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Generative Learning in Research Education for the Knowledge Society

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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, technoparks and design offices, startups and research groups, school forestry and agrosites. 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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