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MODERN ARCHITECTURAL APPROACHES TO SMART CITIES AND EDUCATIONAL FACILITIES

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Abstract
Introduction: This article aims to provide readers with an overview of significant modern architectural approaches to creating sustainable smart city models. Different architectural approaches have piqued the interest of many researchers that study ancient and modern buildings, specifically their characteristics and execution methods. **Purpose of the study:** Interest toward smart architecture has grown due to the extensive development of technology and its integration into all aspects of human and city life, including the learning environment, the psychological effect of various spaces, and environmental impact. **Methods:** Architects, designers, engineers, and psychologists alike must consider these key developments and choose approaches to spaces and buildings that properly reflect the smart building philosophy. Many case studies have been adopted in the current investigation. **Results:** Over the recent years, due to the increasing strain of real estate demands, which led to overcrowding in cities, the need to find the most suitable housing solutions has emerged as a key problem. Architects and researchers are considering the best modern architectural approaches to building a sustainable model for smart cities.

Keywords: modern architecture; architectural approaches; smart cities; sustainable models; sustainable cities; design; engineering; smart architecture; smart buildings; concrete; facade; finishing materials.

Introduction

Today’s ever-increasing expansion of smart technology, which is being adopted rapidly even in remote corners of the planet, coupled with intricate connections between information and data, paints a realistic and evolving picture of smart cities. Smart technology is one of the main pillars that support the future of smart cities.

The term “smart cities” relates to virtual cities, from which the concept of digital cities also derives. The most prominent outcome is the electronic or virtual space (Romano et al., 2018). The Smart Community Forum defined such spaces in 2006 as areas that foster creativity and provide means of communication and data for the local community. Information and communication technologies combine the intelligence of people and organizations to support learning, creativity, and digital spaces, thus enabling innovation and control over knowledge. Academics and practitioners are becoming increasingly interested in expanding the use of smart technology, including computer technologies and communication media. It is important to know how to unify and interconnect a given facility’s systems to increase resource efficiency and to regulate the cost of operation and maintenance, as well as the space’s psychological effects and environmental impact. In the era of smart cities and communications, the technological features of modern facilities have come to play a critical role in knowledge acquisition, which overlaps with their information technology role, as they help support the establishment of smart cities. This includes interconnected and integrated knowledge facilities, transforming the role of digital connectivity from standalone buildings in a given space to an entire interlinked system. This approach to the technology behind smart installations and smart facilities centers on a variety of inputs to provide data in a coordinated and up-to-date manner.

The following sections will outline the types of modern architecture, including concrete, facade and finishing materials, and their potential applications. This will be followed by a discussion section that will highlight the effects on learning environments, spatial psychological effects, and environmental impact, based on key case studies, including Storey’s Field Center, the teaching and learning facilities at the Eddington Nursery, the Düsseldorf Stadttor building, and the Bahrain World Trade Center. The conclusion will provide recommendations for practitioners and outline a future scope for the next steps.

Modern Architecture Types and Applications

“Sustainable architecture” is a general term that describes environmentally conscious design techniques in the field of architecture (Foster, 2020). It can be defined as designing buildings that respect the

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environment and are energy-, material- and resource-efficient, while minimizing the effects of construction and achieving harmony with the natural environment (Bielek, 2016). The corresponding architectural finishes and engineering designs are deployed in smart cities using materials and configurations that can respond to stimuli from the internal and external environment (Elattar, 2013). These materials have the ability to detect and "feel" the various stimuli and adapt to them by integrating functions into their structures. Such stimuli may be electrical or magnetic in nature and are utilized in smart cities to achieve sustainability (Juaristi et al., 2018).

Modern Applications of Concrete in Smart Cities

Many construction materials have been created over the ages, characterized by their smart features and ability to respond to the conditions in the environment around the building. Some examples of these materials are:

Carbon fiber concrete: Short carbon fibers are added to conventional concrete mixes, enabling the detection of even minor pressure and small cracks. Any defects in the concrete structure are located and repaired through the use of electrical sensors installed on the outside of the concrete structure, measuring the underground pressure and predicting earthquakes. This concrete type can also be used for monitoring building occupancy and traffic flow (Elattar, 2013).

Light transmitting concrete: This mixture of concrete and optical fibers offers a view on the space's external surroundings, as it lets light pass through it, creating a contrast between various segments depending on wall thickness.

