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ORIGINAL

Experimental methods of teaching computer graphics and design: Impact on the creative potential of higher education students

Métodos experimentales de enseñanza de gráficos por computadora y diseño: impacto en el potencial creativo de los estudiantes de educación superior

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ABSTRACT

Introduction: the increasing global reliance on digital tools has elevated the demand for specialists adept in computer graphics and design, emphasizing the need for creative thinking and graphic competence. This study investigates the impact of experimental methods for teaching computer graphics and design on fostering the creative potential of higher education students.
Objectives: The primary objectives include defining key concepts like "graphic competence," outlining its components, identifying stages of professional training, and evaluating the content, forms, methods, and tools used in developing graphic competence.
Method: a mixed-methods approach was employed, combining theoretical analysis of educational models and practical experimentation in classroom settings. Data was collected through surveys, portfolio assessments, and reflective journals.
Results: the findings highlight that incorporating activity-based, competence-oriented, and creative approaches significantly enhances students' motivation, spatial imagination, reflection, empathy, and aesthetic taste. The staged training model—comprising search and research, practical and artistic, and formative phases—proved effective in cultivating graphic competence. Key results also show that integrating modern design software, such as Adobe Creative Suite and Blender, alongside tailored pedagogical methods, leads to improved professional readiness and innovative thinking.
Conclusions: in conclusion, the study underscores the transformative role of experimental teaching methods in shaping not only the professional skills but also the creative self-awareness of students. These findings contribute to the ongoing discourse on designing effective educational frameworks for creative disciplines.

Keywords: Creativity; Data Visualisation; Interactive Techniques; Multimedia.

RESUMEN

Introducción: la creciente dependencia global de las herramientas digitales ha incrementado la demanda de especialistas en gráficos por computadora y diseño, destacando la necesidad de fomentar el pensamiento creativo y la competencia gráfica. Este estudio investiga el impacto de los métodos experimentales de enseñanza en gráficos por computadora y diseño para potenciar el potencial creativo de los estudiantes de educación superior.
Objetivos: los objetivos principales incluyen definir conceptos clave como "competencia gráfica", delinear

sus componentes, identificar las etapas de la formación profesional y evaluar los contenidos, formas, métodos y herramientas utilizados para desarrollar la competencia gráfica.
Método: se empleó un enfoque de métodos mixtos, combinando análisis teórico de modelos educativos y experimentación práctica en entornos de aula. Los datos se recopilaron mediante encuestas, evaluaciones de portafolios y diarios reflexivos.
Resultados: los hallazgos destacan que la incorporación de enfoques basados en la actividad, orientados a competencias y centrados en la creatividad mejora significativamente la motivación, la imaginación espacial, la reflexión, la empatía y el gusto estético de los estudiantes. El modelo de formación por etapas —que incluye fases de búsqueda e investigación, práctica artística y formación— demostró ser eficaz en la consolidación de la competencia gráfica. Los resultados clave también muestran que la integración de software moderno de diseño, como Adobe Creative Suite y Blender, junto con métodos pedagógicos personalizados, conduce a una mayor preparación profesional y pensamiento innovador.
Conclusiones: en conclusión, el estudio subraya el papel transformador de los métodos experimentales de enseñanza en la configuración de las habilidades profesionales y la autoconciencia creativa de los estudiantes. Estos hallazgos contribuyen al debate continuo sobre el diseño de marcos educativos efectivos para disciplinas creativas.

Palabras clave: Creatividad; Visualización de Datos; Técnicas Interactivas; Multimedia.

INTRODUCTION

An urgent issue in professional education is the training of computer graphics and design students who not only possess professional knowledge and skills but also have creative thinking, high cultural awareness, and developed creative potential. The focus of education should be on developing skills aligned with professional needs to produce competitive graduates for the labor market. Modern candidates in this field must be able to design high-quality graphical interfaces, create computer graphics, and model 3D objects for game design, virtual or augmented reality, requiring a high level of graphic competence.

A specialist in this field must create innovative aesthetic projects, exhibit dynamic creative thinking, artistic taste, and present products in digital graphic form. This necessitates acquiring extensive graphic knowledge, developing skills in digital synthesis, design, modeling, algorithm development, and visual content processing. The formation of a creative, self-developing, and innovative specialist is a key goal of higher education. [1] Foreign students in computer graphics and design emphasize the importance of creativity over acquiring specific knowledge and skills, indicating the need to foster creativity in higher education.[2,3]

Moreover, modern business demands specialists who can create innovative digital products that have no analogues in the digital world. Training should align with current digital art trends, including mobile platforms, websites, and computers.[4] Trends in digital art include virtual art, 3D printing, open-source software, artificial intelligence, 2D animation combined with modern technologies, 3D painting, and game design.[5,6]

To address these needs, experimental teaching methods should be implemented in higher education. Education should foster an innovative mindset and creativity in programming. Teaching methods in computer graphics and design should be based on didactic principles like science, visibility, creative activity, and a competence-based approach, focusing on evaluating learning outcomes through competencies rather than the quantity of work.[7,8] The purpose of this article is to study the impact of teaching computer graphics and design on the creative potential of higher education students.

Objectives of the article:

1. Clarify the essence of key concepts that reveal the content of graphic competence of higher education students: “graphic abilities”, “computer graphics”, “computer design”, “digital design”, “graphic training of higher education students”, “graphic competence”, “methods of teaching computer graphics and design”.
2. Describe the components of graphic competence of higher education students.
3. Identify the stages of professional training of students in the process of teaching design graphics.
4. To find out the content, forms, methods and means of forming graphic competence and their influence on the development of creative thinking of higher education students.

DEVELOPMENT

THEORETICAL ASPECTS OF THE PROBLEM OF FORMING GRAPHIC COMPETENCE

Characteristics of the Key Concepts of the Study of the Problem of Forming Graphic Competence of Higher Education Students

The essence of the concepts that reveal the content of graphic competence in higher education students

is defined. Graphic abilities are defined as a set of knowledge, skills and abilities, caused by a predisposition and (or) nurtured in the process of cognitive and practical graphic activity, which allow a student to carry out graphic activities at a sufficiently high cultural and qualitative level for a particular stage of his or her educational and professional development.[1,9,10]

Computer graphics is understood as a field of scientific knowledge that covers technologies (tools, methods, means) for creating computer two-dimensional and three-dimensional images of various nature (raster, vector two-dimensional, vector three-dimensional, fractal, etc.).[11] Computer design is defined as a field of design in which the computer serves as the main tool for artistic construction and design.[5]

The concept of digital design refers to the processes of designing graphics, design objects of the environment of abovirtual images in the environment of augmented/virtual reality using immersive 3D technologies and special software for digital processing and image generation.[12] In a general sense, this concept can be presented as a project-based application of digital technologies in various areas of contemporary design - the development of elements and systems of information space, multimedia in environmental and exhibition design, and the development of industrial products saturated with interactive capabilities.[5]

Graphic training of higher education applicants is understood as a component of the professional training of future bachelors in computer science, its first and fundamental stage, characterised by the formation of readiness for the direct application of graphic knowledge and skills in the field of graphic language based on the method of designing objects (for example, user interface elements for a web resource, desktop or mobile application, character modelling for computer games, development of game levels or game environment, modelling of the duration of a game). On the other hand, it is a multifaceted and continuous process of forming a student's professional readiness for graphic activity, which has an integrated property in relation to professional (technological, design, programming, etc.) training in a higher education institution.[1,3]

Graphic competence is understood as an integrative property that includes the ability to carry out high-quality organisation and design of software tools, to professionally use modern computer graphics technologies when designing the interface of the software tool being developed, to find the best technologies for achieving the best result, taking into account the ergonomic requirements of the end audience, i.e. users of the tool or consumers of the product.[1]

The implementation of the principles of graphic competence is impossible without knowledge of the visual and figurative graphic language of professional communication. The education received in a higher education institution should contribute to the formation of an innovative level and a qualitatively new attitude of such a specialist to professional work, and create the prerequisites for creativity in programming. Graphic competence contributes to the development of creative thinking, which provides additional opportunities for success in the competitive world.[1]

Methods of teaching computer graphics and design are a set of ordered knowledge about the principles, content, methods, means and forms of organising the relevant educational process.[11]

Components of Graphic Competence of Higher Education Students

Regarding the impact of teaching computer graphics and design on the creative potential of higher education students, the following components of graphic competence are distinguished: motivation, spatial imagination, reflection, empathy, systemic thinking, creativity, aesthetic taste (see figure 1).

Motivation for graphic training is driven by understanding its significance for professional tasks and readiness to apply acquired skills. It involves technical thinking, spatial awareness, and the development of personal and professional qualities. Empathy, crucial for user interface designers, enables understanding and identifying with users' emotions, goals, and motives. Empathy is a conscious experience, where one acknowledges the external source of emotions, preserving rational thinking. This skill is essential for designing solutions that meet users' needs.

Reflection, or critical self-analysis, is also key in UI design, requiring students to assess their emotions and solutions. Spatial imagination, crucial for problem-solving, involves mentally manipulating 2D and 3D figures, facilitating creative thinking in professional tasks. Systemic thinking, which integrates divergent and convergent thinking, is important for computer science specialists in solving complex problems. Creativity in graphic design involves inspired problem-solving and innovation. Aesthetic taste, the ability to discern beauty, enhances graphic competence by ensuring software is both functional and visually appealing, which boosts user engagement. Therefore, aesthetic development is integral to effective design and enhances the quality of software products.[13]

Content of Training in Computer Graphics and Design

For computer graphics and design students the following types of media art are desirable: computer graphics (desktop and animation), video art (moving electronic images on the screen), net art (media installation, projection of images in space), sound art (sound compositions), media performance (interactive communication).[14] The use of computer-graphic design programmes is presented in table 1.

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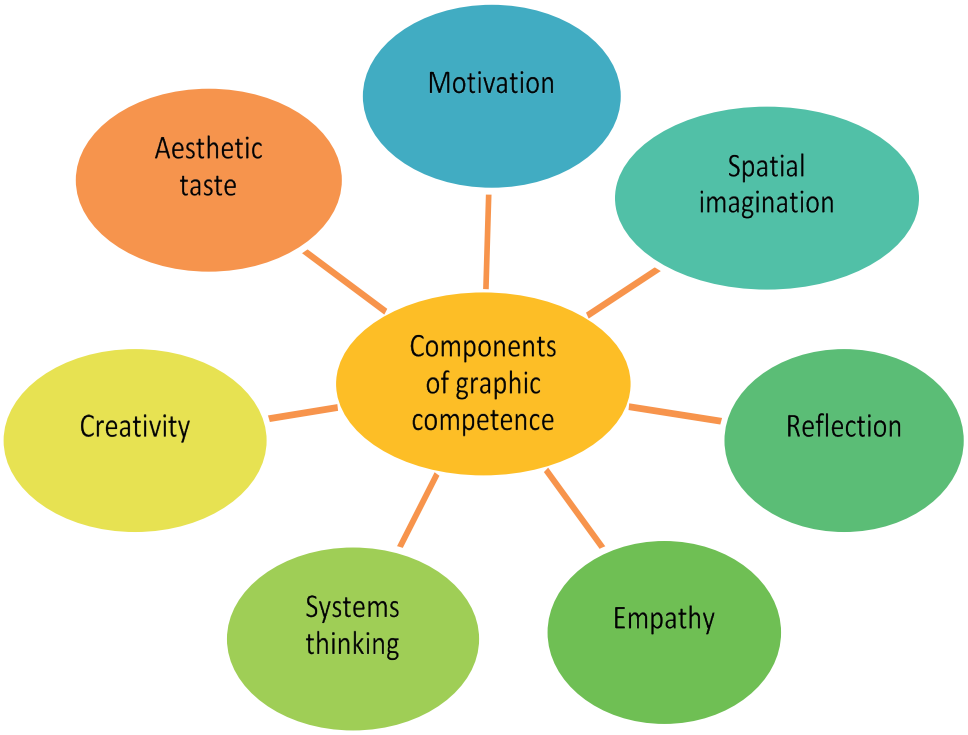

Figure 1. Components of graphic competence of higher education students

Table 1. Computer-aided design programmes

	Programme	Application
Application of computer programmes for artistic and graphic design	Adobe Photoshop	Create and edit digital artwork, photos, and more
	Adobe Illustrator	To create illustrations, logos, and other artistic and graphic artefacts
	CorelDRAW	For print and the web: store and transfer graphic documents with vector, raster, and text information
	Procreate Paintart	For drawing and creating comics, consists of brushes, tools and various artistic tools
Application of computer-graphic interface design software	Adobe In Design	For designing print and digital media
	Canva	Create social media graphics, presentations, and other visualisations
	Figma	To create collaborative UI/UX designs
	Blender	For creating animation, visual effects and other 3D projects

In addition to the aforementioned programmes, other 3D modelling software programmes are also in demand on the labour market: 3DsMax, Maya, Cinema 4D, Houdini, Octane, Autodesk Mudbox, Quixel, Zbrush, Substance Painter, Unity, Unreal Engine 4 and AutoCAD.

Given the wide range of popular software tools for designing user interfaces, the course can be untethered to a specific software tool, but rather based on identifying the most basic and effective ways to build user interfaces based on classical design theory, namely colour theory, the basics of composition, typography, etc. The most relevant tools for three-dimensional modelling are 3DsMax and Maya. Given that both software packages are paid software, but given the possibility of using Maya under a student licence for free for three years, Autodesk Maya can be chosen to build a course on three-dimensional modelling, as a cross-platform, most flexible tool with a wide range of 3D animation, modelling and visualisation functionality, has extensive libraries of standardised objects, logical operators and the built-in programming language Mel (Maya Embedded Language) and Python.[1]

The Blender project platform for creating animation, visual effects, and other 3D projects is also popular.[15] The capabilities of software products allow for the creation of customised solutions based on specific needs. Such solutions usually involve the development or modernisation of a mass standard or a specialised solution adapted to a specific situation.[16]

Google offers a number of free services, which are also presented in the form of applications for most modern mobile devices (both smartphones and tablets), the use of which will not only facilitate work with

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students, but also make it more convenient and interesting. Google Forms allows you to develop an electronic test or survey in a matter of minutes. To do this, you first need to select test tasks, determine the type, and formulate the correct answers.[17]

METHODS OF TEACHING COMPUTER GRAPHICS AND DESIGN

Stages of Professional Training

The main task of the initial training of students is to develop non-standard thinking, to see the problems of graphic presentation of material in translation into computer technological chains with an understanding of the expected result, which allows them to form original project ideas in the course of future professional activities.

It is necessary to master the theory of composition on your own practical experience, know the basic principles of arranging objects on the plane, the laws of construction, shape modelling, and master the techniques of artistic expression and graphics. The professional training of design students in the process of studying design graphics can be divided into three stages:

- search and research (mastering the theoretical foundations of spatial arts, studying graphic techniques, studying the visual heritage and analysing the works of masters);
- practical and artistic (mastering graphic techniques and materials, stages of visualisation of natural objects and design);
- formative (creative orientation of activity).[7]

The formation of students' competencies in artistic and graphic (desktop art design) is the first stage of their mastery of visual design. The development of students' competencies in computer-graphic design of user interfaces (including electronic graphics) is the second stage of their mastery of visual design. The formation of students' competencies in engineering and graphic design is the third stage of their mastery of visual design for technologies of various industries.[14]

Models of Teaching Computer Graphics and Design

The model of computer graphics teaching methods distinguishes several levels: motivational and goal, axiological, activity-process, and reflexive-evaluative.[11]

The outcome of a higher education student's professional training depends on how active their position is during classes and independent work. The effectiveness of training will be ineffective if the student does not understand this or that information, does not understand its essence, importance and prospects for application in future activities.[18] The motivational and goal level can be represented as a hierarchy of operational and perspective levels. The operational one is determined by the content of the state educational standard, and the perspective one includes the training of a competitive specialist who can achieve professional goals in different situations by mastering methods of solving a large class of professional tasks, that is, has the appropriate professional competencies and possesses components of professional creativity in the field of computer graphics.

In the course of study, it is advisable to create a portfolio - an individual portfolio of documents (academic works in the field of computer graphics) that reflects the knowledge, skills and abilities of the student that may be in demand in the labour market. The main purpose of the portfolio is to help future graduates make the transition from education to employment or continuing education at a higher level and to provide employers with the most complete information about the qualifications and academic achievements of students of a higher education institution.[19]

The axiological level emphasizes values and attitudes toward the use of computer graphics in professional activities, fostering a creative and technological environment that integrates societal and individual resources to promote self-expression and self-realization. The activity-process level focuses on organizing teaching methods using personality-oriented and competence-based approaches. It incorporates the didactic principles of science, clarity, and individualization. The principle of scientificity introduces students to relevant scientific knowledge and skills through problem-solving, observation, analysis, and critical discussions. The principle of visibility enhances learning by engaging multiple senses, including motor and tactile sensations. Individualization tailors education to students' cognitive needs, encouraging self-motivation, goal orientation, and self-development. This principle promotes creative, independent work that extends beyond basic learning content.[11]

The reflective and evaluative level involves independent project implementation with artistic and technical training, guided by teacher supervision and feedback. Projects include ongoing evaluations, with intermediate results tracked digitally for monitoring and correction. Both individual and group forms of work are utilized, requiring methodical evaluation strategies. Students' reflections on their thoughts, preferences, and experiences are integral to the process, fostering deeper learning and skill refinement.[20]

These levels collectively support the development of professional competencies and creativity in students, aligning with modern educational demands.

Approaches to Teaching Computer Graphics and Design

The methodology of teaching computer graphics and design in order to develop the creative abilities of higher education students should be based on the use of modern scientific approaches, namely: personality-oriented, competence-based, creative, and activity-based.

Personality-oriented approach in the formation of creative abilities of higher education students

The personality-oriented approach is understood as learning that is focused on the student and provides for the creation of conditions to meet the cognitive needs of the individual, his or her development and creative expression of his or her individuality.

Competence-based approach to the development of creative abilities of higher education students

The competence approach involves a transition from assessing the learning outcome by the amount of labour expended to assessing the outcome through competences, which are a holistic set of knowledge, skills, experience and attitudes, the actualisation of which ensures the effective performance of labour functions by an employee in various professional situations.[21]

Activity-based approach to the development of creative abilities of higher education students

The activity-based approach in teaching computer graphics and design emphasizes the integration of pedagogical processes with knowledge acquisition, fostering intellectual growth and theoretical thinking. This approach relies on students' active participation in real design processes and problem-solving scenarios, promoting creativity, critical thinking, communication, and independence.

Key elements include:

1. Project-based learning: Engages students in solving real design tasks, enhancing practical skills and independence.
2. Role-playing and simulations: Helps students assume roles such as designers or clients, fostering teamwork and understanding design processes.
3. Practical exercises: Encourages creativity and experimentation through hands-on activities.
4. Collaborative learning: Promotes group projects, skill exchange, and teamwork.
5. Real clients and projects: Provides real-world experience by working on practical assignments with constraints.
6. Technological tools: Incorporates modern software and online resources for effective project implementation.
7. Feedback: Offers constructive input to refine skills and improve outcomes.[22]
8. Reflection and self-assessment: Encourages self-evaluation to enhance skills and approaches.
9. Task flexibility: Allows students to select tasks that align with their interests and strengths.

This approach fosters creative potential, practical expertise, and independent decision-making while reducing psychological stress. It creates a harmonious system of interpersonal and professional communication, supporting autonomy and reflection skills.[23]

Creative approach to the development of creative abilities of higher education students

Promoting the development of an individual's creative abilities requires the teacher to use a creative approach that takes into account various aspects such as cognitive abilities, emotional state and motivation. Each student of higher education has his or her own unique construct of giftedness, which combines different aspects of creative abilities and the general ability to create. The purpose of using a creative approach in the training of students is to stimulate creativity, develop innovative thinking, form individuality, prepare for the challenges of the industry, enrich professional experience, and find an individual source of inspiration.

The creative approach is based on psychological, pedagogical and philosophical principles aimed at stimulating and developing students' creativity, namely:

Stimulating creative thinking - the creative approach is designed to develop students' ability to think outside the box and generate new ideas. It is based on the realisation that creativity can be taught and developed through appropriate teaching methods.

Support for individuality - takes into account the diversity of individual abilities and design styles. It gives students the opportunity to express their uniqueness and create original solutions.

Support for experimentation and risk - emphasises the importance of experimentation and risk-taking. It helps students learn from their mistakes and inspires them to try new approaches.

Interdisciplinarity - recognises the importance of knowledge and insights from different fields, such as psychology, art history, art history, technology, etc., to broaden students' horizons and foster their creative development.

Fostering collaboration and exchange of ideas - supports collaboration between students, which stimulates the exchange of ideas and can lead to synergistic results.

Focus on innovation - emphasises the importance of creating innovative solutions in design and prepares students for the challenges of the innovation industry.[24]

Forms, