Architecture of innovative educational spaces of a university campus. On the example of SYSTEMS Centre of Engineering Systems in Construction at KSUAE (Kazan, Russia)

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Abstract. University campuses in Russia require updating educational methods, modernizing buildings and territories, improving the material and technical base. Transformations should take place in accordance with the latest trends in the design of educational spaces. The article proposes an integrated approach in the design of innovative educational spaces, guided by the basic principles: openness and connectedness; multifunctionality and transformability; harmony. This method was used in the design and implementation of the modernization project of the Center for Engineering Systems in the construction of Kazan State University of Architecture and Engineering. The successful launch and operation of the center confirms the relevance of the method used.

Keywords: university campus, university complex, innovative educational spaces, educational space, educational environment, modernization of university buildings, an integrated approach.

1 Introduction

At the moment there is a particular increased interest in engineering education and higher education in general, as evidenced by the laws and programs administered by the state, together with production and business. However, this interest is confirmed by the presence of a number of problems in this area, a change in the general policy and the request of the state, leading industries and society. Statistics confirm this, in Russia one of the lowest levels of labor productivity at the moment, etc. President Vladimir Putin instructed to achieve growth in 2018 by 50% compared with the 2011 level. The needs of the construction industry are also changing. Problems exist in several aspects and are a challenge of our time. There is a problem of the gap between the theoretical knowledge of specialists and real practical work, the problem of an insufficient level of creative approach in the work of students and specialists, the problem of fragmentation (discreteness) in education (the division of the entire learning process into separate non-interrelated disciplines; the discrepancy of related courses for several years of training); the problem of poor technical support and the slow introduction of innovative training technologies [1]. Contributing to the solution of these problems should be changing the content, methodology and learning process, as well as revising the architectural environment and architecture of university campuses. Let us first consider the first aspect.

As for the features of organization of educational process and educational space in Russia it is necessary to consider and take into account several factors largely influencing it: namely, the inclusion of Russia in the Bologna process, the inclusion of the international non-profit WorldSkills and interest in CDIO. Russia joined the Bologna process in 2003 and became the 34th participating country. This project was a unique example of a voluntary rapprochement of educational systems of different countries due to methods of "soft" integration, adopted by the European Union [2].

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The movement WorldSkills Russia joined in 2013. The mission of the movement is to raise the standards of training. The movement develops with the support and supervision of educational institutions of higher education, this contributes to the development of both types of education. It contributes to the development of both types of education. Competence-based approach of many contemporary high schools is based on the principle of "case" learning simulations, "simulation". This requires a transformable space and rich technical equipment [3].

The concept of CDIO (Conceive, Design, Implement, Operate), in the translation “Think, Develop, Implement and Manage”, or “Plan, Design, Produce and Apply”, was created to improve the quality of training of design engineers and process engineers. The concept was developed as a part of the international CDIO Initiative project at the initiative of the Massachusetts Institute of Technology (MIT, USA). The CDIO Initiative international project aims to resolve the apparent contradiction and establish a consensus between theory and practice in engineering education [4]. The basis of the modernization of engineering education according to the CDIO concept is the preparation of graduates for integrated engineering activities at all stages of the life cycle of products, processes and systems [5, 6]. In fact, this is a comprehensive integrated approach to the organization of the educational process and the formation of the necessary university environment for the preparation of a new generation of engineers.

It should be noted that the practice-oriented teaching method has been widely introduced since the 60s of the XX century in general secondary, specialized secondary and higher technical education in the Soviet Union. In schools over the past years of study, students have mastered the working profession. Student design bureaus (SKB in Russia) at the departments of technical universities also make a significant contribution to the development of specialists [7].

The list of standards is available at the official website of the movement. The success of the concept and the project method of teaching repeatedly confirmed and is described on the example of different countries [8-10]. A detailed comparative analysis of the traditional method and the CDIO concept presented in [11]. The application of modern educational technologies in high engineering education is considered in [12-14]. Thus, a mixed and interdisciplinary training defines the modern methodology of training [15, 16].

There is an inextricable link between the content, process of education and the environment in which it is carried out as inside buildings and outdoor (surrounding of buildings). The subject of the relationship of learning, environment and nature is discussed in detail in [17].

The aim of the study was to identify the main architectural and urban planning principles which facilitate the formation of innovative learning environment within the existing University campus, providing optimal conditions for productive interdisciplinary training.

It is possible to contribute to improving the quality of education by introducing changes in the content and learning process, as well as by reviewing the architectural environment and architecture of the university campuses in which they are located. The University campus is a great opportunity of organizing the modern educational landscape, combining a space for learning, research, socialization, organized leisure and recreation [18]. The attitude and perception of University campuses more and more conform to the Western model. Today the campus is a cluster complex, which may include educational, research and laboratory, experimental industrial, public-recreational and residential facilities and space at a single isolated site owned by the same organization, with a predominantly pedestrian accessibility of all facilities of the complex [3].

University campus is as a rule already formed structures within the urban fabric, they can be closed and isolated and open [19].

Basic principles of creation of University campuses highlighted such as the unity of educational and scientific processes, the involvement of industry, "immersion" training of students directly in research, design and project development [20].

Before considering an innovative educational space, should be sorted out the concept of "educational space". As rightly observed Tuktamyshov N.K., the use of the term "space" is extremely widespread in education: the common educational space, cultural and educational space, educational
space, etc [21]. Also the system of continuous professional education "pre-vocational-elementary-secondary-higher-extra" can be represented in the form of a single educational space, in which the development and formation of professional-personal qualities of future specialists. [22]. According to Ryabov O.R. educational space – spaces designed for the development of intellectual, socio-moral and behavioral skills in different population groups [20]. In Russia the concept "educational space" Frumin I.D., Elkonin B.D. used in their article in 1993 [24].

The concept of educational space can be interpolated on the scale of the University as a unified educational space, which is proposed to be read in conjunction with the surrounding public space with which it is inextricably linked. Public space is a space of communication and social activity, organized according to the dominant function. According to Gel'fond A.L., on object-typological basis in accordance with the dominant function of a University complex is included in the classification of open and closed public spaces [25]. A number of Russian and foreign researchers have devoted their work to the topic of public spaces in the structure of university campuses [26-30]. It is important to emphasize that the environment of the campus should be full of public spaces, for joint work and relaxation, most effective become a space corresponding with the human scale [31]. The communication spaces of the University with nature and the environment are addressed in the work of José Ripper Kós [17]. In the educational complex such as the University Dyd'kova E.V. identifies the following problems of public spaces: the isolation of public spaces. Spaces are isolated from each other, from the environment, not inscribed in the environment, create a single image; there are no associated public spaces, created the conditions for comfortable internal and external facilities of the complex [32].

Currently, the University campus is viewed fairly as an integral architectural complex of buildings and public spaces with high spatial environment and unique shape [33].

Advanced countries are actively creating new typologically relevant objects, formed in a close relationship with a comfortable environment that makes them competitive for students and teachers, and scientists. For example, educational facilities in Singapore and the United Arab Emirates (eg, the Dubai Knowledge Village project), research park projects in the United States (eg Research Triangle Park in North Carolina) [3].

Examples of the transformation directly to the premises of educational institutions are considered in the works [34, 35]. In Russia, such a new University complex is a University SKOLKOVO.

The Russian Federation has a rich legacy of the Soviet era, which has enormous potential. University campuses are large complexes of buildings and territories, each with their own traditions and unique environment, which requires the updating. It was necessary to improve the material and technical base, update educational technology, learning approaches, the work of the staff, to modernize educational space according to the latest trends and demands of the time.

The innovative educational space in this article is the space of University campus, focused on creating favorable conditions for interdisciplinary research, educational and creative activity for effective interaction between students, teachers and representatives of industries to work on projects of a full cycle. A prerequisite is high quality and modern technical equipment space.

2 Method

It is proposed to develop universal design solutions for the modernization of existing campuses for both indoor and open spaces. The complex should be comfortable and attractive for students and for teachers and academics that will make it competitive.

The first – most important – an integrated approach, at various levels, from the organization of interior space, architectural interior solutions and building and city planning (environment building), including public space. Architectural tools make the whole complex a single educational space comfortable for both professional and social life. An integrated approach as a synergetic able to give a better result compared to a sum of the results of individual decisions.

The authors propose the following key principles in the architecture of innovative educational spaces.
2.1 Openness and connectedness
At the urban level, the openness provided by active interaction with the environment, the architectural solution should ensure transparency of the processes taking place inside the object. Thus, the viewer, who from the side can observe what is happening inside, can show interest and get involved in the process. Subsequently, this may facilitate interdisciplinary interaction. Openness and visual connectivity of spaces allows observing the process of each individual unit of innovative educational space.

2.2 Multifunctionality and transformability
The openness of the planning level allows to organize and multifunctionality of the adjacent open spaces. So, in the open air square in front of the educational center, you can use it for large-scale projects and exhibitions, small safe tests of design samples, and use it for specialized events of various sizes. The versatility in the organization of the interior spaces makes it easy to adapt to quickly changing conditions and challenges. So, with the help of mobile modular furniture you can quickly transform the space.

2.3 Harmony
Organic – the fit of architectural decisions to the context of time and place. These are very important factors. The timing says about the relevance of the decisions made, they should be modern and innovative. Correspondence of time is also compliance with the principles of sustainable development. At the moment, each constructed and, if possible, reconstructed object must take into account these aspects, which can reduce the negative impact on the environment and allow you to take into account all the cycles of the building. With regard to compliance, the facility needs to take into account the existing objects, the context and identity of place.

2.4 Testing
This integrated approach was tested in modernization of the Hydraulics laboratory building of the Kazan State University of Architecture and Engineering.

The idea is to create a centre of engineering systems in construction, as an innovative educational space for interdisciplinary work and comprehensive training in technical and engineering areas with the integration of the industrial complex.

The architectural idea of the project is to create an object that functionally meets the requirements of the educational process and revealing it, and also the complex formation of the main square of the University.

The urban characteristics of the area of an object is its location relative to one of the main entrances to the territory, opening onto the main square, in the neighborhood of the monument and formed green area. When moving from the entrance to the campus to the main buildings of the university, the object meets the “guest” with its butt. That is why it was important to solve the front facade (figure 1). Previously, the laboratory building did not interact with the main square. Main planning principle is openness. It has therefore been suggested to attach the multifunctional input group, which shows what is happening in the laboratory, thus the object opens the University area, and visible when driving to it (figures 2, 3).

Openness is provided by two factors: the creation of a translucent structure of the entrance group and the increase in the window openings of the object. This makes visually open what is happening inside the educational center. Such spaces contribute to innovative processes, a generation of new ideas and communications (to interact and share experiences).
Figure 1. Photos of the Hydraulics Laboratory of KSUAE before modernization (photos of the authors): a) general view (exterior); b) educational audience; c-d) interior.

Figure 2. The project of the Center for Engineering Systems in Construction (illustrations of the authors): a) general view; b) the main facade.
Figure 3. Implementation of the project of the Center for Engineering Systems in Construction. Exterior (photos of the authors): a) general view; b) general view (in the evening); c) entrance group; d) entrance group (in the evening).

2.5 Versatility
Internal space for equipment was inadequate and needed upgrading (figure 1. b-d). According to project domestic space is subject to clear zoning, the first space is universal, multifunction, three more thematic halls: heat generation and microclimate, water supply and sanitation, renewable sources of energy. Despite the clear zoning, the boundaries between the rooms are conditional, as they are created by glass partitions. All spaces are fully functional and allow for lecture classes group and practical, using the necessary specialized equipment. It provides capabilities for the full cycle of training, from concept to implementation and introduction of the developments. Each room of the educational space is provided by the heating and ventilation equipment. Thus, students and young specialists can visually observe and use in their research all the necessary equipment (figure 4). Modular mobile furniture allows to quickly transform the space for different tasks (figure 5).

Harmony. The project is organically integrated into the context, which is confirmed by the formation of the main square of the university. The object has the features of modern dynamic architecture, relevant to our time. It is also relevant to use local renewable materials, sun protection on the south side and alternative energy sources in the project.
Figure 4. Implementation of the project of the Center for Engineering Systems in Construction. Interior. (photos of the authors):

a) lecture hall; b) general view (the relationship of the spaces of the Hall № 1 and the lecture hall); c) Hall № 2; d) Hall number 3 with a classroom.

Figure 5. Plan of the Center for Engineering Systems in construction (illustrations of the authors):

a) an arrangement of furniture 1; b) an arrangement of furniture 2.
3 Result
The new innovative Center for Engineering Systems in Construction, which was called the “Systems” of Kazan State University of Architecture and Engineering, was designed on the basis of the proposed method of designing innovative educational space. The center received many positive reviews from students, university staff, representatives of professional equipment manufacturers and representatives of relevant industries. In addition, the mayor of Kazan called the exemplary project and significant for the city and the Republic. The object really works. It hosts master classes from manufacturers, practical exercises on equipment, which allows you to directly implement the developed project. Thus, the architecture of innovative educational spaces is able to create a favorable environment and contribute to the progressive development of the educational process in the context of modern technologies.

4 Discussion
There are no mathematical calculations of the effectiveness of the developed solutions. In contrast to the narrowly specialized works aimed at implementing the specific educational concepts adopted now, such as, for example, CDIO, this work presents complex architectural solutions that are more universal and adaptive in case of a change of concept.

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