals involved. The learning environment, which is more open and rich in context, offers a wide range of opportunities for the verification of individual vocation. The curriculum focuses on cultural-contextual learning, cultural and pedagogical interactionism, i.e. it acquires the character of a culturally open didactic system.

Organization of research education

Research education relying upon generative didactics involves a specific organization of academic activities.

At the institutional level, cooperation of school with outside organizations is being established, these organizations producing a new knowledge or technologize it. In this way, a learner gets access to scientific laboratories of universities and research institutes, to field expeditions, factory shops and innovation organizations. Cooperation of an educational institution and professional organizations is developed into a partnership, which was called an "integrated scientific and educational system" (Karpov, 2003). This system becomes the main link of the new educational sociomorphism.

At the environmental level, the infrastructure of science is being organized in the institution, which includes study groups and scientific laboratories, techno-parks and design offices, startups and research groups, school forestry and agro-sites. In this way local creative spaces are established, which provide the opportunities to cognize the world using "adult" methods. Here a young research worker is the main participant, but at the same time, in addition to a teacher, a professional instructor is also available, both making a "pedagogical couple". In the local creative space, research education uses the resources that are provided by the integrated educational system. This structurization of the internal area of the institution creates what we call "academic scientific innovative environment" (Karpov, 2002). It functions as an ontologically enriched educational space, endowed with diachronically changing configuration of world-view models, and relies upon patterns of organized reality.

At the level of learning, the scientific research method is functioning, which presupposes: first, the involvement of learners through the basic system of primary cognitive practices; second, building individual problem-cognitive programs; third, testing the achievements and their inclusion into the system of scientific knowledge and into technical and social activities of the society.

The basic system of primary cognitive practices underlies the involvement in research training, this system allowing determining the range of cognitive interests. It relies on a complex of research tasks that are given to a student "of his own choice" or are formulated by himself individually. The themes of research are often connected with specific life problems. For example, the creation of a

compact spinning wheel driven by electricity by Hazret Bifov from Nalchik made his mother's work easier. The study of cockroaches, the most ancient creatures on the planet, made by Maxim Marshancev from Kyzyl, discovered their ability to withstand modern technologies available to man. In the list of primary cognitive practices one can find the reconstruction of ancient pottery baking ovens, the use of the golden section in creating national ornaments, the investigation of soil instability, observation and analysis of meteor showers, etc.

Fifteen-year-old Anton Gureev from Samara was involved in research activity due to his interest towards a laser beam, which he used to test carrots, zucchini, cabbage and potatoes. The experience received in the school laboratory led him to identifying anomalies, hiding in the depth of organic material. At the age of 18, at the Russian Fair "The Step into the Future", he demonstrated a laser detector that could find hidden subcutaneous tumors in human bodies. However, before Anton developed the method of early laser diagnostics of cancer, he had studied a human body in an anatomical theatre and made many technical findings.

Thereby, from the basic system of primary cognitive practices, an individual problem-cognitive program is growing up, in which a cognitive trajectory of personal development is expressed. The latter is not a direct succession in the search of the problem solution. However, the continuity of the motion from one problematic situation to another and its multi-year duration are what distinguishes the scientific research method from individual projects used in teaching schoolchildren.

In 2000, Anastasia Efimenko, a schoolgirl from Russia, won the right to present the young scientists of the EU at the Ceremony of awarding Nobel prizes. In Stockholm Nastya made a re-port "My challenge to children's mortality". The problem-cognitive program of Anastasia Efimenko, the "Nobel" representative of "The Step into the Future" Programme, started at the age of 13 in maths classes. At the same time, she took a great interest in biology, which led her to the development of models of population genetics based on genetic laws of Hardy-Weinberg. Wanting to check the heuristic potential of her models, Anastasia applied for medical statistics at the station of blood transfusion. However, in the 1990th, during the period of reforms, this sphere came in full decline, and Nastya had to collect the relevant data piecemeal and process it by herself. Then she managed to find and prove the dependence of infant mortality in Karelia on migratory factors. In her student years, Anastasia became interested in the hereditary predisposition to diseases. At Moscow University, she was involved in embedding of "necessary" genes to help the diseased who had had myocardial infarction. In September of 2011, Anastasia Efimenko defended a dissertation dedicated to the study of the regenerative potential of mesenchymal stem cells, which is one of the most promising types of cells for cell therapy during ageing.

