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OPTIMIZATION OF THE EDUCATIONAL PROCESS OF GRAPHIC TRAINING USING ARTIFICIAL INTELLIGENCE

Modern design and architecture require students to master a huge range of tools: from classical sketching skills, composition theory to complex modeling using graphic editors. Facilitating the teaching of graphic disciplines for future designers and artists using artificial intelligence (AI) is not just automating routine, but an urgent need and priority task. It is in this case that AI becomes the link that helps to master the profession faster. The article explores the transformative potential of AI technologies in the process of teaching a graphic creative discipline, such as Calligraphy, at the Department of Descriptive Geometry and Engineering Graphics of the Odessa State Academy of Civil Engineering and Architecture. The relevance of the work is due to the rapid development of generative models and the need to adapt educational programs to the requirements of the modern design and architecture industry.

The authors analyzed key AI tools and identified their role in the formation of students' professional competencies. The study proposed implementation stages that allow optimizing routine operations and focusing on the development of creative thinking and visual culture. The effectiveness of using a neural network is not manifested in replacing a person, but in radically accelerating technical processes and expanding creative capabilities. AI does not replace fundamental knowledge, but serves as a powerful amplifier of the intelligence of design and architecture specialists.

The results of the study indicate that the use of AI contributes to increasing the speed of project tasks, improving the quality of visualization, and stimulating the individualization of learning. The main challenges and ethical aspects of implementing automated systems in the creative educational process are identified. As for the implementation of artificial intelligence tools in the teaching methodology of Descriptive Geometry, this is a long-term process that involves further development and expansion of the application of AI to other topics.

Key words: *artificial intelligence, graphic disciplines, generative networks, digital education, computer graphics, educational technologies, visualization.*

Сидорова Наталія, Доценко Юлія, Перпері Алла. ОПТИМІЗАЦІЯ ОСВІТНЬОГО ПРОЦЕСУ ГРАФІЧНОЇ ПІДГОТОВКИ ЗАСОБАМИ ШТУЧНОГО ІНТЕЛЕКТУ

Сучасний дизайн та архітектура вимагають від студента володіння колосальним обсягом інструментів: від класичних навичок ескізування, теорії композиції до складного моделювання з використанням графічних редакторів. Полегшення викладання графічних дисциплін для майбутніх дизайнерів та художників за допомогою штучного інтелекту (ШІ) – це не просто автоматизація рутини, а нагальна потреба та пріоритетне завдання. Саме в цьому випадку ШІ стає тим зв'язком, який допомагає швидше опанувати професію. У статті досліджено трансформаційний потенціал технологій ШІ у процесі викладання

графічних творчих дисциплін, таких як Каліграфія на кафедрі нарисної геометрії та інженерної графіки Одеської державної академії будівництва та архітектури.. Актуальність роботи зумовлена стрімким розвитком генеративних моделей та необхідністю адаптації освітніх програм до вимог сучасної індустрії дизайну та архітектури.

Авторами проаналізовано ключові інструменти ШІ та визначено їх роль у формуванні професійних компетенцій студентів. У дослідженні запропоновано етапи впровадження, що дозволяє оптимізувати рутинні операції та зосередити увагу на розвитку творчого мислення та візуальної культури. Ефективність використання нейромережі виявляється не у заміні людини, а в радикальному прискоренні технічних процесів та розширенні творчих можливостей. ШІ не замінює фундаментальні знання, а слугує потужним підсилювачем інтелекту фахівців з дизайну та архітектури.

Результати дослідження свідчать, що використання ШІ сприяє підвищенню швидкості виконання проєктних завдань, покращенню якості візуалізації та стимулює індивідуалізацію навчання. Визначено основні виклики та етичні аспекти впровадження автоматизованих систем у творчий освітній процес. Щодо впровадження інструментів штучного інтелекту в методику викладання Нарисної геометрії, то це є довготривалий процес, який передбачає подальший розвиток та розширення застосування ШІ на інші теми.

Ключові слова: *штучний інтелект, графічні дисципліни, генеративні мережі, цифрова освіта, комп'ютерна графіка, освітні технології, візуалізація.*

Relevance of the study. Modern architectural and artistic education is in the process of digital transformation, which requires the teacher not only traditional knowledge and methods, but also the ability to use the latest technologies. In the traditional system of general education, graphic training for years focused on the long-term mastery of technical skills of sketching and drawing, which often became a barrier to students' self-expression. One of the current directions of development of the educational process, which has prospects for the future, is the implementation of artificial intelligence (AI) systems. The integration of artificial intelligence fundamentally changes this concept: instead of technical reproduction of objects, the priority becomes the development of visual thinking, composition and the ability to formulate ideas. For Calligraphy, a practical creative and graphic discipline, AI opens up new opportunities in demonstration, analysis, experimentation and individualization of learning [1; 2].

