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**UNIVERSITIES IN THE KNOWLEDGE SOCIETY: MODELS OF
GENERATIVE LEARNING ENVIRONMENT**

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Abstract

This work proposes a theoretical approach to the problem of designing the creativity-active and cognition-enriched environments of a modern university that are intended for education of professionals capable of producing knowledge, their materializing and integrating into life of the society. It is based on the idea of generativity that they are a prompting agent to cognition knowledge, creation of new knowledge, and its socio-economic application. This approach is in opposition to the tradition of treating the learning environment as an adaptive phenomenon. The empirical and theoretical material summarized in this paper is collected as a result of studies of cognitive environments at universities, including in the scientific and cognitive space of the “Step into the Future” Program - one of the most powerful systems of research education in present-day Russia. As a result of completed studies, the concept of generative learning environment at a research-type university and its constructional and creative models are developed. The constructional model is presented in the form of a learning-scientific innovation environment containing components of structurally complex epistemic surroundings. The creative model is described as a system of creative spaces of a cognitive-generative type. Key points of the methodology used in the structural-functional analysis of creative spaces at the university, that has been verified in practice at the Bauman Moscow State Technical University are defined. A conclusion is drawn that a modern university is structurally and functionally complex, and its learning environment should be formed as a generative rather than an adaptive system.

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1. Introduction

In conditions of knowledge society formation, creativity-active, cognition-enriched or, in other words, generative learning environments constitute a fundamental basis of a modern university. Unlike adaptive environments that provide only supportive surrounding for learning activities, they are a prompting agent to cognition knowledge, a tool for comprehending and transforming the problematic reality, a place for institutionalizing the creative thinking.

In 2007, the report of the European University Association (EUA) states that creativity, and, above all, creativity in universities is a key factor to address complicated social and economic problems and a key driving force behind the development of the knowledge society (Creativity in Higher Education, 2007, p. 6, 10, 20). In 2008, the UN “Creative Economy” report informs about the emergence of a new development paradigm where creativity promotes entrepreneurship, innovations, economic growth (Creative Economy Report 2008, 2008, p. 3, 4).

From the early 2000s, the process of integrating universities into regionally wide creative ecosystems that promote innovation and social prosperity is making progress (Peters & Besley, 2013, p. viii, ix). These ecosystems increase scientific discovery resources with a commercial potential to such an extent, that it will be a viable business (Curley & Formica, 2015b, p. 20). In 2003-2004, 53 companies demerged from Imperial College London, 48 companies – from the University of Manchester, and 45 companies – from the University of Oxford. In this period, more than 150 new companies were founded every year around the Massachusetts Institute of Technology (MIT) (Wissemma, 2009, p. 138, 96). Within five years, the University of Cambridge ecosystem has given rise to 11 companies with a combined valuation of £1.3 billion (University of Cambridge Enterprise, 2016, p. 1, 3, 32). Today, the Catholic University of Leuven has 586 active families in its patent portfolio, i.e. groups of patents issued in different countries for the same invention (Ewalt, 2017). The multi-campus systems of higher education in the United States promote the formation of multidisciplinary and cross-institutional collaborations for solution of complex socio-economic problems (Lane, 2013, p. 10, 12).

The basis of the University’s innovative ecosystem is a generative-type learning environment. In this ecosystem, student ideas become world-changing technologies (Overview of the MIT Innovation Initiative, 2016, p. 8, 10). Indeed, MIT has announced a new approach to innovation education, where education should be carried out in expanded innovation-centric spaces. They should 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, 2016, p. 22, 2). Ability to apply knowledge in actual conditions of an employer is indicated among the most valuable results of education, providing a professional growth in the knowledge society (Falling Short?, 2015, p. 1-3).

New learning methods, e.g. research learning, blended learning, problem-based learning, personalized learning, deeper learning, are generating special creative environments, where the latest technologies are making an instrumental basis (Johnson, Becker, Ectrada, & Freeman, 2015, p. 16, 22, 26). The flipped classroom model implemented at the Simon Fraser University, made it possible to create in the course of education 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, p. 7, 8). MakeSchools Alliance founded by 40 American

colleges and universities informs about implementation of the “creative spaces” concept (Makerspaces or spaces for developers). They integrate 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 are generated to take creative risks and tackle difficult tasks (Byrne & Davidson, 2015, p. 3, 5, 11). By implementation of research training methods, the Russian “Step into the Future” scientific and social program creates local creative spaces on the basis of universities that give a potential to study the world by “adult” methods; among them are youth scientific laboratories, design bureaus, forestry and agricultural experiment stations (Karpov, 2012b, p. 729-730).

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 (OESD Skills Outlook 2013, 2013, p. 99). Digital literacy is not only a capacity for technical transformation of information, but, to a much greater extent, a special “cybernetic” thinking, which requires special university environments for its evolution. Indeed, the ICT literacy model for higher education proposed by Perez and Murray (2010, p. 132), makes generativity achievement by a computer user a cornerstone, i.e. the ability to acquire new skills and generate new knowledge which form the basis for innovations and creativity.

Pointing to an urgent character of the problem to design the effective learning environments, experts direct attention to a discrepancy between intellectual needs of students and educational environment (Shernoff, 2013, p. 12-14); an educational problematic character of “smart” classes, when they are transformed into an intricate bundle of technical gadgets (Strauss, 2002); cognitive losses caused by new technologies (Johnson *et al.*, 2016, p. 30, 31).

2. Problem Statement

This study looks at the problem of developing a theory of university propelled generative learning environments designed for education of highly-skilled persons who are able to produce knowledge, materialize them and integrate into life of society.

3. Research Questions

What are structural-functional contents of the university learning environment that cultivate generativity capacity, stimulating and canalizing cognitive activities towards productive attitudes to problematic reality?

4. Purpose of the Study

The aim of this study is to provide a conceptual description of the generative learning environment from the standpoint of a research-type creative activity; to develop constructional and creative models of the generative learning environment that determine key structural elements, their functions and a design of a modern university’s creative space.

5. Research Methods

The following research methods were used: social-epistemological analysis, classification and generalization of empirical and theoretical data collected as a result of studies of cognitive environments at universities; didactic analysis and theoretical modeling of learning processes that use a scientific infrastructure and research methods of cognition; development of a structural-functional approach to designing the University's creative spaces. A considerable amount of empirical data has been collected in the scientific-cognitive space of the "Step into the Future" Program, which is one of the most powerful research education systems in present-day Russia.

6. Findings

6.1. Generative learning environment

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 in research education is aimed at developing abilities for discovery of new knowledge and methods of its transformation (Karpov, 2016, p. 1625-1629). 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) (Karpov, 2017a, p. 337-339).

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. 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 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. 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.

Analysis of the generative environment as structurally complicated epistemic *surrounding* leads to cognitive-constructive concepts, where the “learning and scientific innovation environment” model developed by me falls into this category. By accentuating the feature of generative environment as a *creative origin*, i.e. focusing on cognitive-operational functions, I came to theoretical understanding of this environment as a creative space. Main points of the constructional and creative models of the generative learning environment will be briefly discussed below.

6.2. Constructional model of generative learning environment

The “learning and scientific innovation environment” model can be interpreted as an epistemic mega-constructor containing socio-morphic extracurricular-type structures performing specialized work with research cognition and its products.

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.

Structural-functional components of the learning and scientific 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. Among the “constructed” objects that fill the learning and scientific innovation environment, the structural-functional components are the first principles, i.e. primary and bearing elements.

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 environment of an individual educational institution up to an academic community located both within the integrated educational system (Karpov, 2015, p. 531-536) and beyond its limits. As a rule, they are associated with structurally complex organizational forms of cognitive activity and knowledge materialization. Experience in working with innovative knowledge acquired in collectives acting at the structural-functional level is accumulated in the educational institution's environment through the integrating structures; representation of this experience in social structures of the outer world is realized;

cognitive investments in public life are made. At the same time, the meta-environment constructions contribute the experience and resources of the outer world to the environment of cognitive groups.

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, macromodels of professional segments in the society. They bring elements of self-management into learning. An authentic inter-translation of realities of the outer world and the learning world takes place through these organizations. 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, 2015a, p. 5, 6).

The metalevel 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 metalevel 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, 2012a, p. 47-65).

6.3. Concept of creative spaces

Based on the analysis of scientific sources and contents of information resources of universities, I identify three types of conceptualizations of university creative spaces: a model of environment surrounding, a model of cognitive processes, a model of cognitive system linking processes of knowledge acquisition and creation to epistemically active (generative) environment (Karpov, 2017b, p. 922). In my opinion, the third conceptualization – the process-environmental model, is the most promising in the context of study and construction a creative university. It rests on a comprehensive approach that is justified by the fact that *the educational environment in the knowledge society more and more predetermines possibilities of the cognition method, and the cognition method requires its own environment.*

In the first type of conceptualization – in the model of environment surrounding, the creative space means ergonomics and technical equipment of training premises, scientific laboratories, rehearsal rooms, Fab-laboratories, etc. (Martin, Morris, Rogers, & Kilgallon, 2010, p. 23). The main propulsor in distribution of this approach is commercial interests of architectural companies, design studios, gadgets manufacturers, and large corporations.

An example of the second type of conceptualization – the model of cognitive processes, is an approach proposed by Wierzbicki and Nakamori (2005, p. 9-11), where the “creative space” denotes a conceptual scheme of knowledge creation on the basis of the SECI-spiral model by Nonaka and Takeuchi. In the latter, the knowledge increment process is described as a result of four successive transitions: Socialization, Externalization, Combination, and Internalization.

The third – the process-environmental type of conceptualizations is at the stage of theoretical development. For instance, Boys calls “to look beyond ... ‘beanbag’ approach to learning space design”, which focuses on “playful settings, bright colors, natural lighting and softer furnishings” and rests on “learning cafés, informal seating areas, corridor alcoves or social hubs”. His standpoint lies in the fact that “the space is therefore one of our means of thinking about the world and of embodying thought into

action". Therefore, specific sets of social and spatial practices should be analyzed in a *relevant* context to understand the relationship between learning and space at different levels (Boys, 2011, p. 1, 6, 7).

Within the process-environment concept, the creative space is defined by me as a cognitive-generative system stimulating creativity and development processes of the creative thinking function via a link between cognitive activity and epistemic-active environment.

With respect to knowledge generation, the type of universities is determined by the following academic missions: University 1.0 – only an educational institution, University 2.0 – learning and research missions, University 3.0, in addition to the latter two, undertakes the mission of social and economic development. Each of them cultivates its own dominant type of cognitive attitude and specialized creativity.

For different types of the university this definition means, that its creative spaces should be socially-enriched and creatively promoting towards cognition (University 1.0); they should actively act as a factor in creation of scientific and technological innovations (University 2.0), as well as actively participate in processes of their moving towards practical application (University 3.0); i.e. be generative in their structure and functions. They should function as a common episteme-didactic complex, through which the university becomes a direct actor of social action aimed at progress of the knowledge society.

Creative spaces of the university in their action should be directed to education a person in line with university's dominant missions, not just students, future engineers and specialists. For University 1.0, it is academic training of professionals (single-discipline or multi-skilled specialists) possessing the propensity for creativity within the acquired disciplinary knowledge system. For University 2.0 (research-type university), the creative spaces are focused on research training of future scientists and engineers-scientists, i.e. they are examined through lens of training young people capable to create new knowledge, techniques, and technologies. For University 3.0, in addition to the above-listed, the creative spaces should be oriented towards education of professionals possessing scientific-entrepreneurial creativity.

6.4. Creative model of generative learning environment

Let's study the process-environment concept of a creative space as applied to designing a creative model of the generative learning environment.

The university creative space is a place of psychosocial and professional growth for very heterogeneous subject of knowledge. In addition to undergraduate and graduate students and postgrads, the University provides its own cognitive resources to in-house or outsourced teachers, scientists, professionals as well as students of other educational institutions, including school children (Karpov, 2018, p. 88-90). The subject of knowledge heterogeneity is one of the main reasons for a variety of creative spaces at the modern university. Another reason is originality of environmental factors influencing on the cognizing personality creativity.