Transparent concrete: Made of crushed glass and plastic, transforming the building facade into a large glass window. This material is superior to conventional concrete in terms of bearing compression and bending (Brownell, 2016).

Aerated concrete: Invented in 1914 in Sweden. When aluminum powder is added to cement, lime and water, it produces a foamy mixture. After melding and hardening, it is treated in pressurized steam rooms, which results in lightweight concrete that can be used at high altitudes and the inner walls of the building.

Pervious concrete: A type of concrete with a porous structure that lets rainwater pass through it to the ground. Used in sidewalks and floors, and characterized by strength and durability. It consists of Portland cement and coarse rocks (Dogne and Choudhary, 2014).

Smart bricks: Bricks filled with sensors, processors and wireless signal connections to send warnings about hidden stress and damage in the aftermath of natural disasters such as earthquakes and hurricanes. These bricks can monitor the building's temperature, vibration and movement, transmitting signals at regular intervals. This provides firefighters and rescue teams with important and necessary information, keeping both them and disaster victims safe (Elattar, 2013).

Smart cement: Contains magnesium carbonate instead of calcium carbonate and absorbs carbon dioxide from the atmosphere (0.4 tons of carbon dioxide per ton of cement) (Brownell, 2016).

Modern Applications of Facades in Smart Cities

Digital facades: Considered an integral part of a digital building, an element essential to the building's internal life (Funari et al., 2021). Conceptually, digital facades are presented as practical and instrumental to reducing energy consumption and improving the building's internal conditions through responding to external changes mechanically and automatically (Zolfagharpour et al., 2022). They interact with external changes, either through material elements (like canvas) that are affixed at the facade or through digital materials with characteristics that respond to changes in external conditions (Wigginton and Harris, 2002). Double facades are considered an exciting modern development as they allow for isolating the interior (Vasileva et al., 2022). Double facades can be created by adding a layer of glass outside the facade in order to provide buildings with ventilation and sound insulation, which is one of their most critical functions (Knaack et al., 2007).

Second-skin facade: This facade type features a second layer of glass along the outer surface of the whole building. It is distinguished by technical and structural simplicity, but provides little ability to control the internal environment (Strahle, 2012).

Corridor facade: Such facades are divided horizontally. Vertical joints separate the internal and external facade to reduce airflow horizontally and prevent fires. This, however, does not insulate against noise.

Shaft-box facade: Divided into square openings, or openings of other shapes, which distribute internal air depending on pressure differences and allow it to spill over vertically between floors to increase thermal efficiency.

Double digital facades: Come in different types, depending on the nature of external facades that help with moving air within the internal space and providing suitable ventilation.

Interactive facades: Interactive facades are considered as the ideal technique in the field of smart architecture, as they can respond to different environmental conditions. They are powered by control systems, where the automation process can be adjusted in order to guarantee ideal building performance and the highly efficient exploitation of the available natural resources, such as lighting and ventilation (Dewidar et al., 2010).

Kinetic facade: Kinetic facades are distinguished by their ability to modify their shape, shift, and create a given number of openings depending on various external environmental conditions, including temperature, moisture, and wind. These facades are considered to have a high impact on reducing energy. These facades need to be accounted for at the very first stages of the designing process, making it possible to integrate them into all parts of the building and thus achieve automation and reduce energy consumption.

Solar facades: Solar facades are contributing to reducing energy consumption, as they use renewable solar energy. Their structure is based on solar and photovoltaic cells that produce electricity, which can be used for heating, cooling, and lighting purposes. Such facades are compatible with sustainable green buildings (Ghaffarianhoseini et al., 2012).

Digital building upgrades must account for many aspects, the most important of which is the building facades, which can play an effective role in optimal energy performance. Many studies recommend making digital facades from sustainable materials to reduce energy consumption, reach zero level of non-renewable energy, and increase the facades' ability to respond to stimuli inside and outside the building.

Modern Applications of Finishing Materials in Smart Cities

The finishing materials have varied over the years, evolving to keep pace with the technical and technological development of the buildings themselves. Examples of smart finishing materials include:

Reflective indoor coating: A type of paint that reflects light better than ordinary paints, thus enhancing illumination and space perception. It further helps to reduce the amount of energy used in industrial lighting and increases perception and energy consumption by up to 20%. Such materials can last for 5–10 years without losing their performance and reliability. Reflective paint is suitable for regions with limited daylight intensity and duration, such as Central and Northern Europe (Bax et al., 2013).