The implementation of the scientific research method at the advanced stage of learning is based upon the research activity in professional research teams. Alexander Obuschenko from Krasnoyarsk began to study astronomy in the educational system of "The Step into the Future" Programme when he was 12. A year later, he had already participated in astrophysical research in the laboratory of a scientific institute, where he could use the newest telescope. In order to start simulations of astrophysical processes, Sasha, by the age of 15, had mastered the necessary sections of the University courses on mathematics, physics and

chemistry. By the age of 16, he had completed his first scientific paper, which was entitled "Light-induced particle aggregation" and two more years later, in one of the most prestigious international journals "Physical Review" an article was published with his participation.

Innovative activity is both one of the components of the scientific research method cultivated by "The Step into the Future" Programme and its logical result. At the age of 14, Valeria Gregorieva from Astrakhan was involved into the problem of recycling fish-flour processing waste material, and at 17 she developed an economic method of obtaining from this waste a unique solution for cleaning grease and oil tanks from precipitations, which she romantically named "Shampoo for tankers". At the 5th International salon of innovation and investments, held in February 2005 in Moscow, the innovative project made by Valeria "Shampoo for tankers" was awarded the bronze medal.

Discussions

Education is the main cultural and socioeconomic institution of the knowledge society construction. The connection of education with research is defined as a strategic factor in the development of this society (The Role of the Universities in the Europe of Knowledge, 2003). Scientific education of the research type forms a dominating type of thinking, creating cultural novelties – scientific novelties, innovative technologies and social innovations. The education of the future man is based on new cultural principles involving the development of creativity in the conditions of the expanding system of knowledge and open sociocultural environment.

In connection with the new social reality, experts note the cultural backwardness of science education from cognitive conditions of the time, since scientific thinking is looked upon today through the conceptual vocabulary of Bohr, Heisenberg and Prigogine, whereas the curricula have a propensity to the epistemic system of Descartes, Newton and Laplace (Doll, 1993). The bulk of the Russian education system regards the language of our great compatriots Landau, Sakharov and Prokhorov as alien. In 2011, 81% of respondents of the all-Russian Center for public opinion study (VTSIOM) failed to remember the names of contemporary scientists (in 2007 the percentage was 67%).

The conception of "education through research" determines the nearest prospects in the sphere of educational reforms. The main issue here is the issue of pedagogy and psychology of creativity: how to organize education in order to gain the educational environment in which learners could acquire the skills of carrying out research. Here we also mean pedagogical techniques, the accomplishment of creative tasks, the research method of learning, a special form of mentoring in the teacher-learner interaction that could be able to implement "cognitive learning" (Simons, 2006). Among basic instrumental competences formed by generative education are the following: (1) acquisition and operation with dynamically changing knowledge; (2) instrumentalization of brainwork and technologization of its products; (3) creation of mental innovations which possess a growth potential in the system of knowledge production.

Conclusion

Modern scientific education deals with a rapidly changing system of knowledge and understanding of the world.

Generative didactics is a theory of research education, which treats the practice, environment, knowledge and cognition in the context of an education process and intellectual up-bringing a personality capable of production and technologization of knowledge. Acquisition of knowledge in generative education is not just an uptake of factual information with subsequent integration into activities, but the psycho-cultural assimilation of scientific innovations lying at its basis, which means the understanding of new principles of functioning of technologized types of knowledge, i.e. a work with epistemic changes of a paradigm nature. Generative education involves the following principles: cognitive flexibility, cognitive generatively, social-cultural interaction.

Modern research education assumes a three-stage educational process:

- *Institutional level*. It means cooperation between an educational institution and companies directly involved in creation of new knowledge or its technologization.
- *Infrastructure level*. An educational institution develops an infrastructure of science, which incorporates science study groups and laboratories, technology parks and design bureaus, startups and research groups, school forestry units and agro-fields.
- *Learning level*. A method of scientific research is functioning at the learning level: involvement in practice, development of an individual problem-oriented educational program, approbation of outcomes and their integration into the system of scientific knowledge.

Disclosure statement

No potential conflict of interest was reported by the authors.

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