My definition of the creative space rests on the idea of an external positive impact on creative activities of an individual, which is objectified in the institutional structure as a set of cognitive-generative systems. Bearers of these cognitive-generative systems (local creative spaces) at the University have different functions and different forms of organization. An university department, a research team, a research laboratory, and an institute as well as communicative-cognitive actions (exhibitions,

conferences, and scientific schools) perform *scientific education* function. *Innovative and scientific entrepreneurial* activities are implemented through such organizational forms as start-ups, business-incubators, small innovative companies, engineering centers. A library, a museum, a debating club, a pilot plant, a dormitory, and a culture & art center play specific *customized* role in the creative structure of the University. Scientific societies and youth groups, creative resources in Internet, partnership networks, where external relations of the university are put into life, have a distinctive creative effect.

Any local creative space is characterized by its unique set of components having an effect on creativity. They include cognitive roles, epistemic processes, research and cognitive instruments, physical space, “mental atmosphere”, values, attitudes, traditions.

Theoretically, the creative space is described as an *ideal type*, i.e. not as a *specific* university department, laboratory, research group, library, etc.; but as their collective image concentrating and representing maximal generative potential (in terms of knowledge, personal development, available opportunities). Definition and qualitative description of the *system* of local creative spaces as ideal types make it possible to construct a creative university model in a most enriched and productive version with due account of possible interlinks and interactions. Comparison of this model with the reality of one or another university reveals opportunities for its modernization.

To study the creative space as an ideal type, it is necessary to find a complete set of key factors influencing on creative activity of a subject of knowledge. These factors can be categorized and grouped into functional complexes identifying the types of creative space activity. For example, the content of *the complex of scientific and social development of an individual* at the university includes processes of involvement into research-cognitive activity, its management and supervision, ways for involvement into collectives of cognitive personality growth, social positioning mechanisms, etc. The *epistemic-psychological complex* includes tools to generate motivations to creative activity, scientific attitude to the truth, scientific-type research behavior, value orientation and attitudes regulating scientific creativity, etc. The *exchanging communicative complex* contains ideas and knowledge transmission processes, their mediators and configurations, including network and institutional interactions. And so on.

The total university creative space can be figuratively presented as a set of stratifying local creative spaces constituting its “horizontal” scheme. In order to describe the total university creative space in the form of a coherent whole, it is necessary to structure a conglomerate of “vertical” links that govern the interaction between “horizontal” loci in the implementation of the university’s creative function. Method for construction the order in these complicated relations is combination of *homonymous* functional complexes of different creative spaces into a structurally functional system.

Interactions between homonymous key factors influencing on creative activity of subjects of knowledge belonging to different creative spaces should be studied within each of these “vertical” systems. Let’s take, for example, processes of involvement into research-cognitive activities as this homonymous set of factors. Analysis of their interaction between creative spaces of a department, a research laboratory, a business incubator, a library, etc. can find one of “vertical” elements contained in the structure of links between local complexes of scientific and social development of an individual. More complicated vertical-type functional dependences can be derived from the analysis of links between

heteronymous key factors and their sets (including going beyond one complex), functional complexes alone, and their sets.

A set of structural and functional systems forms a “vertical” scheme of the total university creative space. It includes such structural-functional systems as personality scientific and social development, epistemic-psychological, exchanging-communicative, infrastructural-environmental, meta-functional (provides emergent links between intentions, ideas, activity, cognitive cooperation). The totality of links between structural-functional systems can be treated as a “horizontal-vertical” scheme of the university creative space.

The structural-functional analysis of creative spaces for a specific university consists in identification the content and internal links in “horizontal”, “vertical” and “horizontal-vertical” schemes.

The methodology of structural-functional analysis of creative spaces developed by the author has been tested in the study completed by a research team of the “Innovative Education at the Technical University” laboratory at the Bauman Moscow State Technical University. The results have showed a high level of its potential to explore and develop the university creative environment.

7. Conclusion

The modern university is a structurally and functionally complicated phenomenon. Its learning environment should be formed as a generative rather than adaptive structure, i.e. be an active agent in education of a knowledge worker. The constructional model of the generative learning environment can be described as a learning and scientific innovation environment, that includes a vast variety of organized forms of cognitive activity. The creative design of the generative learning environment is determined by a configuration of creative spaces, each of them acting as a cognitive-generative system providing and guiding a professional and socio-cognitive development of the personality.

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