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Education for Knowledge Society: Learning and Scientific Innovation Environment

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Abstract

Cognitive-active learning research-type environment is the fundamental component of the education system for the knowledge society. The purpose of the research is the development of conceptual bases and a constructional model of a cognitively active learning environment that stimulates the creation of new knowledge and its socio-economic application. Research methods include epistemic-didactic analysis of empirical material collected as a result of the study of research environments at schools and universities; conceptualization and theoretical modeling of the cognitively active surrounding, which provides an infrastructure of the research-type cognitive process. The empirical material summarized in this work was collected in the research-cognitive space of the "Step into the Future" program, which is one of the most powerful systems of research education in present-day Russia. The article presents key points of the author's concept of generative learning environments and a model of learning and scientific innovation environment implemented at Russian schools and universities.

Keywords: *environment, learning, research, knowledge society, innovation.*

Introduction

The knowledge society is a dynamically developing socio-economic system within the modern society. This system, being *a part* of the society, is striving for using the scientific thinking as a primary force of production and development of the society *as a whole.* In this system, science is increasingly transforming into a single source of additional knowledge, and knowledge positions itself as a new axial principle of the society (Stehr, 1994). Education is upbringing young people who are gifted in scientific creativity, i.e. research education plays the role of a culture-producing foundation of the knowledge society.

Research education is based on a teaching system that uses the methods of cognition peculiar to science (Karpov, 2015a). This sector of education has a high level of institutional diversity. It includes a research school and a research university (including an entrepreneurial type) that are interconnected by scientific-cognitive continuity both at the level of environment

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and teaching methods. Its institutional basis is cluster-network partnerships with scientific institutes, high-tech companies, innovation development organizations.

Creation of creativity-active cognitive research-type environments with a center at schools and universities is a prerequisite for upbringing young people who are able to participate in knowledge production. Theoretical solution of this problem will make it possible to define characteristics of learning institutions for the education model in the knowledge society.

Literature Review

By the end of the 20th century, the concept of *education through scientific research* gained a footing in industrialized countries, according to which researches should be used as teaching methodologies (Simons, 2006). They began to form an educational environment, a teaching process, and a cognitive function of thinking.

At the beginning of the 21st century, universities occupy a key place in establishment of the knowledge society (The Role of the Universities in the Europe of Knowledge, 2003). At the political level, universities are declared as the basis of economic competitiveness (Delivering on the Modernisation Agenda for Universities: Education, Research and Innovation, 2006). The idea of consolidation the scientific environment of universities plays a leading role in creation of excellence networks (Response to the Communication from the Commission "The Role of the Universities in the Europe of Knowledge", 2003). Formation of university ecosystems based on distributed-type creative environments is taking place (Curley and Formica, 2015b). Experience in creation of creative spaces at the Stanford University shows that they are an effective way to change behavior (Kembel, 2012). The conceptual document "Designing Spaces for Effective Learning" (2006) drawn up for the UK's higher education system states that "a learning space should be able to motivate learners and promote learning as an activity, support collaborative as well as formal practice, provide a personalized and inclusive environment, and be flexible in the face of changing needs". Innovative and entrepreneurial activity of students is becoming a key factor in university competitiveness (Karpov, 2016e; Mauch & Tarman, 2016).

Among its objectives, the MIT Innovation Initiative (2013) points to the creation of "an ecosystem where student ideas become world-changing technologies" (Overview of the MIT Innovation Initiative, 2016). At the same time, education should be provided in the expanded innovation-centric spaces to be the place of activities for creative collaborations of students, research staff, and faculty and provide effective linking of knowledge and experiences to real

world problems (MIT Innovation Initiative: Final Report of Community Feedback and Recommendations , 2016).

In secondary-level education, methods of research cognition began to penetrate relatively recently. In the late 1950's – early 1960's, the scientific-research approach to school education became the subject of special political attention of the US government that was caused by Soviet achievements in the field of military and space technologies (Trow, 1968). In the Report to the Club of Rome (1979), learning is treated from generative positions that are focused on the active role of a person in his attitude towards knowledge and society (Botkin et. al., 1999). In the 1980s, the European Union Commission makes research activities at school a part of the policy of human potential development. In the early 2000's, in Western education the issue of bringing to teaching the institutions, specialized on functions performed by knowledge in the post-industrial culture was being discussed (Carr, 2003). Bruner (2006) introduces the concept of a "soft technology" that focuses on the *process* of solving scientific problems and is able to provide the best learning results. In Russia, project and research education at school emerges in mid-1990s as a result of the "Step into the Future" program. Academic, professional and cultural institutions of the society were included into the scope of educational institutions (Arlamov et al., 2011). As stated by J. Tomlinson (2000), J. Graham called this kind of association the "transformative partnerships" and W.E. Doll (1993) named it "dynamic social communities".

Today, the very possibility of research university activities depends on the level of cognitive readiness of a schoolchild to master sophisticated systems of scientific knowledge. Formation of research competencies requires long time; therefore, it should start at the stage of secondary education. Research education empowers a growing personality with dynamic competence required for working in complex systems of knowledge production (Karpov, 2016a). It becomes an instrument of research-type socialization, which makes young people ready for life in the knowledge society (Karpov, 2016d).

This new type of socialization, for the first time described by me, achieves global social significance. It occurs in cognitively saturated environments that can motivate learners and be flexible for their various needs. As shown by results of the Strata-Etan group, the competencies involved in conducting researches have a high degree of coincidence with "for employment" competencies on the modern labor market (Developing Foresight for the Development of Higher Education/Research Relations in the Perspective of the European Research Area (ERA), 2002).

The modern education absorbs the latest technologies, which become the instrumental basis for development of creative environments formed by new learning methods. Indeed, the OECD report emphasizes that the solution to problems in technology-rich environments is found as a result of combination of digital and cognitive skills (OECD Skills Outlook 2013: First Results from the Survey of Adults Skills, 2013). The ICT literacy model for higher education proposed by J. Perez and M.C. Murray (2010) makes computer user's generativity a cornerstone, i.e. the ability to acquire new skills and generate new knowledge which forms the basis for innovations and creativity. The flipped classroom model used at the Simon Fraser University, Canada, made it possible to create a socially dynamic educational environment focused on interactive and collaborative solutions of problems in the field of environmental protection and prevention of occupational diseases (Galway et. al., 2014). The report by MakeSchools Alliance founded by 40 American colleges and universities informs about implementation of the Makerspaces concept integrating different tools and disciplines and may combine an art studio, a machine shop, a computer lab, a bio lab, etc. Their technological infrastructure is used as a place of "blending practical learning and creativity", where deep experience of interdisciplinary collaboration and maker culture emerge, "can-do" thinking is developed, and abilities to take creative risks and tackle difficult tasks are generated (Byrne & Davidson, 2015; Tarman, 2016).

Meanwhile, training programs up to now use the conceptual dictionary of Descartes, Newton and Laplace, whereas modern scientific thinking operates in the epistemic system of Bohr, Heisenberg and Prigozhin (Doll, 1993). Experts direct attention to a lack of studies in the field of theoretical understanding of creativity in education (Hammershoj, 2009); discrepancy between intellectual needs of students and educational environment (Shernoff, 2013).

Purpose and Methods of the Study

The purpose of this study is the development of conceptual bases and a constructional model of a cognitively active learning environment that stimulates the creation of new knowledge and its socio-economic application.

Research methods include epistemic-didactic analysis of empirical materials collected as a result of the study of research environments at schools and universities; conceptualization and theoretical modeling of the cognitively active surrounding, which provides an infrastructure of the research-type cognitive process.

The empirical material summarized in this work was collected in the research-cognitive space of the “Step into the Future” program, which is one of the most powerful systems of research education in present-day Russia. The “Step into the Future” program was founded by me 25 years ago. Today, more than 150 thousand young researchers - schoolchildren and students – take part in this program. Program support centers are distributed throughout the country. They represent partner structures that unite schools, universities, research institutes, various types of enterprises and organizations of innovative development. As a result of this association, the equipped research-cognitive spaces for the research and development activities of learners are taking shape.

The European Union Commission and partners from 42 countries cooperate with the “Step into the Future” program, giving a potential to accumulate in its activity the most advanced experience in training of young researchers. At the World Innovation Summit for Education (WISE, Doha, 2011), the “Step into the Future” program along with the Skolkovo Center was recognized as one of the two major innovation projects in Russia.

Results and Discussion

Generative learning environment

Experts underline a special role of the cognitively active learning environment in modern education. J. Boys (2011) looks at the learning environments from the perspective of development the conceptual principles and methods that can help mapping of socio-spatial practices of education at universities and colleges in order to improve it. The author's standpoint lies in the fact that ”the space is therefore one of our means of thinking about the world and embodying thought into action” (Boys, 2011). By A.P. Wierzbicki and Y. Nakamori (2005) definition, the creative environment means “a place and space in which knowledge is shared, created and used, including *physical* space (offices, buildings), *virtual* space (computer network services), and *mental* space (experiences, ideas, emotions) – shortly, a place and environment in which creative activity can be performed”. The creative environment in the Creative Center at the University of Brighton (the UK) is thought of as something greater than its physical part. It is represented by an assemblage of such spaces as a *physical space (*arrangement of training places), a *virtual space (*electronic networks), a *psychological space (*character, values, beliefs, emotions), a *biological space* (mental and physical abilities), and an *interpersonal space (*communications, social interaction) (Martin et. al., 2010).

