Digital Technologies and Artificial Intelligence in Architectural Education

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Abstract: The article provides an overview and comparison of modern innovations in the field of educational activities for future architects in the Russian Federation. An analysis has been made of the most widely used computer programs for architectural education, features and prospects for the use of artificial intelligence in world practice in general. An analysis of the capabilities of artificial intelligence programs and chats was also carried out. The advantages and disadvantages identified during the analysis and use of artificial intelligence for design in the field of urban planning, architecture and design are outlined. BIM design is considered as a modern approach to design and construction. The BIM extension – Historical Building Information Modeling (HBIM) (Historical BIM) is highlighted as the most relevant for the preservation and popularization of architectural monuments, urban planning, archeology and history. It has been determined that the most promising technology for the development of the architectural environment in a broad sense is the development of digital analogues of buildings. Recommendations for the optimal formation of educational programs and curricula with the mandatory presence of traditional manual design methods and modern technologies are outlined.

1 INTRODUCTION

Currently, for successful work, a specialist in the field of design, construction, urban planning, reconstruction, restoration and similar specialties must master at a higher educational institution and throughout his professional activity constantly develop and improve knowledge, skills and abilities in working with digital technologies. And recently, in addition to confident mastery of professional programs, the need to know the principles of working with artificial intelligence has been added.

"Taking into account demographic challenges in the coming years, the Russian economy will experience a high need and even a shortage of personnel. ... It is critically important to increase labor productivity, modernize industry, the agro-industrial complex, the service sector, and many other sectors of the economy and social sphere using digital technologies, production automation and management processes, which in turn should directly lead to improved working conditions for specialists and an increase in their income." – President of Russia V.V. Putin (Putin, 2024).

The purpose of the study is to analyze the current situation regarding the use of artificial intelligence and digital technologies in the field of architectural education, as well as to make a forecast about the results of their use.

2 RESEARCH METHODOLOGY

During the study, the following methods were used: scientific analysis, comparison, generalization, forecasting.

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3 RESEARCH RESULTS

Currently, the traditional view of training a future architect or urban planner requires significant reassessment and clarification.

In this regard, many leading universities in the Russian Federation are already making adjustments to their curricula, opening new digital departments, developing advanced training courses and programs for additional professional education in the field of using digital technologies and artificial intelligence. Due to the political situation, work is being carried out on import substitution of software. Based on the results of an analysis of the experience of using computer programs and complexes in the educational process in Russian architectural universities, the most popular products were identified: Photoshop, CorelDRAW, SketchUp, AutoCAD, 3D Studio MAX, ArchiCAD, Lumion 3d, Revit, Renga. Domestic software developments by Renga, nanoCAD, and Revit are gaining popularity. A review of the application features and advantages of the selected software products has been made, as a result of which it has been proven that for full-fledged work, an architect must have a complex of knowledge and skills of several programs for competent professional activity and continuously self-train taking into account updates to software products.

BIM design (Building Information Modeling), which allows you to design an object comprehensively, taking into account the entire life cycle, has occupied a special place in the mandatory basic educational process. Also, during the BIM study, a very relevant extension of it was identified - Information Modeling of Historical Buildings (HBIM or Historical BIM), which allows you to work with cultural heritage objects at a new modern level. This extension is also recommended for future architects to add to their knowledge base.

The development of digital technologies is not just a trend of our time, but an entire government strategy. Digital twins are now actively developing in the new design and operation of buildings and structures, in urban planning, and in the optimization of industrial processes. Right now it is necessary to think about creating a digital asset and a unified register of digital twins of cultural heritage objects .

Digital education is an integral part of architectural education and, in the modern world, plays one of the key roles in unlocking the creative potential of students and how they apply knowledge and skills in the digital environment of professional activity.

It is undoubtedly easier for students to master new technologies due to the physiological characteristics of a young organism and their impact on cognitive abilities. Scientists have proven that the speed of information processing grows until the age of 18-19, and then gradually begins to decline. After 35 years, memorization begins to become worse for a person, and it takes more and more time to draw any conclusions and make a decision. Of course, a person learns and accumulates information throughout his life, but it is during his student years that its assimilation, associated with high brain productivity, is most effective (Stasevich, 2024).

An important factor indicating the priority of obtaining the necessary knowledge during their student years is the relative freedom of students from unnecessary obligations: urgent work, obligations to the family and other circumstances that complicate the allocation of time for additional education or advanced training necessary for further development in the professional field.