The problem is stated in general terms. One of the main tasks of the teacher is to teach the student to combine the technical mastery of the instrument with the creative expression of the form of letters. The integration of artificial intelligence into this process allows for the instant visualization of abstract concepts, freeing the student from daily constant actions in order to develop creative thinking and strategic management of modern digital tools.

Analysis of recent research and publications. Recent studies confirm that artificial intelligence, especially generative AI, is rapidly transforming the teaching of graphic creative disciplines, acting as a powerful tool, not a replacement for teachers and students [3; 4; 5]. The main conclusions are focused on increasing the effectiveness of learning, personalization, developing creativity and the need to update curricula. Studies show that groups of students who used AI systems demonstrate a significant increase in the quality of graphic education and design skills. This is due to the possibility of individually designed suggestions and real-time feedback, which accelerates the learning process [6; 7].

Purpose. The purpose of the work is to study the possibilities and determine effective ways of integrating artificial intelligence tools into the methodology of teaching creative and graphic disciplines, in particular calligraphy, in the system of architectural and artistic education. The task of the article is to substantiate the potential of AI as a means of optimizing the educational process, improving the quality of visualization, developing creative and visual thinking of students, as well as forming modern professional competencies of future designers and architects.

Research objectives. The research is aimed at theoretically substantiating and identifying the most effective ways to integrate artificial intelligence algorithms into the methodology of teaching calligraphy and creative graphic

disciplines. The work considers the possibilities of using neural networks as a tool for stimulating creative search, developing students' visual thinking, and significantly improving the quality of graphic visualization.

Presentation of the main material. The modern model of teaching graphic creative disciplines faces a challenge between traditional teaching methods and a modern approach using AI. The traditional approach is based on step-by-step reproduction of the sketching sequence, often does not take into account the individual speed of students' assimilation of the material. The introduction of artificial intelligence into the process of graphic training should be classified by functional areas: automation of routine actions, generative design (creation of objects using AI-based software), intelligent knowledge testing systems [8; 9; 10].

Calligraphy is one of the fundamental disciplines in the training of design students, as it forms the foundations of artistic thinking, develops a sense of rhythm, harmony and plastic form. The study of calligraphy helps future designers to understand the regularities of letter construction, proportions, lines, and also to understand how text can be transformed into an expressive visual image. By working with a tool such as a pen, brush or marker, students master the precision of movements, concentration and accuracy, which contributes to the development of coordination and artistic discipline. Calligraphy is the direct basis of type design, as it teaches to see the structure of the letter, its plasticity and rhythm, which further helps to create original fonts, logos and corporate styles. It also reveals the relationship between text and image, allowing students to harmoniously combine word and composition in visual projects. In addition to practical skills, the discipline fosters respect for the history and traditions of writing, introduces the evolution of font forms and cultural features of different eras. At the same time, calligraphy stimulates creative search and experimentation, because the process of writing a letter becomes an act of artistic self-expression [11; 12].

Therefore, calligraphy in the training of designers is not just a technique of beautiful writing, but a means of developing professional vision, aesthetic culture and individual style. An example of performing graphic work in the discipline of Calligraphy is presented in Fig. 1. In this work, the overall harmony of the composition, its purity, and the apt combination of fonts of different nature are particularly impressive.

Fig. 1. Font composition from the discipline Calligraphy

AI can greatly facilitate the teaching of Calligraphy by automating routine processes and providing personalized feedback, namely:

1. Creation of an infinite number of prescriptions, exercises and individual templates in various historical styles.

2. Evaluation with AI of the angle of inclination, pressure force and smoothness of the student's strokes using computer vision in real time.

3. Rapid conversion of handwritten texts into vector formats for further editing or printing.

4. Instant search and classification of rare manuscripts for demonstration in classes.

5. AI as a personal assistant in teaching calligraphy, creating font compositions through analysis of technique and generation of samples (Fig. 2).

During the semester in the discipline of Calligraphy, students perform the following control graphic works:

– Arabic calligraphy,

– Creating a book cover using classical calligraphy,

– Font composition.

AI provides maximum support in all areas of understanding and completing each task.

Using AI in the study of Arabic calligraphy opens up incredible possibilities: from instant analysis of the pen's tilt to the generation of ideal samples for copying (Fig. 3). How does AI help with the Arabic calligraphy task?

