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The role of functional requirements for university campus facilities in their design and operation

This article is a continuation of a series of publications on the further development of the network of university campuses as innovative educational spaces in our country. At the moment, the Russian economy is facing great challenges in the field of technological development. And the integration of education, science and technology on the basis of modern educational spaces plays a new role as a fundamental element in the implementation of national projects and the solution of many global problems. In previous publications, within the framework of this direction, the author disclosed the results of his research, determining the possibility and effectiveness of implementation and application of a number of multifunctional tools, such as "Educational-technological conditions", "Educational-technological task", "Combinatorial matrices" within the development of innovative educational spaces. The ways of integration of "Educational-technological task" with information models of capital construction objects within campuses were described. The peculiarities of life cycle management of various objects of university campuses were analyzed.

This article is devoted to the identification of the determining role of functional requirements and their prevalence in the modern educational environment over architectural, constructive, technical and other requirements. After all, they determine the properties of the created and developed material and spatial environment of the university, which in turn contributes to the prestige and competitiveness of higher education. The article touches upon the interdisciplinary approach to the stages of design, operation, repair, modernization of campus facilities, determined by the need to solve a variety of tasks in them, involving in their functioning students, teachers, scientists, entrepreneurs of different ages, with different interests. It is the interdisciplinary approach that can ensure density and intensity of communications, quality of space, flexibility, ability to rebuild and experiment, diversity of non-academic functions, formation of effective economic and management models.

Keywords: *scientific and technological development, innovative methods, material and spatial environment, technological companies, requirements, interdisciplinary approach, environment parameters*

INTRODUCTION

In the next 10–15 years, according to the Strategy for Scientific and Technological Development of the Russian Federation, the priorities of scientific and technological development of Russia will be those areas that will allow to obtain advanced scientific and scientific-technical results, to form breakthrough technologies that are the basis for innovative development of the domestic market of products and services, sustainable position of the country in the foreign market. They will enable the transition to advanced digital, intelligent production systems, creation and application of high-tech products [1].

Accordingly, systemic changes in approaches to scientific and technological development of the country are required to achieve technological sovereignty in the field of critical and cross-cutting technologies. And on this path, it is necessary to consolidate the efforts of federal public authorities, public authorities of the subjects of the Russian Federation, scientific, educational and business community, civil society institutions to create favorable conditions for the development and application of science and technology in the interests of socio-economic development of Russia [2].

In order to ensure leadership in traditional and new markets of technologies, products and services, to build an integrated national innovation system, it is necessary to concentrate resources in order to obtain new scientific results necessary for

the country's transition to the next technological modes. It is necessary to implement a set of organizational, legal and other measures aimed at a significant increase in the efficiency of expenditures on research and development, increasing the return on investment in the relevant areas of the economy for the development of national research and development centers. The creation of effective partnerships with domestic and foreign research centers, the emergence and development of private companies capable of becoming leaders in technological markets can play an important role in this direction.

This is what the Standard of Innovative Educational Environment (campuses) [3] is largely aimed at with its requirements and provisions, such as:

- creation of campuses as centers of new opportunities, points of migration, technological and investment attraction;
- end-to-end implementation of digital twin technologies;
- necessity and possibility of creating innovative products, modern technologies, patents on the basis of research infrastructure;
- maximum involvement of students of all levels in project, research activities, technological entrepreneurship, and sports life of the university;
- creation and continuous increase in the number of high-performance jobs;
- formation of flexible ecosystems of techno-

logical entrepreneurship with support from industrial partners, development institutions;

- provision of elements of related business infrastructure and continuous improvement of user satisfaction.

The campus that provides these conditions will be transformed into a center of innovative production and implementation of new technologies, attract the most highly productive and creative workforce due to the availability of innovative infrastructure and high standard of living on its territory [4]. This is the target image of new-type campuses. But for this, it will be necessary to revise the approaches and ensure a variety of factors in the design and organization of the material and spatial environment.

PRINCIPLES AND FACTORS OF SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT

In the current situation and under the conditions of providing complex functional requirements, the subjects of scientific and technological development in our country can become:

- associations (technological holdings, etc.), including educational, research, design and production base, pilot production, which can be formed around technical universities or technological companies on the basis of an integrated approach [5];
- research consortia, capable of implementing large-scale technological projects up to the development of prototypes ready for commercialization, the main functionality of which will be aimed at the operational solution of scientific and educational tasks by building effective interaction between the consortium members by combining their own and external resources, redistribution of these tasks between them and optimization of costs for research, development and technological work [2].