Therefore, it seems extremely relevant to include in the curricula of higher educational institutions that train specialists in the fields of architectural, urban planning, reconstruction and restoration of buildings and structures, academic disciplines in information technology and the use of artificial intelligence, forming their digital instrumental literacy.

As a result of generalizing information about modern architectural activity, the main components of its tools have been identified: digital tools, digital resources, graphical computer tools (tablet, stylus, interactive tablet, VR tools, etc.), as well as specialized computer programs for creating and visualizing architectural models, and software systems based on BIM design.

Artificial intelligence is identified as a new challenge in architectural activity. The main areas of application of artificial intelligence have been identified:

• Building design:

- Idea generation: AI can generate various design options, helping architects find optimal solutions.

- Data analytics: AI can process large amounts of data on climate, lighting, energy efficiency, etc. to optimize building design.

- Automate routine tasks: AI can automate tasks such as creating drawings and 3D models, freeing up architects' time for more creative work.

• Urban planning:

- Smart Cities: AI can be used to create smart cities that are more efficient, sustainable and livable.

- Transportation planning: AI can optimize transportation systems, reducing congestion and air pollution.

- Social planning: AI can help plan social facilities such as schools, hospitals and parks based on the needs of the population.

Benefits of using AI:

- Increased efficiency: AI can speed up the design and construction process and improve the quality of the final product.

- Cost reduction: AI can help reduce design and construction costs.

- Improving the quality of life: AI can make cities more comfortable, safe and environmentally friendly.

The analysis of artificial intelligence identified its main advantages (automation, cost reduction, increased security, improved design, speed) and disadvantages (limited creativity, ethical problems, limited availability, dependence on technology). The increasing influence of artificial intelligence on the profession of architect is predicted, which will radically change the principle of training specialists.

An important task for heads of educational programs at present is to find a balance in the need for mandatory mastery of hand-made graphics, basic knowledge and skills for the formation of taste, a sense of harmony and beauty among students, as well as their mastery of modern tools of architectural activity.

4 DISCUSSION OF RESULTS

During the study, an extensive analysis of publications related to important modern methods of teaching architecture students in higher educational institutions of Russia was made. Issues of professional training of architectural specialties were dealt with by O.V. Solnyshkova. (Solnyshkova, 2013),Terskova M.T. (Terskova, 2023),Tokmakov A.A., Kober O.I. (Tokmakov, Kober, 2017), Titov A.L. (Titov, 2022), Mironova N.S. (Mironova, 2023), Bagrova N.V., Zhurin N.P., Pustovetov G.I., Filonov S.V. (Bagrova,. Zhurin,, Pustovetov, Filonov, 2020), Erokhin G.P., Rodionova Yu.V. (Erokhin, Rodionova, 2020) and others.

The Russian state education system has identified interactivity and practical orientation of the learning process as components of the new Federal State Educational Standards for Higher Professional Education. When hiring, specialists who know how to use computer-aided design systems and other specialized software are especially in demand (Solnyshkova, 2013).

The concept of digital instrumental literacy is formulated in the work of Terskova M.T. (Terskova, 2023) as a person's ability to use digital tools to achieve his goal in the fastest and most effective way, both in material and digital space.

It should be noted that digital instrumental literacy is not only knowledge of computer technologies and technical aspects of working with digital tools, but also the ability to use them to solve professional problems.

In the educational process, computer technologies, among others, can realize the following opportunities:

• consolidation of professional knowledge, skills and abilities acquired in other disciplines;

• increasing the level of self-education;

• development of intellectual and creative abilities;

• use of various sources of information, and, therefore, coverage of more knowledge;

• search for non-standard solutions for performing certain design tasks, etc (Tokmakov, Kober, 2017). It is also necessary to take into account the ultra-fast development of technologies based on neural networks, called artificial intelligence.

Today, the concept of "digitalization" occupies more and more space in the human environment and is used in all sectors of the state. Digital literacy began to manifest itself in various fields of science and formed new concepts of "digital environment", "digital community", "digital economy", "digitalization of education", etc.

Review of the use of Artificial Intelligence and Digital Technologies in universities.