Fig. 2. Font composition on the theme "Ukraine Online", created with the help of an AI assistant

Fig. 3. Control work Arabic calligraphy on the topic "Ukraine online" using AI (translated "Ukraine online")

Arabic calligraphy is based on a strict system of points – nukta. The student uploads a photo of his practical tasks, and the neural network overlays a grid with ideal proportions. AI can help the student check the accuracy of execution in real time, without postponing the check until later. In advance, the teacher, using ready-made tools, creates a template with which the tasks will be checked. For Arabic calligraphy, this most often involves recognizing the "knots" of the letter and errors in the angle of inclination, which should usually be about 70–80 degrees. Instead of standard textbooks, AI can create individual spelling options. If a student has difficulty, for example, with just one letter, the teacher can use generative AI to create personalized exercises, and the neural network will generate hundreds of variations of this letter in different combinations.

For Arabic calligraphy, as for all types of calligraphy, an important aspect remains the constant supervision of the teacher in the process of writing letters. Special algorithms created by AI can analyze videos of how a student draws a line and give suggestions. That is, with the help of a neural network, the student will receive constant communication 24/7.

The most common practice that a beginner needs to master calligraphy is creating inscriptions using AI. The student sees a translucent outline on paper and tries to repeat its movement. This trains muscle memory much faster than simply copying from a book.

It should be noted that students without the help of AI cope with the conditions of completing tasks qualitatively and show good results. However, as experience shows, with the help of AI this happens more effectively due to the automation of the complex geometry of traditional styles and instantly generated unique sketches for inspiration (Fig. 4).

Fig. 4. Control work Arabic calligraphy on the topic "Culture of the word: from visuality to meaning" without the use of AI (translated as "A good word is like a good tree....")

The practical application of the acquired skills is implemented in the task "Creating a book cover using classical calligraphy". When performing the task, the teacher should act not only as a critic, but as a mentor, guiding the student through the complex process of combining historical aesthetics, practical support and modern design. This task requires an understanding of rhythm, composition and technical nuances of working with a pen. The stages of completing the task consist of:

1) Analysis and research. It is necessary to study the content, target audience and competitive analysis. Understanding the plot and idea, determining who the book is for, studying the covers of similar works – all this will make it possible to adjust the direction of creating a sketch.

2) Sketching. At this stage, you need to decide on the main symbol or general image, choose the color, font and style of the image, develop several draft versions of the sketches.

3) Final design and visualization – choosing a font according to the genre of the book, developing an illustration and determining the final color scheme (Fig. 5).

Fig. 5. Control work "Creating a book cover using classical calligraphy" without using AI

The student needs to focus on the rhythm of the letters and the space of the cover so that the calligraphic inscription looks like a coherent artistic image.

AI, when performing the task "Creating a book cover using classical calligraphy", will help generate composition ideas, select harmonious color palettes and simulate the appearance of the cover on a real book. It is also useful for quickly digitizing handwritten sketches, cleaning the background and converting them into a vector format for final printing (Fig. 6).

The graphic task "Font Composition" involves creating a holistic artistic solution, in which the font is the main expressive means. Student designers work on the harmonious placement of letters, words and text blocks within the format, selecting font styles, scales, proportions and rhythmic relationships.

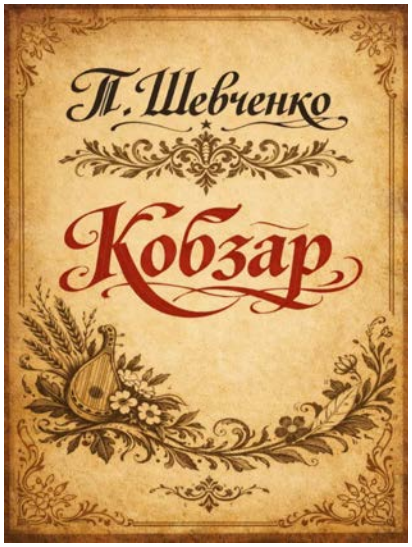

Fig. 6. Control work "Creating a book cover using classical calligraphy" using AI

The main goal of the task is to learn how to convey the content and mood of the composition through the shape of the letters, contrast, dynamics and balance of elements. In the process of work, students analyze the construction of the letter, its plasticity, modularity and interaction with space, develop a compositional center and find the optimal balance between visual expressiveness and readability.

Font composition helps students understand the relationship between calligraphy, typography and graphic design. It develops attention to detail, disciplines the hand, trains visual coordination and artistic taste. When creating compositions, students use various tools – a pen, a flat

brush, markers or digital tools – which allows them to combine traditional and modern methods of graphic expression [13; 14; 15].

