

## **TOWARDS ADAPTIVE AND FLEXIBLE SCHOOL ARCHITECTURE: INTEGRATING INNOVATIVE SOLUTIONS IN UZBEKISTAN**

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**Abstract.** This article explores innovative ways to develop the architecture of comprehensive schools in Uzbekistan. The study identified significant potential for modernizing existing infrastructure. Unlike approaches that focus solely on problems, this paper proposes a strategy based on synthesizing the positive qualities of existing school architectural and planning heritage with cutting-edge global trends in creating educational environments.

The authors also formulated a comprehensive proposal for the development of new national standards, where a key role is given to adaptability, the integration of digital technologies, the implementation of flexible spatial solutions, and the creation of multifunctional spaces capable of being transformed to meet future challenges.

It is noted that the successful integration of innovative approaches contributes to the creation of conditions for improving the quality of education and the harmonious development of students' personalities in the context of the transformation of the educational system of Uzbekistan.

**Key words:** innovations, educational institutions, adaptive architecture, flexible planning structures, architectural modernization of schools, integration of digital technologies into architecture, socially oriented architecture, reconstruction of school buildings.

**INTRODUCTION:** In today's world, technological transformations are rapidly reshaping society, necessitating their integration into education. One key aspect of this transformation is innovation in the architecture of educational institutions. These innovations, in turn, are aimed not simply at creating comfortable and ergonomic spaces, but at developing flexible, multifunctional planning environments that allow for the creation of various types of educational spaces, from traditional lecture halls to collaborative group workspaces and spaces for individual study. In addition, the use of cutting-edge technologies that improve the quality of sound, lighting, and ventilation, creating optimal conditions for creativity and learning [1] is also possible.

The current development of the education system in Uzbekistan is accompanied by large-scale reforms aimed at improving the quality of education and creating a comfortable learning environment. School education is demonstrating dynamic

development. the last seven years construction and repair work was carried out in more than five thousand schools, in In 2024 - V 608. Inclusive education was introduced for the first time in 530 schools. Moreover, in The country plans to build over 100 by 2025 schools and the creation of 257,000 new student places [2]. Under these conditions, the architectural design of general education institutions is particularly important, as it must not only meet functional requirements but also contribute to the development of an adaptive, safe, and innovative school environment.

This issue is particularly pressing in Uzbekistan, where active work is underway to modernize its educational infrastructure. A key focus is the search for architectural planning solutions that reflect both the region's national traditions and climate, as well as international standards in school construction.

An analysis of international experience has shown that approaches to the design of general education institutions have undergone significant changes in recent decades. While previously the priority was given to the functional organization of the educational process and compliance with basic construction and sanitary standards, today architects and designers are focused on creating a multifunctional, flexible, and innovative educational environment. Such an environment should not only ensure comfort and safety but also stimulate the creative, intellectual, and social development of students.

The purpose of this article is to identify current issues in the design of school buildings, analyze and study innovative architectural planning solutions, and consider the possibilities of their integration into educational institutions of Uzbekistan, taking into account national traditions, climatic conditions, and modern educational standards.

### **MAIN PART:**

#### **Analysis of the current state of general education institutions.**

The school education system in Uzbekistan has been undergoing intensive development in recent years. As a result, the existing general education institutions' space-planning solutions largely fail to meet modern standards and require modernization. A significant number of the country's schools were built using standard designs from the Soviet and early post-Soviet periods, which are now outdated and inadequately meet modern educational and social requirements.

Currently, there are more than 10,000 comprehensive schools in the country, serving approximately 8.5 million students. The average capacity of most schools is approximately 600 students, and approximately 15% of these schools are designed for more than 1,000 students. Despite this, a significant portion of these institutions (over 70%) are forced to operate in two shifts due to a lack of space, indicating a serious overload of school infrastructure [3].

The architectural appearance of many buildings was formed during the era of widespread use of standardized designs based on linear buildings with long corridors and standardized classrooms. This structure is oriented toward frontal forms of instruction and does not provide for a flexible organization of the educational process [4].

Natural light and microclimate remain serious issues. In many schools, classrooms have windows on only one side, resulting in insufficient daylight. In the country's hot climate, this leads to overheating in the summer and heating problems in the winter. Consequently, the poor energy efficiency of older buildings increases operating costs and reduces occupant comfort.

In most cases, school sports and cultural infrastructure is poorly developed. Typical buildings typically have a single, small gymnasium, which is insufficient for a full academic program, forcing several classes to be taught simultaneously. Outdoor playgrounds often fail to meet modern standards or are simply absent. Similar problems are observed in multi-purpose halls for cultural events, where the equipment is outdated or inadequate. As a result, schools serve only an educational function, failing to become a full-fledged community center.