The effective use of information and computer technologies, the implementation of their capabilities is an integral part of the training of future architects at Orenburg State University, Altai State Academy of Education V. M. Shukshin; Moscow Architectural University (the department of "Information Technologies in Architecture" was created here - the former educational and research center "Architecture and Computer Technologies"); Ural State University of Architecture and Art N.S. Alferova; St. Petersburg State University of Architecture and Civil Engineering (the Department of Information Technologies was created); Volgograd State Technical University (the department "Digital Technologies in Urbanism, Architecture and Construction" was created); Southern Federal University (the department of graphics and information technologies of architectural design was created), also, digital departments were created at the

Crimean Federal University in 2023 and many other universities in the country.

For example, at Orenburg State University future architects study a multifunctional computer-aided design package, working with computer information systems: Adobe PhotoShop, Corel Graphics Suite; SketchUp, Autodesk 3ds Max, ArchiCAD, AutoCAD, Lumion 3d; Photodex ProShow Producer (Tokmakov, Kober, 2017).

At the Ural State University of Architecture and Art named after N.S. Alferova, Ekaterinburg, Russia (UrGAHU) students study: Photoshop, CorelDRAW, SketchUp, AutoCAD, 3D Studio MAX, ArchiCAD, Revit, Renga (Titov, 2022)

The Department of Information Technologies in Architecture (MARCHI) carries out educational, educational, methodological and scientific activities in the field of computer support for architectural design. The department implements the following disciplines: “Fundamentals of GIS. Tools for urban context analysis.” “Digital means of parametric shaping.” “Computer graphics” “Computer technologies in architectural design” “Computer composition-combinatorial course” .

The Department of Information Technologies (SPbGASU) actively introduces BIM technologies into the educational process and scientific work, and also acts as the organizer of the annual international scientific and practical conference “BIM modeling in construction and architecture problems.”.

The Department of Digital Technologies in Urbanism, Architecture and Construction (DTUAS) of Volgograd State Technical University is developing several scientific areas:

1. Application of ontological engineering at all stages of the life cycle of construction projects and elements of the urban planning system;

2. Analysis of the visual urban environment (computer vision technologies for recognizing elements of the architectural environment, urban areas; development of recommendation systems);

3. Modules for geographic information systems (extraction, processing and generation of data to solve specific practical problems; generation of interactive maps in the field of environmental safety; analysis of the road transport system, etc.; work with plants, climate and terrain);

4. Development of extensions/additions/plugins for specialized software systems (Renga, nanoCAD, Revit, etc.) used in the field of construction and architecture, including the introduction of BIM technologies;

5. Additive technologies and Internet of things (IoT) in the field of construction and architecture;

6. Projects using AR/VR technologies, etc.

Many universities today are working on import substitution of software. The possibilities of domestic developments, such as Renga and nanoCAD, are being studied, and the experimental implementation of these programs in the educational process is being carried out.

BIM (Building Information Modeling) has occupied a special basic niche. The main vector of BIM is aimed at automating the design process, creating a digital model of the building in dynamics and taking into account the entire life cycle of the object in coordination.

Historical Building Information Modeling (HBIM) is an extension of BIM developed specifically for historical buildings and cultural heritage sites. It focuses on managing and documenting historical structures using parametric objects (models) created from both current data and historical research. In 2009, Murphy, McGovern and Pavia coined the term as a combination of building information modelling (BIM) and historic preservation.

Purpose of HBIM:

1. Preservation through documentation: A project can significantly change a historical structure. The project team can capture and document existing conditions for archival purposes.

2. Analysis: HBIM is a powerful tool for understanding underlying problems (such as structural or material failures) that cannot be corrected. This data can allow engineers to plan potential interventions. A good example is the numerous problems that the Leaning Tower of Pisa faced over the years until it finally stabilized in the 21st century.

3. Restoration: All major projects begin with documentation. Restoration projects are no different. Once information is visually archived, the project team can use the HBIM environment to plan, visualize and execute restoration projects in a data-rich context.

4. Management: Conservation societies can use a variety of HBIM platforms such as Layer App to manage the ongoing maintenance, management and protection of cultural heritage assets (Lee, 2023).

Romanov A.S. proposes to introduce a separate concept for wooden architecture objects: HWBIM (Historical Wooden BIM) or Information Model of a Historical Wooden Building. He also notes that to optimize the process of working with objects of Russian wooden architecture, a unified algorithm for constructing an information model is necessary (Romanov, 2023).

Let's highlight the importance of creating digital twins of buildings. These technologies are the future of architecture, construction and operation of facilities under construction. The Russian Federation has approved GOST, which establishes the concept of a digital twin. A digital twin is a virtual model of an object that accurately reproduces the form and actions of the original and is synchronized with it. The technology helps to simulate what will happen to the building under different operating conditions.