The backbone of the author's concept of cognitively active learning environment relies on the idea of generativity as a trigger motivating to learning, creation of new knowledge and its socio-economic application. The term "generative" is an epistemic-didactic feature of both learning and teaching environment.

Generative learning is aimed at developing abilities for discovery of new knowledge and methods of its transformation (Karpov, 2016b). It includes not only processes leading to creativity, but also formation of special set of values specifics for epistemic communities (e.g., in relation to the search for the truth, partnerships, and competition), scientific-type research behavior, scientific cognitive trajectories of personality development (problem-cognitive programs) (Houdyshellm, 2017; Karpov, 2016c).

The generative learning environment is not only cognitively active forms and structures of cognitive attitude, but also a peculiar cognitive operationalism they contribute to learning practices. Characterization of the learning environment as a generative phenomenon is opposed to the tradition to treat it as an adaptive structure having a comfortable environment for creative works and standardized abilities.

Uncertainties embodied in the generative learning environment stimulate imagination; problematic situations it offers, structure cognitive activity; cognition tools it is equipped pay the way to discoveries; and collectives of people being its integral part act as independent creating origin. Along with the fact that this environment is a "driver" in academic cognition, researches, and developments (both training and professional), it contains authoritative truths and rigorous epistemic models to be overcome when searching for new knowledge. In such a way, the generative environment "teaches" to achieve scientific truth.

The generative learning environment operates as a system of cognitive heuristics, i.e. presumably defines the best or optimal methods of cognitive activity in specialized problematic contexts, relying on a complex of dominant epistemic logics. At the same time, here is the place for ideas testing and creative productivity. Using this environment, the school and university goes beyond the boundaries of the pure learning space. It leads to the emergence of principally new properties of the learning process, such as its indeterminacy, openness and transformativeness (self-modification), auto-regulation of cognition, and dynamism of cognitive contexts.

In general, the generative learning environment is defined by me as an educational system that encourages and builds a creative thinking function and possesses required socially active cognitive components. The generative learning environment of the University, focused on the knowledge production fields, is a cross-institutional educational system, which (1) actively creates and guides the process of scientific cognition and making an individual a knowledge worker, (2) is equipped with distributed cognitive structures organizing and providing necessary steps in his/her research and socio-cognitive maturation.

This very general theoretical construct specifies a framework description that can be concretized by models revealing its contents from perspectives of one or another problem solving.

Learning and scientific innovation environment

Analysis of the generative environment as structurally complicated epistemic *surrounding* leads to cognitive-constructive concepts. The "learning and scientific innovation environment" construct developed by me for Russian schools and universities can be interpreted as an epistemic mega-constructor containing socio-morphic extracurricular-type structures performing specialized work with research cognition and its products.

In the research education systems, the learning environment constructively becomes layered. Externally, it is realized in the form of a configuration of educational and professional organizations; at the internal structural level, it exists as a learning and scientific innovation environment. The latter is a special construction of the learning space in which research training is immersed.

Let's give a constructive definition to the "learning and scientific innovation environment" notion.

The learning and scientific innovation environment is a socio-morphic system of internal organization of educational communities resting on contextual forms of transformation of learning activities into research cognition and knowledge technologization, implemented in the system of social relations with scientific and professional institutions of the society. It constructively includes: (1) basic structural-functional components – the specialized forms and methods of working with knowledge, enriched with a problematic content and required instrumental surrounding, (2) meta-components – the integrating structures that perform scientific-organizational, methodological, expert, communication, economic, and other functions

to provide specialized forms of working with knowledge, life activity and development of the total institutional-environmental basis for the educational system.

The distributed learning and scientific innovation environment as a basic component in the architecture of macro-educational communities is the form of *instrumental-contextual* organization of education. It is the basis of socialization in educational research-type systems and an instrument of epistemic invasion of problematic reality. Specialized partner networks endow an educational institution with an innovation ecosystem ensuring cognitive investments into human capital assets. The report of the Association of European Universities states that the creative partner network gives a potential to implement the principle of diversity in learning, involves outside professionals into teaching and gives students a chance to go beyond specific disciplines (Creativity in Higher Education: Report on the EUA Creative Project – 2007, 2007).