In the activities of such entities, it is possible to identify the most significant principles of scientific and technological development and group them by directions: financing, opportunities, support (Table 1).

The described principles, in the conditions of state policy in the field of scientific and technological development of the Russian Federation, suggest the availability of opportunities and prospects

Table 1. Principles of scientific and technological development

Directions	Principles	Significance of the principles
Financing	Integrity of the innovation cycle	Ensuring “seamlessness” and provision of support measures at all stages of technology creation and implementation from research and development to implementation in the real economy within the framework of the technological development ecosystem
	Concentration of resources	Focusing intellectual, financial, organizational and infrastructural resources to support research and development, creation of products and services
Opportunities	Freedom of scientific and technical creativity	Providing opportunities for scientific teams and organizations, other participants of research and development to choose and combine directions, forms of interaction, methods of solving research, technological problems while increasing their responsibility for the effectiveness of their activities and the significance of the results obtained for the development of the national economy and society [6]
	Openness	Effective interaction of scientific organizations, participants of research and development with representatives of the business community, society and the state, as well as based on national interests with the international community
	Recognizing the right to risk	Possibility of failure to achieve the planned results of technological works, including research and development works
Support	Systemic support	Ensuring a full cycle of obtaining new knowledge, developing qualitatively new technologies, creating innovative, breakthrough products and services, forming new markets, and taking a sustainable position in them
	Rational balance	State support for research and development aimed at solving both significant tasks within the framework of the priorities of scientific and technological development of the Russian Federation and tasks initiated by researchers and conditioned by the internal logic of science development, state and public support for fundamental research as a tool for long-term development of the country
	Fair competition	Use of public mechanisms to provide access to public infrastructural, financial and non-financial resources to the most productive research teams, other subjects of scientific, scientific-technical and innovative activity regardless of their organizational and legal form and form of ownership

for the use of innovative methods, new technologies in the transformation of education and science, and the integration of education, science and business.

But such global changes in the organization of scientific, technical and innovation activities lead to the emergence of new significant internal factors for the scientific and technological development of the country, which also need to be taken into account in the analysis of ways to address the goals and objectives [1].

Such factors include:

- compression of the innovation cycle: the time for obtaining new knowledge and creating new technologies, products and services and bringing them to market has been significantly reduced;
- blurring of disciplinary and industry boundaries in research and development;
- a sharp increase in the volume of scientific and technological information and the emergence of fundamentally new ways of working with it;
- changes in the forms of organization, hardware and software tools for research and development;
- growing requirements to the qualification of researchers, international competition for talented highly qualified workers and their involvement in science, engineering, technological entrepreneurship;
- increasing role of international standards;
- the emergence of a limited group of countries dominating in research and development and the formation of a scientific and technological periphery that is losing its scientific identity.

THE ROLE OF FUNCTIONAL REQUIREMENTS

The basic requirements for the functioning of the campus listed in the introduction should be ensured by an appropriate material and spatial environment. For example, in order for the campus to become a platform for joint development of researchers and businesses, incubators and startups, it is necessary to provide a number of multifunctional spaces for joint projects of the university and companies, which will be aimed at the creation and testing of new

▶ technologies. In the necessary volume for the future development and corresponding to a number of functional requirements for the possibility of transformation. Today, in the architectural and urban planning understanding, a modern scientific and educational complex is a cluster system, which includes various types of objects: educational centers, workshops, research laboratories, as well as public recreational and residential facilities [7].

In order to keep the campus oriented towards practice-orientedness, to increase students' responsibility for the results of learning, to form programs of cognitive development of personality, to participate in modular learning, to individualize the educational process, it is necessary to provide the campus infrastructure with appropriate spaces, educational and technological equipment, networks and equipment for building individual educational trajectories or educational trajectories for small groups. And to integrate the campus into the city structure with a balance of functions for convenient life, study and work, it is necessary to adapt its infrastructure, material-spatial environment and management models to the new joint demands of the university, business, municipal authorities, local residents, etc. using parameterization mechanisms. The output should provide the necessary degree of dispersion, i.e. the counter availability of urban infrastructure necessary to ensure the activities of the campus [8].