Super black: An ultra-black paint that reflects 10–20 times less light than normal paint and is used to reduce unwanted reflections (Dogne and Choudhary, 2014).

Luminous bricks: Initially used in international art installations, these bricks are made out of polycarbonate panels and characterized by high strength. They successfully bear greater loads than normal bricks and are 50% lighter than glass. Furthermore, they come in different transparency levels and colors, and can be either molded, curved or sculpted, with a glossy or matte surface.

Shutoff valves: Valves containing sensors that cut off the flow of water in the event of a leak, thereby preventing flooding damage and providing live usage data (Elattar, 2013).

Optical fiber: Optical fibers are devices that direct waves and optical signals and are used for remote sensors. They can be made out of silica, sapphire, fluoride, or neodymium doped silica, with the transmission and sensing speed varying from material to material (Sun, 2015).

Glass: Glass still plays a major role in construction and has evolved into an advanced construction material, now considered a key feature of smart architecture.

Discussion and Case Studies

Digital building is a key architectural term and concept that relates to the production, development, and progress of architectural methods and concepts. The concept integrates modern technological and architectural thoughts, as both aim to fulfill the users' needs. While working on developing definitions and standards for digital buildings and identifying their characteristics, many researchers have stated that digital buildings are specialized entities and communities. The most important aspect is the ability to identify what is inside and outside. The building needs to function as efficiently as possible and respond to the users' needs, providing comfort and protection.

This architectural pattern developed quickly, eventually posing special design requirements, including smart materials that can change their physical properties as an automatic response to the surrounding conditions (Kamila, 2013; Sadeghi et al., 2011). Different smart systems emerged as well, utilizing sensors linked to the building's central control system. Smart facades are an important building feature, as they allow for controlling its internal environment according to external conditions, thus meeting the space requirements and changing needs. From here, it becomes clear that the use of these modern architectural features makes the new smart cities the focus of attention for people that search for distinctive housing with all the elements of smart cities. Eventually, these cities will transform, becoming greener and more architecturally sustainable. It is also worth noting that several famous cities in the world have already implemented modern architecture, turning certain areas into smart sustainable city spaces.

This research office building (Fig. 1), also known as the environmental building, is an example of using technological smart systems. It is considered an important landmark and demonstrates how smart architecture can be applied in environmental buildings. The building is located in Garston in the United Kingdom. The British government considers it a paragon of British innovation, recognizing it through the Millennium nomination. The eco-building's owners wanted it to be a model for other

Fig. 1. Garston Building Research Establishment

future buildings in the United Kingdom. The facade designs were equipped with the smart systems and linked into an internal work network, and the building was also provided with different sensors for measuring the temperature, wind speed and sunlight direction. The system was also pre-programmable, which made automatic control of the building faster while not restricting it as the only option. Instead, there was still room for the users to manually adjust the surrounding environment conditions. It is worth noting that the practical application of the ecological building concept must overlap with the architectural notions of smart architecture, giving the designer a preconceived perception of how to employ smart building features to achieve this, while also considering the best systems and methods and ways of connecting them for the best architectural results (Wigginton and Harris, 2002).

Case Study: Düsseldorf Stadttor ("City Gate")

This structure, located in Düsseldorf, Germany, was designed by Petzinka Pink und Partner for a 1991 competition to construct a new building over a tunnel that attracts traffic to the city center. The building contains offices, studios and media headquarters, and was completed in 1997. It is designed to rely on natural factors such as ventilation and lighting, in addition to the introduction of smart systems (Fig. 2). Moreover, the building utilizes air facades, where there is a distance ranging between 1.4 and 0.9 meters between the inner and outer facade (Strahle, 2012).

Case Study: Bahrain World Trade Center

The Bahrain World Trade Center is the first smart building in Bahrain, and the building includes many smart technological features, the most important of which is the use of a high-speed Internet connection system, in addition to telephone communication via Internet protocols and unified wireless messages in one network for audio and visual data. The building management system functions by connecting the Internet networks to a dedicated computer device, downloading dynamic schedules, and monitoring system integration. The system reduces costs and allows the building occupants to receive a single bill that includes fees for energy use, rent, and information and communication technology. The building uses advanced, smart security systems for protection, monitoring, and response to alarms (Fig. 3).

Case Study: Storey's Field Center, the Teaching and Learning Facilities at the Eddington Nursery, and Their Psychological Impact

This segment of the study aims to evaluate the environmental influence on psychological awareness and attitude, as well as explore the psychological impact of digital learning spaces on students at Storey's Field Center and the Eddington Nursery (Fig. 4). Furthermore, we shall discuss the relationship between the modern architecture's

Fig. 2. Düsseldorf Stadttor building

applications and students at Storey's Field Center and the Eddington Nursery, and the role of the working environment in the students' lives. The paper by Schuilenburg and Peeters (2018) discusses spatial psychology among students and evaluates the impact of the environment and architectural design on flexible and productive outcomes. It presents a comprehensive assessment of psychological effects on students. Architectural design institutes contribute to a better understanding of environmental influences. Various institutes offer both numerous traditional study spaces and a selection of innovative, flexible study spaces. The educational norms that drive this transition offer an intriguing research backdrop, and the tension between various types of learning spaces is now prominent in many other places. Furthermore, the choice also depends on the study participants and access to appropriate resources. Learning spaces can greatly emphasize discipline and group thinking, which is reflected in their traditional theoretical architectural styles and interior features. The space tends to create a relaxed interdisciplinary environment with rich color combinations, comfortable interiors, location and flexibility, and an increased sense of ownership and autonomy (Adams-Hutcheson and Johnston, 2019).

Fig. 3. Bahrain World Trade Center

Fig. 4. Storey's Field Center and Eddington Nursery

To go beyond this historical approach to learning environments, we provide the following set of guidelines for designing and executing university spaces. Hopefully, these principles will result in facilities that are less prescriptive and functionally specific than they are now. The aim is to foster a sense of community ownership among students through using and occupying certain campus spaces (Lam et al., 2019). We believe that new spaces should be used in conjunction with existing design concepts rather than replacing them. Instead of expressing a new set of intentions, emphasis shifts to the way these environments are used (Fig. 5).

Learning spaces are designed to be optimal for specific purposes (such as transcription in lecture halls, computer-based activities in computer labs, and use of tools other than information and communication technology during tutorials or group classes). This is the current strategy for building new facilities for Storey's Field Center and the Eddington Nursery. The design of the new learning environment must be flexible enough to accommodate a wide range of functions. This covers teacher-centered and student-centered approaches, formal planned meetings, and various unstructured ways in which students use technology (Simpeh and Shakantu, 2019). Using a student-centered collaborative learning approach, along with consultative assessment, will increase the diversity of student engagement at Storey's Field Center and the Eddington Nursery (Fig. 5).

The online space and official website must gradually adapt to the needs of informal users, such as students who use the facilities outside of planned courses. As pointed out in (Schmidt, 2020), students spend 80% of their time on campus engaging in social and extracurricular activities. As a result, when they are not in formal classrooms, they are forced to gather in libraries or cafes, which are not ideal for big student groups working together. This situation is unsustainable from a pedagogical and economic point of view. Information and communication technology may be required when appropriate infrastructure is unavailable, or when remaining in an authorized formal classroom areas may hinder collaborative activities (Foteinaki et al., 2018).

Since its inception, architecture has predominantly focused on how to use ground space. The possibilities offered by the creative use of vertical dimensions should be utilized better. Whiteboards and other collaboration tools can be placed on the wall for students to plan and document their ideas, as well as work together with others. Stage performances can benefit from a raised floor. Ceilings and skylights can be created to enhance the spontaneity and visual value of specific architectural spaces (Fig. 6).

Where feasible, campus amenities should be added to prevent current services and functions from becoming isolated. Facilities that serve food and drinks, communal spaces for casual conversation, and comfortable furniture will allow students to enjoy this environment and integrate social interactions and personal activities into it. Covered walkways, arcades, galleries, and corridors serve as a convenient transition zone between interior and outdoor spaces and should be explicitly considered when designing areas outside of the architectural space.

It should be assumed that teachers and students can completely control the facility's functionality and environment. Videoconferencing or computer labs can become expensive and intrusive if they

Fig. 5. Nursery classroom design (source: Hartman, 2018)

Fig. 6. Main hall (source: Hartman, 2018)

rely on tech support from a single location. In most cases, tech support is prioritized for official, teacher-led activities, which makes it much less accessible in informal student-led environments without the teacher's personal intervention.

As university campuses offer a variety of lessons, courses, and extracurricular activities, it is necessary for them to provide a variety of formal and informal learning environments. For instance, if a science test site is structured to have an extensive study area supplemented by some smaller, more specialized rooms, a laboratory could be classified as such. To reduce the number of large, underutilized special-purpose laboratories that can become barriers to the adoption of alternative pedagogical practices, enhanced through information and communication technology, it is necessary to downsize these laboratories.

It is vital to review requirements from every field of study in order to assess how educational objectives are currently being met, including what new technologies have been suggested and which other advancements or trends may become important in the future.

Students are developing an increased sense of responsibility for their own learning experience. The overall controlled environment hampers the results that most organizations envision for their campus services. A student-centered approach requires resources that are available to students 24/7 (such as libraries, information and communication technology-equipped areas, and classrooms).

It is possible to improve a facility's visual design without compromising its function. To nurture people who think critically and actively embrace social difference, we must counter the tendency to institutionalize and standardize design. Students should have plenty of opportunities to develop a sense of ownership of the building and its maintenance in the locations that they use daily, especially department- or faculty-specific ones.

In the mid-1990s, the capital management program at the Australian National University Learning Studio opened several new facilities with a planning horizon of over 5 years ahead. Many of those buildings offered new teaching and learning resources, including technology. In 1997, a decision was made to establish an experimental "learning studio" for testing different spatial arrangements. The proposal included high-tech classroom furniture arrangement that differed significantly from existing arrangements (Dane, 2019).

Case Study: Technology at Storey's Field Center and the Eddington Nursery

This learning space, housed in a former commercial bank building in Eddington, welcomes students from both international, domestic and indigenous backgrounds. The teaching team's experience with pedagogical and architectural issues highlights many of the critical components we mentioned earlier. The architecture of an educational facility should facilitate a certain learning style while also considering the surrounding cultural context (Dane, 2019). According to the program's coordinator, encouraging inquisitiveness is the most important organizational aspect of the curriculum, both in general terms of teaching and learning, and specifically in the context of the program. Both the individual and the community highly value the wisdom of their fellow humans. The personal and cultural experiences of students and their families are valued, and the focus is on informal contacts and strong community relationships, as well as on practice and on making personal theories after a period of intensive study. The project's ultimate goal is to provide public access to natural areas that are currently inaccessible, such as rivers and woodlands. This concept has been applied throughout the building, resulting in a learning environment that is both integrated and informal. First- and second-year students will be able to learn from one another because the same subjects will be taught in both years simultaneously. Instead of confining individuals and putting them in "boxes", the surrounding environment could be used to foster a universal sense of belonging. Furthermore, there must be enough room for students to read, talk to one another, and do research.

Here, the building greatly benefits from having a large open area in the center. One of the classrooms has been converted into a small kitchen area, where students may now prepare their tea or coffee. The individual in charge of the project most likely worked at the bank's management office. There is a carving on one of the main walls in the third room. The remaining room was initially empty, leaving the teachers and students to use it as they pleased. They partitioned the space using whiteboards and overhead projectors. If necessary, seats and tables may also be set up. In 1999, many students visited the center to study numerous subjects.

Choosing the facility's teaching philosophy is critical when constructing a new campus infrastructure that emphasizes student-centered learning practices. Children learn in various formal and informal ways, and educators have long recognized this. The teacher should aid them in their educational endeavors rather than simply impart knowledge. Moreover, students and elders from the indigenous community come to exchange knowledge and work as a team to better their education. The learning process of this specific group of children has been influenced by several indigenous tribes' stories.

They were instructed to utilize all of the resources available to them at the time of getting an education.

As students worked alone or in groups, instructors were more motivated, and consequently more likely, to deliver lectures for small classes. Although students were required to meet deadlines, they were also encouraged to study and collaborate at their own speed, regardless of circumstances. Due to the nature of activity and the high number of students that participated, the furniture had to be moved. Courses were held on campus and in surrounding parks to maximize efficiency and make the most of the group's landholdings.

Rearranging the furniture proved easier in open spaces. Teachers and students could design multi-activity learning environments suited to their unique requirements. If there were enough attendees to warrant it, the institution would remain open late, and the staff would sometimes offer midnight events for those who could not make it during normal business hours. While most students were expected to attend specific courses, they were encouraged to work on campus as much as they wanted. Because of the educational institution's location, it was required to offer a kitchenette and other facilities. Local companies provided meals for the campus dining hall. The curriculum requirements were predicated on the idea that students were responsible for their own education and living environment. Instructors were given much freedom in how they used the facilities.