In the process of training architecture students, it is necessary not only to adhere to classical educational methods, but also to give them the opportunity to get acquainted with modern technologies. For example, how a digital twin of a building, both designed and reconstructed, is created and for what purposes can it be used.

One of the technologies that allows you to create a digital twin of a historical building quickly is laser scanning. The object is scanned with a laser scanner, all data is uploaded to a computer, which subsequently still needs to be "stitched" into a digital model, into a single field of points. Further, students, scientists, and restorers can work with this model. In the future, these models made by students could be included in a unified digital register of historical objects, buildings and structures. The main disadvantage is the high price of laser equipment and software (for example, Trimble RealWorks).

There is another way, but it is more labor-intensive and time-consuming. This is collecting materials in the classical way - collecting materials in archives, measurements, research. Based on the work done, you can create a digital twin using software and BIM technologies.

Creating digital twins of historical objects will allow preserving lost invaluable experience and the appearance of cultural objects, recreating lost materials, the design, skill of the author, planning and urban planning solutions in the digital environment (Mironova, 2023).

Features of the use of various computer programs during teaching architecture were described in their works by: Gerasimenko A. (Gerasimenko, 2021), Sukhanova I. I., Fedorov S. V., Stolbikhin Yu. V., Sukhanov K. O. (Sukhanova, 2024), Lozhkina E. A. (Lozhkina, Lozhkin, 2019), Smorodina E. I. (Smorodina, 2020), Zelenina V. (Zelenina, Puysans, 2007) and others.

Today, there are many software packages that can answer the frequently asked questions of modern architects and designers. But in order to analyze such an abundance of programs, they should be structured according to functions and tasks that can be solved in a particular program, but taking into account an integrated approach when developing a project:

1. Programs based on BIM technologies
2. Local programs for specific tasks

Of course, the absolute favorites in the development of software products for the design and modeling of buildings and structures, especially for architectural specialties, are the foreign companies AUTODESK and GRAPHISOFT, which develop software for industrial and civil construction projects based on building information modeling technology.

1. AUTODESK AutoCAD is one of the most famous computer-aided design systems (Gerasimenko, 2021). The first version of the program appeared on the market in December 1982 and already had impressive potential in the field of two-dimensional drawing. Throughout its existence, the program has been constantly improved, new modules and plug-ins have been added, digital processes have been optimized, a full range of creating and editing 3D models of bodies and surfaces has been included, and a database of normative, reference and technical documentation has also been included.

The main product areas for the architectural and construction industry: AutoCAD Architecture and AutoCAD Civil 3D.

This program is still in great demand for design specialties.

2. AUTODESK Revit. A software package designed for computer-aided design that implements the principle of building information modeling (Sukhanova, 2024). This program is more in demand for architectural specialties due to the creation of three-dimensional prototypes of buildings and structures that can be visualized. One of the key features of Revit is the relationship of project elements with each other, and the slightest change in one element is immediately reflected in others, thus eliminating inaccuracies in the project.

3. AUTODESK 3ds Max. This program is one of the most difficult to master, but has serious potential for an integrated approach to project development. Main areas of the program: three-dimensional modeling; creating animation and dynamics in the environment; rendering and compositing (Lozhkina, Lozhkin, 2019). The program has advanced tools for creating complex, varied shapes and three-dimensional computer models using different techniques. Visualization is represented by a large number of modules for any task (V-Ray, FinalRender, Corona Renderer, etc.), and the high quality of post-processing of design solutions (interiors, exteriors,

environment, etc.) makes the program very popular for its development.

Of course, such products cannot but have disadvantages. 3ds Max is subject to high requirements in terms of mastering functional elements and operating skills, as well as having high specifications for computer equipment.

4. GRAPHISOHT ArchiCAD is more focused on architects, however, given the functionality of the program, it can also be targeted at other specialties. ArchiCAD, like the previously mentioned products, works on the basis of BIM technology, which allows you to solve many problems at a high level (Smorodina, 2020).

The main functionality of the program: three-dimensional modeling of objects, creation of floor plans, the ability to edit project elements in real time in connection with the entire model, and also has an impressive package of software:

- SketchUp - a program for creating 3D design and architectural design. Most often used by architects for designing and modeling capital construction projects, creating and visualizing the environment. A distinctive feature of the program is its support for the Google Earth software resource (virtual globe).