At the same time, functional requirements to campus facilities by their specificity can have functional-organizational, functional-technological, functional-infrastructure or functional-operational properties. And refer primarily not to architectural and structural or volume-planning solutions, but to the possibility of transformation and adaptation of spaces, the possibility of using different combinations of educational, technological, research equipment, the availability of technological networks and structures, the ability to change temperature and humidity conditions, the ability to change the magnitude and nature of the load on building structures, the presence and operation of digital systems that create a unified digital campus environment, the availability of integration digital platforms. By their properties, functional requirements can be included and interconnected in the Educational and technological task as a document containing the initial data for design [9]. And the overall functionality of the campus should correspond to the target model of the HEI defined in the program of its development.

The standard of innovative educational environment (campuses) [3] establishes an extensive set of basic requirements for the functioning of the campus in terms of its basic functionality and scientific and educational infrastructure, necessary to ensure at the stages of design and operation of campus facilities. In their main directions, these requirements provide the following capabilities:

- realization of activities within the framework of national and federal projects;
- conducting research and development, creating results of intellectual activity and high-tech products;

- creation of structural subdivisions of universities together with external partners;
- implementation of practice-oriented educational programs together with industrial partners, network programs;
- organization of industry events, including those for city residents, etc.

It is these basic functional requirements that determine the possibility of achieving the socio-economic effects of the campus program at the national level, at the entity level, at the institutional level [10]. In turn, most of the basic requirements consist of groups of detailed requirements that determine the possibility of their clear formulation, control and confirmation.

If we analyze the functional-oriented requirements of the Standard and systematize them by scope of application, we can get a clear picture of what the campus program focuses on (Table 2).

The comparison shows that the main part of the requirements is focused on creating a favorable, efficient, safe environment for education, science and business. And from the significant difference between the number of basic and detailed requirements, we can conclude about the necessary flexibility and transformability of this environment. Thus, we can conclude that in accordance with the Standard, it is supposed to create not only a convenient and compliant infrastructure, but also an educational and material-spatial environment in which it will be possible to realize the stated goals and objectives of innovative development.

Speaking about the lists of requirements defined by the Standard, it would be rational to propose to form a corresponding register of them for more convenient and efficient work with them at the stages of design and operation. The Strategy for the development of the construction industry and housing and communal services of the Russian Federation for the period up to 2030 with a forecast up to 2035 defines that the "register principle of development of technical requirements" is the principle of development of technical requirements, which implies the possibility of their practical implementation (including on a mandatory basis) only after the inclusion of such requirements in the relevant register [11].

In addition, it is obvious to assume that requirements, even those included in the relevant register, cannot be equivalent. In connection with the entry into force of SP 555.1325800.2025, it is possible to define that a requirement is a provision (normative document) containing quantitative and (or) qualitative criteria that must be met to divide the requirements into groups [12]. At the same time, key requirements can be singled out as requirements, the fulfillment of which during the entire life cycle of a building or structure (including the implementation of such requirements in the process of construction, reconstruction, capital repair, as well as maintenance of parameters and characteristics of buildings and structures at the level set by these requirements in the process of operation) directly ensures the fulfillment of the relevant tasks, i.e. ensuring the functional characteristics of the capital construction object.

Table 2. Systematization of functional requirements for campus facilities

Types of requirements	Number of basic requirements	Number of detailed requirements
Functional-technological (including requirements for the level of digital services and technological entrepreneurship ecosystem)	25	74
Functional and organizational (including service and openness requirements)	12	18
Functional and infrastructural (including requirements for material and technical equipment)	27	68
Functional and operational (including requirements provided at the design stage)	14	43

CHALLENGES TO IMPROVE THE FUNCTIONALITY OF CAMPUSES

In the conditions of rapid economic development it is important to provide not only opportunities for advanced education, but also for advanced architectural and construction design of higher education institutions.

It is necessary to use the results of modern ergonomic research (anatomical, physiological and psychological changes that a person undergoes during work) not only in the organization of workplaces and within the framework of industrial design [13], but also in the organization of "educational" places and the design of the necessary material and spatial environment of innovative campuses. Only in this case there is an opportunity to increase the productivity of the participants of the educational and research process. At the same time, it is especially difficult, but also important, to ensure the communication between educational, research and innovation centers on the basis of spaces suitable for conducting joint projects.

