The use of transformable systems in the architecture of buildings of educational organizations

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Abstract. This article discusses the educational organizations buildings architectural formation relevance based on the transformable systems use. On the identified modern trends basis in the educational organizations’ buildings design and construction, the main innovative technologies application areas based on transformation in the architecture of such buildings are identified. On the conducted research basis, the main educational organizations buildings architectural formation techniques in the conditions of constantly changing requirements, the emergence of new technologies and materials are revealed. The necessity of using transformable systems in the design of buildings and educational organizations complexes in modern conditions of the society sustainable development has been revealed. The architectural transformation basic principles during the educational organizations’ buildings space-planning decisions formation are defined.

Introduction

To date, innovative technologies based on the transformable systems and the latest materials use continue to be actively developed in architectural and construction practice. Transformable systems are the systems associated with a dynamic architecture, based on the use of a built-in movement mechanism that allows to modify the building’s geometric shape, the imaginative solution or set its individual elements in motion [1]. The transformable systems implementation could not be realized without the use of the latest technologies, structural elements and materials.

In modern architectural practice, ideas of transformable architecture are implemented in different types of buildings [2-4]. The dynamic architecture application in buildings with an educational function has become topical. The use of transformable systems in buildings of educational organizations is dictated not only by the need to meet modern requirements of the society sustainable development, but also by the need to implement educational tasks in the context of constantly changing requirements for the educational process.

The aim of the work is to determine the educational organizations buildings architectural formation basic principles based on the use of transformable systems based on innovative technologies and materials.

In accordance with the goal it is necessary to solve the following main tasks:

1. To determine the current trends in the education development, which require constant adaptation of the material and technical base of educational buildings.
2. Identify the transformable systems application main areas in the buildings of educational organizations, both in terms of reconstruction and in new construction.

3. To conduct a comprehensive analysis of the designing experience, construction and operation of educational organizations, in order to identify the feasibility of using transformable systems (structures) in the educational buildings architecture.

4. To determine the basic principles of the transformed architecture in the educational organizations’ buildings space-planning decisions formation.

The educational organizations buildings architectural formation concept is based on the use of transformable systems.

The modern education system is aimed at the relevance and feasibility of a new image of the education system as a system creating conditions, opportunities and options for personal and professional development [5]. New educational technologies are emerging requiring special equipment, additional spaces, the creation of the necessary microclimate, etc.

The educational organizations buildings are those buildings that are to meet all modern requirements of the educational process, and therefore have the opportunity to continuously adapt to changing requirements [6].

In order to identify modern trends in the educational organizations design, as well as the application of innovative technologies implementing all the necessary conditions, as well as with possible adaptation to ever-changing requirements, world experience in designing and constructing buildings of educational organizations was analyzed.

Based on the modern educational development programs analysis, world experience in designing and building educational organizations, as well as theoretical and experimental developments in the field of modern architecture, the main trends in the architectural formation of buildings and complexes with an educational function were formulated:

1. Creation of an individual figurative solution (various approaches in the formation of a figurative solution of a building), based on the author's, conceptual solutions;

2. Formation of a space-planning solution that meets the modern requirements of the educational process and provides quality education and comfortable conditions, taking into account ever-changing requirements;

3. Compliance with the society sustainable development requirements - the principles of sustainable architecture based on environmental approaches in the design and construction of buildings are becoming basic:
   - the use of “green architecture”, the introduction into the volume of the building, and in the green spaces’ infrastructure - exploited roofs, terraces, clusters, etc.;
   - the use of energy-saving technologies and alternative energy sources, environmentally friendly natural building materials;
   - application of the bioclimatic architecture principles;
   - the use of intelligent technologies (the use of computer control systems for engineering equipment, optimization of technological processes, increasing the level of comfort, protection, etc.);
   - providing signs of a high-tech building
     (the architecture of the building, its shape allows maximum use of the influence of the outdoor climate on the building; the use of environmental energy and a combined climate control system, etc.).

One of the promising directions in the architectural and construction practice of educational facilities that implements all the necessary requirements may be the transformable systems use in the architecture of such buildings.

Based on a comprehensive study of modern educational facilities, five main levels of transformable systems application were identified:

1. Application at the level of planning decisions;
2. Application at the facade level;
3. The use of transformable elements;
4. Application at the volume level;
5. Application complex (combination of all above listed)

The use of transformable systems at the building plan level. It allows to implement a flexible planning structure. To realize the spaces versatility, by combining or separating the premises. So, in the Baidu multifunctional educational complex in Beijing (China), in the Missouri Innovation Campus (see: Figure 1), the Skolkovo Innovation and Education Center, Moscow (Russia), etc., the use of transformable interior spaces makes it possible to adapt premises for individual and group activities - sliding glass walls, mobile furniture, sliding partitions.

![Figure 1.](image1)

Figure 1. [7] Transformable partitions that separate and unite the individual rooms spaces. Missouri Innovative Campus

The transformable facade systems use. Dynamic facade elements allow to create not only a unique building appearance, but also provide the necessary microclimate in the premises. In combination with innovative technologies and materials, they allow implementing directions of a sustainable architecture and applying energy efficient systems.

One such example is the building of the University SDU Campus Kolding. Dynamic facade elements, provide comfortable lighting in the premises during the day. Solar shading system consists of about 1600 triangular perforated steel blinds. They are mounted on the facade in such a way that they can be adapted to the changing daylight. The panels create an interesting appearance of the building and at the same time provide the necessary microclimate (see: Figure 2). Thus, in the educational organizations modern buildings design the transformable systems in conjunction with sustainable technologies are applied. Educational complexes such as the Cornell Tech Educational Complex on Roosevelt Island, the Educational Center Hall at Cornell University on Ithaca Island, the Emerson College complex in Los Angeles and others have demonstrated the principle of dynamic exterior architecture, in the form of transformable facade elements.

![Figure 2.](image2)

Figure 2. [8]. Transformable facade systems. University in Denmark, Kolding (SDU Campus Kolding), 2012-14gg.
The use of facades dynamic elements provides the necessary microclimate of the premises, as a rule, allows to reduce energy consumption, conserves natural resources.

The transformable elements use can be carried out both inside the building and outside. Forms spaces for various purposes, takes into account climatic features, external transformable elements can take into account the seasonal nature.

For example, in the Singapore University of Technology and Design campus building in Singapore, a luminous-color transformation, which serves for navigation, transforming awning curtains on the windows, hinder intense sunlight is used.

The use of transformable systems that change the building volumetric solution. It is carried out on the basis of transformable building shells, floors, walls, which allows changing the building’s figurative solution, its parameters, and implementing various functional processes. For example, in separate blocks a transformable overlap, walls can be used.

Vivid examples of the transformable systems use in the architecture of educational organizations include the modern educational complex of the Polytechnic University in Leyklend, Florida (Florida Polytechnic University), architect Santiago Calatrava (see: Figure 3). The building of the educational organization has become the center of science, innovation and technology. In the building, the transformation of the outer shell is applied: the building is enveloped outside with aluminum spider web, which is dynamic, makes the complex architecturally attractive, and also protects the interiors from direct sunlight. In addition to the transformable interior spaces customary for modern educational organizations, external transformable structures are inherent in the complex: movable controlled hydraulic aluminum lamellae follow the sun setting, providing adjustment of the level of natural lighting in the central public space and saving energy consumption due to solar panels. The artificial reservoir, in the center of which the building is erected, is a collector for storm sewer and a source of moisture for the surrounding park, adds spectacularism to the overall architectural appearance of the complex [9]. The transformable systems use in a building allows to create multifunctional interior spaces, applies the latest technologies of eco-sustainable architecture, creates a unique figurative solution.

Figure 3. [9]. Transformable systems at Florida Polytechnic University, Florida Polytechnic University, architect Santiago Calatrava

It should be noted that transformable systems allowed an integrated approach in ensuring both the basic educational function of the building and all aspects of modern sustainable architecture in this facility.

**Integrated application of transformable systems. The combination of different dynamic elements and systems depending on the tasks to be solved**

Thus, it is possible to formulate the basic principles of transformation used in the buildings of educational organizations:
1. The principle of complex transformation. Transformable systems and dynamic forms allow not only to create unique figurative solutions, but also to provide all the necessary functional processes, as well as provide for the possibility of their change in connection with the emerging, with time, new needs. Such systems allow to adapt existing spaces to new conditions, change of function, capacity, etc. Creating a changing space can be achieved by the use of mobile structures, elements. At the same time, the transformation can be internal with the use of transformable walls, partitions and other elements inside the building and (or) external, based on changing the volume of the building itself, its envelope. The external and internal transformation use allows to change the layout characteristics, create multi-functional spaces, favorable conditions, taking into account the climatic features (convertible aluminum blinds on the facade and on the canopies provide light and shadow).

2. The external transformation principle. Formation of the architectural decision of the building of the educational organization, based on the use of transformable systems, allowing to create the unique objects having a figurative individuality and uniqueness. The imaginative solution of such buildings can change based on the dynamic technologies’ implementation. Transformable systems based on innovative technologies allow to take into account the achievements and requirements of a sustainable architecture associated with eco-technologies and materials. Such transformable systems are based on dynamic structural elements that allow to regulate the microclimate (for example, transformable facade systems allow you to adjust the microclimate parameters in the room, constantly changing under the influence of the environment: sun, wind, precipitation, etc.).

3. The internal transformation principle. It allows to provide the necessary functional processes and create the adapting spaces possibility, ensuring their multifunctionality.

On the basis of the conducted research, it was revealed that the educational organizations formation in the conditions of constantly changing requirements, in the conditions of sustainable development should be based on the possibility of continuous adaptation to the new requirements, natural conditions, modern technologies, etc. These opportunities provision can be achieved with the use of transformable systems in the architecture of buildings and complexes of educational organizations: dynamic systems, transformable elements, transforming spaces and other variable technologies.

Thus, the introduction of transformable systems into architectural solutions of buildings and complexes of educational organizations, both in terms of new construction and reconstruction [10,11] will create the necessary material and technical base, as well as provide an environment capable of adapting to changing requirements, in conditions of the society sustainable development.

Summary
The practical value of the work:
These studies can become the basic for the further development of architectural and planning solutions for buildings of educational organizations. The transformation formulated principles application in the architectural design of buildings of educational organizations will provide an integrated approach that not only expands the shaping boundaries, but also meets the requirements for educational processes, provides an opportunity to introduce the sustainable technologies, expand the range of functionality, ensure comfort.

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