Another important aspect of school life is the condition of school grounds and school yards. Yards often serve only as a passageway, not suitable for recreation or events. The lack of greenery, shaded areas, and recreational spaces is especially noticeable in continental climates, where a well-maintained grounds play a key role in the health and safety of children [4].



*Fig. 1.* General plan  
School No. 280



*Fig. 2.* Facade solutions for school No. 280



*Fig. 3.* Volumetric  
solution of the  
school entrance  
group  
No. 280

Nevertheless, standard schools also have a number of advantages, which are particularly evident when analyzing specific examples. For example, Sergei Yesenin Comprehensive School No. 280, located in the Chilanar District of Tashkent (*Figs. 1–3*), demonstrates rational solutions in the organization of its interior space.

This institution is classified as a medium-sized comprehensive school, designed to accommodate approximately 800-1,000 students, but the actual enrollment significantly exceeds its design capacity. The school building is a three-story enclosed structure with an additional annex located in the rear. The entrance is located in the center of the main façade, accessible through an interior courtyard formed by the main structure.

The functional zoning is quite rational: the left wing, near the entrance, houses classrooms for elementary grades, while the opposite wing houses spaces for older students. The annex building, connected to the lobby, has two floors: the first level houses the cafeteria and workshops, while the second level houses the assembly hall and gymnasium.

Positive aspects of the layout include the effective functional separation of flows, as well as the location of active areas (the gym and auditorium) in the central part of the complex, providing convenient access from all academic blocks. The separation of spaces for the junior and senior classes is also a rational solution. The courtyard formed by the building's shape offers an additional advantage: it can be used as a space for events and school assemblies.

However, this school faces the same problems as most educational institutions: overcrowding, limited infrastructure, and outdated solutions for ensuring comfort.

Thus, an analysis of the current state of schools in Uzbekistan shows that the architectural environment often does not meet modern educational and social objectives.

*The following problems can be identified as the main ones:*

- overcrowding of buildings and working in two shifts;
- outdated planning solutions;
- insufficient natural light and energy efficiency;
- limited sports and cultural areas;
- poor landscaping of territories.

This analysis reflects the current state of affairs and serves as a starting point for finding innovative solutions in the design of new educational institutions.

### **Modern trends in the design of educational institutions.**

Traditional schools in post-Soviet countries (Russia, Uzbekistan, Eastern Europe) were long built using standard designs with rigid layouts: long corridors, classrooms located on either side, and administrative and support spaces. This approach implied a hierarchical, "closed" architectural model, where the educational process was strictly regulated and spatially limited. However, the modern architecture of educational institutions around the world is rapidly transforming, reflecting changes in pedagogical paradigms and societal demands.

In advanced countries such as Finland, the Netherlands, Canada, and Australia, there is a shift away from the classic "cell" structure in favor of open, flexible spaces. More and more schools are being designed based on open concepts. plan , flexible learning environments and learning Commons are spaces that can be quickly transformed to accommodate a variety of educational scenarios. Instead of separate

classrooms, multifunctional zones are created for individual, group, and project-based work, using sliding walls, mobile furniture, storage units, and carpeted floor areas.

The role of corridors also changes dramatically: they are transformed into "platform corridors"—areas for relaxation, socializing, and informal learning, equipped with upholstered furniture, drawing panels, and even library shelves. This "blurred" structure encourages students to engage in the educational process beyond the classroom.

Modern schools are increasingly implementing biophilic design ideas. The use of natural materials (wood, stone, cork), panoramic glazing, living plants, and the integration of indoor and outdoor spaces not only improve the environmental performance of buildings but also contribute to the creation of a comfortable environment conducive to students' mental health. **Orestad School is an example. Gymnasium** (Copenhagen, Denmark) (Fig. 4) . The architecture of this school erases the boundaries between learning spaces: instead of separate classrooms, four boomerang-shaped platforms function around a central atrium with an open staircase—the entire structure forms a single flexible space. Ø restad The Gymnasium is a building in which the clear structure gives way to an open interaction. The space is organized around platforms with "islands" for group work, glass partitions, and mobile furniture. The transparency and flexibility of the space promote respect and collaboration between students and teachers [6] .