Future Scope

This paper explored the ways in which higher education is evolving, specifically in terms of location and physical space. There have been several studies on these learning environment elements, but we believe that none of them looked at how educational institutions teach and influence their students. From the papers included in the current issue of Higher Education Research and Development, it is clear that, despite recent advances in pedagogy and classroom design, these innovations have not yet been fully integrated into the education system. This is what will be considered in this section.

A concerted attempt to examine how instructors and students interact with constructed settings today and in the future is highly likely to lead to improvements in on-campus teaching and learning facilities. Yet getting resources in this sector is already challenging, and it remains uncertain how things will progress in the future. Instead, a stage designer may be able to develop an original solution. Rather than following our notion of developing a physical structure to serve as a *shell* for educational activities, the way things are done today is incompatible with our concept. The idea of designing a *shell* is inspired by stage and set design techniques that focus on the capacity to move freely within the boundaries of a confined area, as well as within environmental and budgetary constraints. An on-campus teaching and learning facility similar to those discussed above may serve as an exemplary model for other institutions.

Conclusion

In light of the issues covered above, many collaboration opportunities should be made more accessible in the classroom for instructors and students to use. If the relevant fixtures and fittings were readily accessible, it would be far easier to tailor them to satisfy the specific requirements of different groups of individuals. It is important to be more flexible when integrating information and communication technology to avoid reducing mobility and participation. New teaching and learning environments may be created and implemented throughout the whole school or just a few departments. A single building acts as the focal point for the entire process. There are plans to make construction projects more strategic and institutional in nature, reducing duplication across departments.

This transition will need adjustments in the strategic facility management planning. Similarly, if instructors and students decided to design and build their classrooms and learning environments from the ground up, the results would be the same. In either case, it would be impossible to function without the same authorization. The expansion of academic departments' responsibilities during the last decade has resulted in a wide range of tasks that they need to complete, including designing and managing the physical settings where study activities take place. Later on, information and communication technology and constructed environments will be combined with teaching and learning. Let us suppose that new information and communication technologies will not modify the relationship between pedagogy and the physical environment. In that case, students will be forced to attend classes in a facility constructed decades ago for purposes that are opposed to those they are pursuing today.

Recommendations

Consequently, designers who adopt this architectural trend should consider:

Identifying the nature of the building's conditions and functions, including the system of spatial arrangement and the mechanism of bringing the spaces together.

Identifying common environmental conditions and the suitable building and finishing materials that can adjust to them. Identifying and customizing spaces suitable for the building's main control systems. Studying the building's facades and architectural design in order to select the most suitable option, integrated into the building's concept. Engaging with stakeholders from diverse fields, including psychology, engineering, and design, and getting them involved in the conceptualization and planning phases of smart architectural spaces.

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СОВРЕМЕННЫЕ АРХИТЕКТУРНЫЕ ПОДХОДЫ К УМНЫМ ГОРОДАМ И ОБРАЗОВАТЕЛЬНЫМ УЧРЕЖДЕНИЯМ

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Аннотация
Введение: Цель настоящей статьи — ознакомить читателя с основными современными архитектурными подходами к созданию устойчивых моделей умного города. Различные архитектурные подходы представляют интерес для исследователей, изучающих древние и современные здания, в частности их характеристики и методы исполнения. **Цель исследования:** Интерес к «умной» архитектуре растет благодаря активному развитию технологий и их интеграции во все аспекты жизни общества и города, включая образовательную среду, психологический эффект различных пространств и воздействие на окружающую природу. **Методы:** Специалисты — как архитекторы, дизайнеры и инженеры, так и психологи — должны учитывать столь существенные перемены и выбирать подходы к созданию пространств и сооружений, должным образом отражающие философию «умного здания». **Результаты:** В последние годы поиск рациональных решений в сфере жилья стоит на повестке дня, поскольку спрос на недвижимость неуклонно растет, приводя к перенаселению в городах. Архитекторы и исследователи рассматривают оптимальные современные архитектурные подходы к созданию устойчивой модели умного города.

Ключевые слова: современная архитектура; архитектурные подходы; умные города; устойчивые модели; устойчивые города; дизайн; проектирование; умная архитектура; умные здания; бетон; фасад; отделочные материалы.