- Sweet Home 3D. This program is presented for the design of individual premises. It has a fairly rich catalog of interior decoration elements and the ability to edit them.

- Plan Pro. Another product for creating quick and easy plans for frame houses. The program allows you to develop the appearance of buildings, design individual rooms, and organize the interior space.

- Lumion – a program for 3D visualization and rendering. The program has the ability to simulate the internal space of an object and create an environment, but more often the program is used as a visualization tool in a pre-prepared project. The program is compatible with many raster and vector formats.

5. Programs for processing orthogonal views of a project, with the help of which you can create a nice picture and compose a design solution. Suitable programs are: Adobe Photoshop, Adobe Illustration, Corel, etc. (Zelenina, Puysans, 2007).

As a result of analysis of publications (Litvinenko, 2023; Vlasova, Vlasova, Borovikova, Karelin, 2023) and our own observations let's take a closer look at the benefits of using AI:

- Increased efficiency: AI can speed up the design and construction process and improve the quality of the final product.

- Cost reduction: AI can help reduce design and construction costs.

- Improving the quality of life: AI can make cities more comfortable, safe and environmentally friendly.

- Automation: AI can automate routine tasks such as drafting, 3D modeling, data analysis and documentation. This frees up architects to be more creative and strategic. AI can be used to generate design options, allowing architects to find optimal solutions faster and more efficiently.

- Design improvement: AI can be used to analyze data about users and the environment, leading to more comfortable and functional buildings. AI can be used to optimize energy consumption and other aspects of sustainability.

- Increased security: AI can be used to identify potential safety issues during the design phase. AI can be used to monitor the condition of buildings and structures, which allows timely measures to be taken to prevent accidents.

Disadvantages of AI in architecture identified from the analysis of publications (Milgizin, Baeva, 2017; Popescu, 2023; Meyrand, 2023; Babich, 2021; Khokhlova, 2017; Bakunov, 2022) and experimental work of the authors:

- Limited creativity: AI is not capable of original ideas and solutions. AI can only generate designs that are based on available data.

- Ethical issues: AI can be used to create buildings that do not take human needs into account. AI can be used to create surveillance and control systems that can violate people's privacy.

- Limited Availability: AI technologies in architecture are still at an early stage of development. Only large companies and research centers have access to these technologies.

- Dependence on technology: overuse of AI may cause architects to lose their manual design skills. If AI systems fail, serious problems can arise.

5 CONCLUSIONS

The basis of the professional competence of an architect is readiness for design activities, since the meaning of his work is to create a social-production system that realizes the needs of society in organizing the spatial environment of life. Many projects of the 21st century are created exclusively with the help of computer technology, therefore, for the productive work of an architect in the modern information world, fundamental basic computer graphics training is needed.

However, in the field of higher architectural education, the potential of modern information technologies is far from being fully used. The creative

capabilities of computer technologies are not used, which shifts the emphasis of professional architectural education towards technocratization to the detriment of the creative, artistic component.

Currently, it is obvious that training in modern IT technologies is necessary for bachelors of architects and urban planners. But the implementation of these programs leads to a simplification of the architecture itself, to the suppression of individual author's styles. After all, in the estimated time allotted for design, it is easier for a student to make a simple model and get a high grade for it than to try to show his individuality.

Therefore, from junior design courses, teachers need to show the importance of acquiring basic architectural and artistic knowledge and hand-graphics skills for a conscious choice of artistic preferences, for practicing their own compositional and figurative techniques, their own author's style, although this will take a lot of time.

Despite the availability of information modelling technology in modern software products, when developing design and working documentation, you should still have the skills to work in several programs. And the reason for this is the optimization and tailoring of each program for specific tasks. The article discusses examples of programs in which all problems can be solved, but the method of solving them can be presented in different ways: in one action, two or more; what knowledge and skills will be required to solve a specific problem; what resources will be used, etc.

The profession of an architect has always been complex and multi-tasking, and with the development of scientific and technological progress in the form of the emergence of CAD systems and the establishment of requirements for the development of relevant documentation, it is necessary to constantly improve and optimize the work process by studying new software systems.

AI has great potential to transform architecture. However, it is important to use these technologies responsibly and ethically.

In conclusion, it should be summarized that artificial intelligence does not replace architects, but complements their capabilities. AI can help architects create more beautiful, functional and sustainable buildings in less time.

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