When creating a font composition, special attention is paid to the harmonious combination of text with the plane, the plasticity of lines, the silhouette of forms, and the expressiveness of rhythm. The task is aimed not only at the technical reproduction of letters, but also at the transmission of emotional content through the graphics of the inscription, which is important for designers in their future professional activities. Through work on such compositions, students master the culture of writing, form an author's style and learn to create original font images that can convey the content and mood of a design project (Fig. 7).

Fig. 7. Font composition on the theme "Coffee" without using AI

AI can be an effective assistant for a student designer when performing the task “Font Composition”, as it combines analytical capabilities with creative support. First of all, AI helps at the stage of searching for ideas and inspiration – it can generate variants of font compositions, combinations of styles and proportions, suggest original compositional solutions or create visual sketches based on the student’s description. This approach allows you to move faster from idea to visualization, which is especially useful at the initial stages of learning.

In addition, intelligent tools can analyze the structure of the font, identify errors in proportions, interletter spaces, rhythmic constructions and help correct them automatically or with recommendations. This allows the student to understand the patterns of harmonious text construction and improve the quality of the composition.

The neural network is also used to create your own fonts – systems are able to convert handwritten sketches into digital fonts, which opens up the possibility of combining calligraphic individuality with professional font design. Using generative models, a student can experiment with variations in shape, stroke thickness, slope, contrast, and also select color schemes and background solutions for the composition.

Additionally, artificial intelligence contributes to the learning of font stylistics analysis: it can compare historical samples, explain the features of their construction, and suggest how to adapt classical calligraphic principles to modern design tasks. The use of AI helps the student not only achieve high-quality results faster, but also develop analytical thinking, flexibility in creative searches, and an understanding of how to combine tradition with innovation in font composition (Fig. 8).

Fig. 8. Font composition created using AI

Comparison of traditional and AI-assisted learning in the discipline of Calligraphy (Table 1).

Teachers of the Department of Descriptive Geometry and Engineering Graphics use AI to improve the teaching of not only creative disciplines. This approach has also been applied to the graphic discipline Descriptive Geometry.

Descriptive Geometry is a basic discipline that forms spatial thinking, skills in graphical representation of an object on a plane. Teaching this subject is traditionally based on step-by-step constructions, accuracy of execution, and understanding of spatial relationships.

AI opens up new opportunities for improving the educational process of this discipline. Automation of template operations makes it possible to create individual tasks for each student with different sizes and parameters, where plagiarism is completely excluded. Thanks to generative design, variability of task modifications appears. The neural network creates and offers a certain number of options, from which the student must analyze and choose the only correct one from the point of view of the task conditions [16].

The question of checking the drawings by the teacher always remains open. Traditional testing has always taken and takes a lot of time. AI will automate this process. The system can compare the student's task with an example or analogue, identifying inconsistencies, errors and the absence of construction lines. The student can receive tips from AI directly while working on a graphic task. This makes it possible to immediately receive help without waiting for consultation with the teacher in any format.

Using the example of completing the task "Construction of a perspective of a group of buildings using the architects' method with two points of coincidence" (Fig. 9) in descriptive geometry, we will analyze the use and assistance of AI, which can significantly facilitate the mastery of this topic, not replacing learning, but supporting the understanding of spatial thinking.

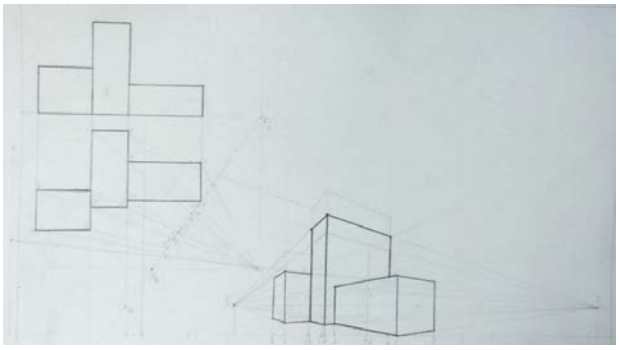

Fig. 9. Control work on descriptive geometry "Construction of the perspective of a group of buildings using the architects' method with two points of coincidence"

First of all, AI helps to visualize complex spatial constructions. A student can use image generators or 3D modeling to see what a group of prismatic bodies looks like in a two-point perspective, observe the change in the appearance of objects when moving the horizon line or points of coincidence. This greatly facilitates spatial thinking (Fig. 10).