In particular, by providing pre-determined and justified requirements and parameters for the material-spatial environment that enhance its functionality, it is possible to:

- close the needs of students, faculty and staff in a comfortable environment for living, learning and working;
- avoid the deficit of teaching and laboratory spaces, places in dormitories and sports and recreational infrastructure [6];
- to recalculate the standards of space per 1 student, which at the moment do not correspond to the realities and foreign analogs;
- expand options for conducting relevant scientific research and engaging in innovative activities;
- close the demand for the use of end-to-end technologies in the educational process, for example, technologies for storing and analyzing big data, virtual and augmented reality technologies, quantum computing, etc.;
- provide conditions for the implementation of joint projects with business, ordering research and R&D from the university.

It is important to note that the weakest point in the prospects of the campus program is the organization and management of interaction between universities and the real sector of the economy and industry business [14]. The discontinuity of the innovation cycle leads to the fact that public investments in human capital actually ensure the growth of competitiveness of other economies, as a result of which, the ability to retain the most effective scientists, engineers, entrepreneurs who create breakthrough products is significantly reduced in comparison with the countries leading in innovation. Against this backdrop, there is a perception that increasing the functionality of existing and emerging campus facilities will offer participants the environment necessary to realize innovative ideas and quickly bring new products to market, increase the general interest in the implementation of joint projects, entail investments in infrastructure, and benefit companies from such partnerships.

Considering the campus program at the state level, one cannot but note that in order to ensure the independence and competitiveness of our country through the creation of an effective system for building up and making the fullest use of the intellectual potential of the nation, it is necessary to solve a number of complex and still open tasks. Among them:

- creation and development of mechanisms for identifying talented young people and building a successful career in science, technology and innovation;

- creation of a system of conditions for conducting research and development, corresponding to modern principles of organization of scientific, scientific-technical, innovative activity with the best Russian and world partners;
- formation of an effective system of communication in the field of science, technology and innovations, providing increased receptivity of the economy and society to innovations, as well as conditions for the development of knowledge-intensive business;
- formation of an effective modern end-to-end management system in the field of science, technology and innovation;
- promoting the formation and development of models of international scientific and technological cooperation and international integration in the field of research and technological development.

CONCLUSIONS

Today there is a need to consolidate around the program of university campuses researchers in the field of construction, design, pedagogy, psychology in order to study the impact of the functional characteristics of the material and spatial environment of universities on the effectiveness of the educational and scientific process, integration with business and industry, and design options in accordance with the requirements of tomorrow. Only such consolidation will allow to ensure the possibility of an effective response to technological challenges, taking into account the increasing relevance of synthetic knowledge and technologies created at the junctions of multiple disciplines. And the campus begins to represent an optimal form of organization of complex forms of activity between permanent residents-participants of the project campuses, partner network and external consumer environment, which cannot occur separately [15]. In this case, the object of management in the campus becomes the creation of conditions for the emergence of joint activities and the appropriate selection of tools.

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Роль функциональных требований к объектам университетских кампусов при их проектировании и эксплуатации

Данная статья является продолжением серии публикаций, посвященных дальнейшему развитию в нашей стране сети университетских кампусов как инновационных образовательных пространств. В настоящий момент перед российской экономикой стоят большие вызовы в области технологического развития. А интеграция образования, науки и технологий на базе современных образовательных пространств играет новую роль как основополагающий элемент реализации национальных проектов и решения многих глобальных проблем. В предыдущих публикациях в рамках данного направления автор раскрыл результаты своих исследований, определяющих возможность и эффективность внедрения и применения в рамках развития инновационных образовательных пространств ряда многофункциональных инструментов, таких как «Образовательно-технологические условия», «Образовательно-технологическое задание», «Комбинаторные матрицы». Были описаны пути интеграции «Образовательно-технологического задания» с информационными моделями объектов капитального строительства в составе кампусов. Проанализированы особенности управления жизненным циклом разнообразных объектов университетских кампусов.

Настоящая статья посвящается выявлению определяющей роли функциональных требований и их превалирования в современной образовательной среде над архитектурными, конструктивными, техническими и другими требованиями. Ведь именно они определяют свойства создаваемой и развиваемой материально-пространственной среды университета, которая, в свою очередь, способствует повышению престижа и конкурентоспособности высшего образования. В статье затронут междисциплинарный подход к этапам проектирования, эксплуатации, ремонта, модернизации кампусных объектов, определяемых необходимостью решения в них разнообразных задач, вовлечения в их функционирование студентов, преподавателей, ученых, предпринимателей разных возрастов с различными интересами. Именно междисциплинарный подход может обеспечить плотность и интенсивность коммуникаций, качество пространства, гибкость, способность перестраивать и экспериментировать, разнообразие неакадемических функций, формирование эффективных экономических и управленческих моделей.

Ключевые слова: научно-технологическое развитие, инновационные методы, материально-пространственная среда, технологические компании, требования, междисциплинарный подход, параметры среды

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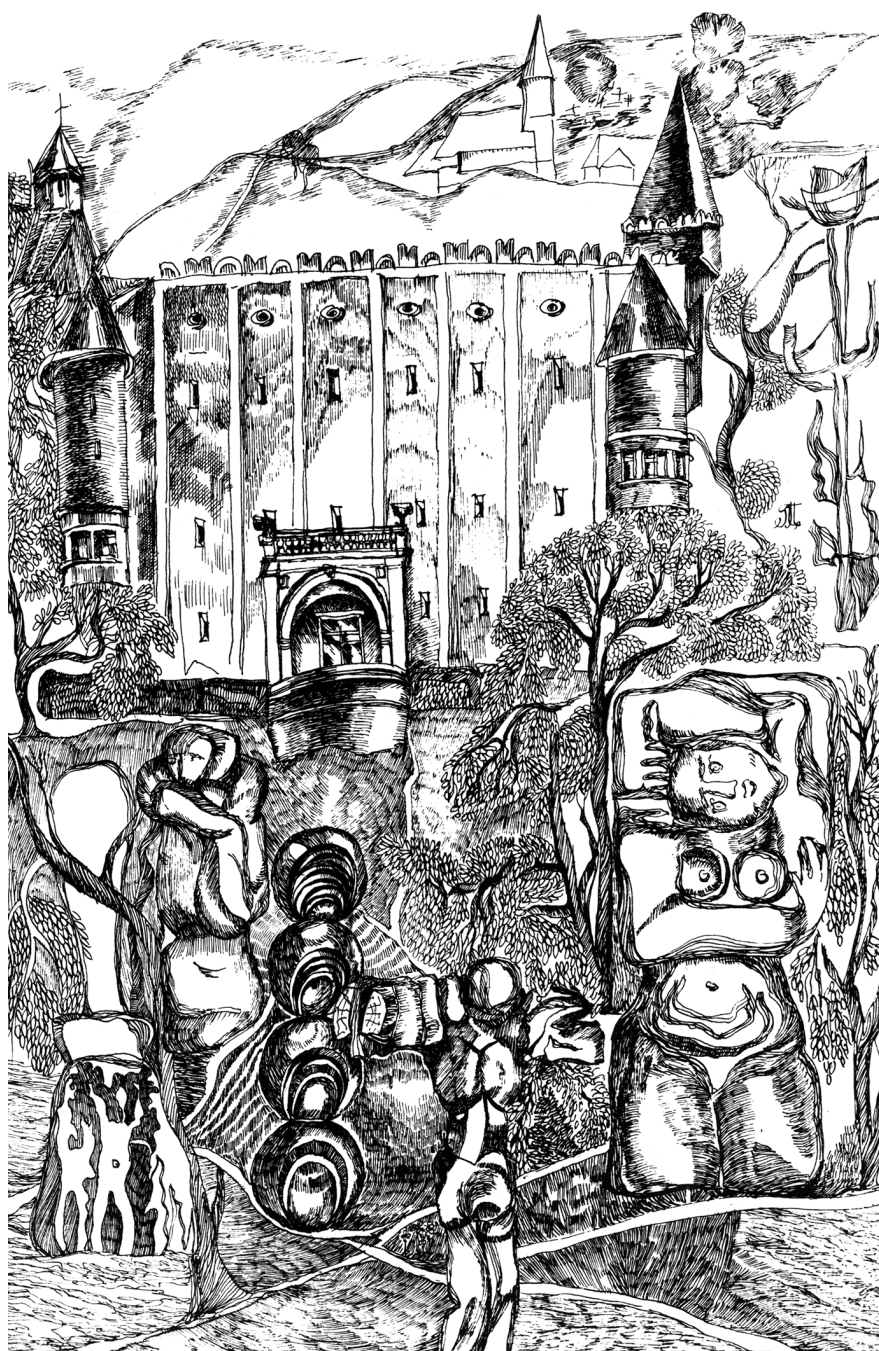
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