Structural-functional components of the learning and scientific innovation innovation environment represent forms of organization and methods of cognitive activity of a learner in professional and socio-cultural contexts, resulting in creation of new knowledge or its transformation into a technical object. The structural-functional components include cognitive collectives (including youth groups) acting in the forms of research groups, laboratories, design bureaus, creative workshops. Today, this variety includes small innovative companies, business incubators, technology transfer centers, knowledge distribution offices and other organizations involved in the processes of technological transformation and commercialization of knowledge.

Integrating structures are meta-environmental structures that expand the learning and scientific innovation, innovation environment of an individual educational institution up to an academic community located both within the integrated educational system (Karpov, 2015b) and beyond its limits.

Let us briefly characterize a number of meta-components, having been already "classical", in the learning and scientific innovation environment.

The scientific societies of learners are, first of all, macro models of professional segments in the society. They bring elements of self-management into learning. Complex programs and projects combine dissimilar socio-cultural contexts and tools of cognitive activity, diversified professional institutions and role functions. Similar cognitive actions are carried out by both educational institutions and external organizations. Methodical associations transform and bring pedagogical experience into everyday work with knowledge. Scientific educational exhibitions,

conferences, training schools-seminars, including distant, carry out missions related to scientific consulting and professional training, approbation and transfer the results of learner's research activity to consumers.

Let's study innovative components of the learning and scientific environment at a research university.

At the structural-functional (basic) level, innovative activities of students and schoolchildren, who are successful in scientific and engineering efforts, consolidate into modern organizational forms, in particular, into a system of small innovation business enterprises that can be startup companies. The economic activity of this company is based on innovative developments or technologies that are marketable; what is more, the degree of novelty of the business-product can be either local, i.e. for a specific market, or global. For creation and development an innovation environment, it is important not only to form "ready-made" startups, but also be able to organize a system of competitive selection of students-managers and students-developers, engaging the most talented persons in works of these companies.

One of the forms of assistance to innovation entrepreneurs is a business-incubator, which has a technical infrastructure, a system of workplaces, and consultation services. To attract funds for implementation and commercialization of developments of students and young scientists, investment sites are arranged at the universities. The teaching-educational functions in the innovation environment are carried out by a knowledge distribution office. The form of the entity providing commercialization of an innovative product is a technology transfer center, and the form of infrastructural and technical support for its production is an innovation and technology center.

A new and effective form of innovation activity organization has become an experimental business-laboratory. In contrast to business incubators it extends "the incubation process beyond the limits of the business plan to encompass experimentation and the simulation of new business concepts". A specific micro-ecosystem of aspiring entrepreneurs and other engaged persons emerges in its environment (Curley & Formica, 2015).

The meta level of the innovative component of the learning and scientific environment carries out a mission of systemic management of structural and functional components. The agents of the innovation meta level are: (1) technological consortiums that unite innovative divisions of educational institutions and business; (2) generalized knowledge funds of

universities and scientific organizations; (3) scientific parks producing a common creative space for science-intensive companies and research teams; (4) techno-parks with infrastructure that can provide a full cycle for materialization of scientific innovations. The system configuration of these meta-elements can be built in terms of bridging three main gaps in innovation activity: between fundamental and applied science in the scientific environment; in the environment of relations between a scientific community and a corporation of process engineers, i.e. on the border of applied science and experimental production, and finally, in the process of technology transfer from developers to producers, or, in other words, between experimental production and industry.

One of the ways to bridge innovation gaps is building engineering-type consortiums – the contact network structures that combine the knowledge generation environment with the knowledge technologization environment, and provide deep engineering in case of interaction of these environments. In 2011, the author, based on the learning and scientific innovation environment theory, developed a concept and a business model of an expert-technological consortium, representing an in-depth type engineering platform for network transfer of technologies in the system of interaction between universities, research organizations, high-tech companies and venture business (Karpov, 2012).

Conclusion

The strategic task of present-day social development is the creation of a scientific and education system giving a potential for formation of the knowledge society. It should be based on a specific form of learning environment that can provide creative, interdisciplinary and proactive training focused on innovative forms of working with knowledge. Its institutional basis is different-level educational institutions, scientific institutions, high-tech companies, innovation firms, industrial consortiums, institutions of innovation-driven growth.

This learning and scientific innovation environment is the core of the modern research education system. It combines the learning process at different stages of education (at school and university) with scientific search and technological transformation of knowledge. It gives a wide range of options for verification an individual vocation. It provides a cognitively active environment for solving practical and theoretical problems, including in developments of new equipment, technology, products, and services, in researches in the field of basic sciences, in

studies of environment - natural, technogenic, social. It can train personnel with the highest qualification, who are able to create scientific products transforming the world.

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