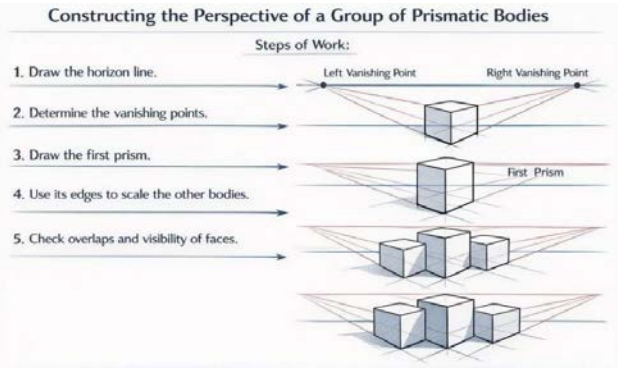

Fig. 10. Step-by-step visualization of complex spatial structures with the help of AI

Table 1

	Aspect	Traditional approach	Using AI
1	Sources of information	Limited number of textbooks	Variability, uniqueness and speed of a multitude of ideas, sketches and images based on the request
2	Deadlines for checking assignments by the teacher	Link to class and consultation schedule	24/7 availability of checking
3	Feedback	Waiting for teacher review	Instant analysis and photo review
4	Analytics	Subjective vision of progress	Tracking the accuracy and proportion of lines in dynamics over a certain period

Further, using AI, you can automatically build a perspective based on the initial data – for example, enter the dimensions of the prism, the coordinates of the horizon points, and the program will create an accurate drawing with the construction of straight lines to the points of coincidence. This way, the student sees the step-by-step construction process, which strengthens the understanding of the principle of the architects' method (Fig. 11).

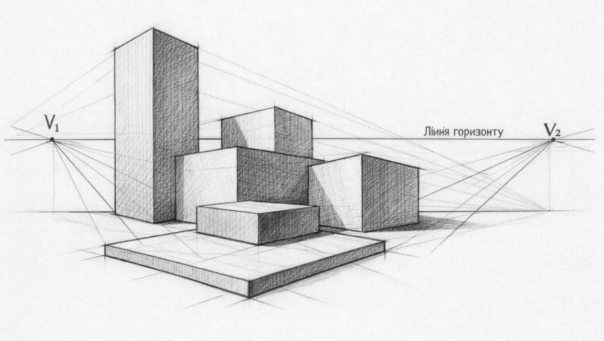

Fig. 11. Construction of a perspective of a group of buildings using the architects' method with two points of coincidence using AI

AI is also useful in checking and correcting errors in drawings: the algorithm can detect inaccuracies in the directions of perspective lines, incorrect position of the horizon line or point of view, suggesting corrections. In addition, artificial intelligence can create interactive simulators – environments where the student changes the parameters of space (angle of view, distance, height of the horizon) and instantly sees how this affects the appearance of objects. This forms a practical understanding of perspective through experimentation. AI can also generate task options of varying levels of complexity, from simple cubic shapes to complex combinations of prisms and parallelepipeds, helping to train perspective construction skills.

A comparison in teaching of the traditional approach to studying descriptive geometry and the approach using AI is presented in Table 2.

Conclusions. As a result of the conducted research, it was found that the integration of artificial intelligence tools into the educational process of graphic creative disciplines is an effective means of modernizing architectural and artistic education. The use of AI in teaching Calligraphy allows you to optimize routine technical operations, accelerate the process of visualizing educational material and create conditions for a deeper understanding of the composition, rhythm and plasticity of letter forms.

The use of generative and analytical neural network models contributes to an individual approach to learning, as students get the opportunity to work with different stylistic variations, experiment with form and promptly analyze their own mistakes. At the same time, AI does not replace fundamental knowledge and manual skills, but acts as a tool to support and strengthen the student's creative potential.

However, the introduction of artificial intelligence into the educational process requires methodological justification, development of ethical norms for use and training of teachers to work with new generation digital tools. Further development of these approaches will allow to form a flexible, adaptive and competitive system of training of specialists in the field of design and architecture, capable of working effectively in the conditions of digital transformation of the professional environment.

Prospects for further research. A promising direction for further research is to expand the use of AI to other graphic disciplines, in particular, descriptive geometry, engineering and computer graphics, and typography. In these areas, AI can be used for automated analysis of geometric constructions, generation of spatial solution options, visualization of complex projections and transformations of forms, as well as for supporting an interdisciplinary approach to learning.

Table 2

	Training stage	Traditional method	Using AI
1	Drawing the condition	Drawing by hand using tools (long process)	Generating the condition of the task variant per minute
2	Problem solution drawing	Manual drawing of all constructions	AI-based parametric modeling
3	Assignment check	The teacher checks each assignment	An automatic script checks the standards
4	Task evaluation	Subjective factor	Objective verification by parameters

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