**Fig. 4. Floor** planning and façade solutions schools **Orestad Gymnasium** ( Copenhagen, Denmark) [].

In Scandinavia, there is an emphasis on *psychological well-being and equality*. Schools in Denmark and Sweden lack a strict class hierarchy: teachers and students are perceived as partners in the learning process. Architecture supports this approach—buildings are designed to be transparent, barrier-free, and allow for open dialogue. In a Swedish school **Vittra Telefonplan** (*Fig. 5, Fig. 6.*) For example, there are no walls between classrooms, and islands of color and lighting serve as learning areas. At the Vittra school Telefonplan abandoned traditional classrooms. They needed an environment— **a learning landscape** —that would itself become an educational tool and facilitate active learning (as noted by the students themselves) [4].



*Fig . 5 . Plans floors schools Vittra Telefonplan [].*

*Fig . 6 . Interior schools Vittra Telefonplan [].*

In African and Latin American countries, despite resource constraints, striking examples of sustainable architecture with an emphasis on local materials and cultural context are being implemented. In Kenya, for example, the **Kibera School project Hamlets** (*Fig. 7*) The structure is based on the use of recycled materials—plastic, metal, and wood. The design is made of modular components—scaffolding, corrugated metal, and thick plastic sheets. These



*Fig. 7. Kibera school Hamlets [].*

The materials are available in the region and can be easily adapted to the architecture . The polycarbonate covering allows light to penetrate and protects against overheating. The building has two levels: a wide staircase, an enlarged classroom, a balcony, and a covered courtyard for group and individual activities. [5] .

Thus, modern educational institutions are increasingly transforming into intelligent, sustainable, and adaptive spaces , where architecture becomes part of the educational process. Every area—from the stairwell to the schoolyard—should serve a learning and developmental function. Examples include stairs decorated with numbers and formulas, puzzles built into the walls, or creative workshops where students can experiment with materials.

Global experience shows that school architecture is no longer just a shell. It is becoming an active tool for education, socialization, and personal development. These principles are particularly relevant for countries undergoing educational system reform, such as Uzbekistan, where there is a demand for new approaches to school design—flexible, accessible, sustainable, and inspiring.

### **Additional modern premises and spaces in school design.**

An analysis of international experience has shown that approaches to school design have changed significantly in recent decades. While previously the emphasis was primarily on the functional organization of space and compliance with sanitary and hygienic requirements, today architects and designers strive to create multifunctional, adaptive, and stimulating educational environments that support the physical, emotional, and intellectual development of students.

In modern Western schools, in addition to basic service areas, additional spaces are designed that perform educational, social, and developmental functions:

- **STEAM laboratories** (USA, Finland) - special workshops, Where students offered experiment, invent And experiment With various materials And technologies [6].
- **Flexible coworking spaces** (Denmark, Netherlands) are spaces for group work and independent learning [7].
- **Relaxation zones** (Sweden, Germany) are specially equipped spaces designed to reduce stress, support psycho-emotional well-being and inclusive education [8].
- **Media centers** (Canada, UK) are spaces for recording podcasts, creating school news, and video projects. Even elementary schools can organize a podcast club, where students gain experience in interviewing, speaking effectively, and technical editing. [9]
- **Culinary studios** (France, USA) – developing healthy eating and practical living skills; as part of one of the training programs at **George Washington Carver Center for Arts and Technology (USA)** - operates " **Carver" Café** ” , a working café where students gain practical experience in the culinary field [10].
- **Eco-classrooms and winter gardens** (Singapore, UAE, Australia) are spaces with living plants and areas for hands-on ecology learning. Schools in Singapore and the UAE feature areas designed as winter gardens or mini-biolabs, with plants, aquariums, and ecosystem study elements, making the learning environment more vibrant and

interactive.

At **The Arbor School , Dubai** has created several climate biodomes , including a tropical ecosystem, which is used to teach environmental literacy [11].

- **Multifunctional public spaces (amphitheaters, open verandas)** (USA, Italy, Australia) are spaces for gatherings, presentations, and informal interactions. A school in Connecticut (USA) is equipped with multifunctional amphitheater doors that open on all four sides, transforming the space into an open-air hall for events and gatherings [12].

It's also important to note that anticipatory design skills are becoming critically important. Architects, and especially emerging professionals, must learn to anticipate how educational functions will change in 30-50 years. Buildings must be flexible and adaptable enough to remain relevant in the mid- and late 21st century, easily transforming to meet new challenges.

This is directly influenced by global trends such as **the widespread use of gadgets and the digitalization of education** . This necessitates the integration of not just computer labs but high-tech spaces into schools: **virtual and augmented reality (VR/AR) labs for immersive learning** , robotics and 3D modeling areas, and media libraries with professional equipment.

Digitalization is also changing the format of learning itself, making hybrid and online models an integral part of the process [15,16,17]. For example, if a student is ill or learning remotely, they should be able to not only watch a recorded lesson, but **also fully participate in it in real time** . This requires:

- **Interactive panels and a video conferencing system** in each classroom allow remote students to see the board, teacher, and classmates, and ask questions.
- **Digital educational platforms** where assignments and materials are posted, progress records are maintained, and communication is organized in a single space.
- **“Smart” classrooms** with automatic recording and broadcasting systems for lectures, which is a standard in many leading universities around the world (similar solutions are being actively implemented within the framework of “Smart Campus ” initiatives around the world) [15,16,17].

All these additional functions require the possibility of rethinking the planning solution not only of the school itself but also of the classrooms in particular.

An example of such a comprehensive approach to designing schools of the future can be found in the developments of such organizations as:

- **OECD's CELE (Centre for Effective Learning Environments )** publishes research and recommendations for the design of educational spaces [18].
- **Rosan Bosch Studio ( Denmark)** is known for its creative and motivating school designs that challenge traditional notions of the classroom [19].

Thus, modernizing school infrastructure in Uzbekistan is a complex task that requires revising standards, educational programs at universities, and implementing the most modern technological solutions to create schools that will serve many generations.

An analysis revealed that the majority of general education institutions in Uzbekistan were built using standard Soviet-era designs, which currently do not meet modern educational and social requirements. The main problems with existing schools include overcrowded buildings, insufficient natural light and energy efficiency, poor sports and cultural infrastructure, and poor landscaping in the surrounding areas.

It should be noted that the situation is uneven. In the central regions and the main provincial cities of the republic, the situation is somewhat better—renovations and upgrades to facilities are more frequent there. Meanwhile, schools in remote areas, in addition to systemic architectural and planning issues, are often in disrepair, posing a direct threat to the safety of students and staff.

However, focusing solely on the negatives is the wrong approach. It's essential to highlight and preserve the positive aspects of the old layouts. These include:

1. **Structural strength and durability.** Many buildings constructed decades ago possess significant structural integrity, providing a reliable foundation for potential renovation.
2. **Clear and rational functional zoning.** Standard designs often included a logical division into educational blocks, recreational spaces, and utility areas, which ensured a basic order for organizing the educational process.
3. **High ceilings and large windows,** which, with the right modernization, can be transformed into an advantage, providing excellent insulation and a feeling of spaciousness.

The challenge of the current era is not to demolish this entire legacy, but to creatively reimagine it. These time-tested positive qualities must be combined with cutting-edge international practices in educational architecture. This synthesis should form the basis for the development of new national school design standards that will meet both current and future challenges.

This process must begin at the root—with changes to the curricula and assignments at the country's architecture universities. Student projects should focus not on abstract objects, but on creating a flexible, multifunctional, and inclusive educational environment. This approach will properly guide the minds of future architects from the very beginning. This will further establish a chain: *graduate architect* → *competent project* → *the possibility of high-quality renovation or construction of new schools with well-thought-out functional zoning.*

An analysis of international experience conducted for this research article demonstrates that modern approaches to school design are focused on creating a hybrid, adaptive, easily transformable, environmentally friendly and inclusive educational environment, where architecture becomes an active element in the education and socialization of students.

In particular, given Uzbekistan's geographic location, a pressing task is not only the integration of innovative architectural and planning solutions, taking into account national traditions, but also the updating of climatic conditions and social needs, which will allow for the development of new-generation educational institutions.

**CONCLUSION.** Integrating the above approaches into the design of general education institutions is a crucial task in modernizing Uzbekistan's education system. The use of energy-efficient technologies, environmentally friendly materials, digital management systems, and flexible spatial solutions will enable the creation of schools that meet international standards and respond to societal needs. A modern school should be not only a place for learning but also a space for harmonious personal development, socialization, and education. In this context, architecture becomes an active tool in shaping the educational environment, and the successful implementation of innovative solutions will contribute to improving the quality of education and developing a competitive knowledge society.

In the future, modernizing school infrastructure in Uzbekistan could become not only the foundation for reforming the education system but also a factor in the country's socioeconomic development. The creation of modern, next-generation schools will open up opportunities for implementing advanced teaching methods, fostering an inclusive environment, and nurturing young people focused on innovation and sustainable development. A full understanding is needed that architectural and planning solutions in education should be viewed as a strategic resource, ensuring long-term results for society and the country as a whole.

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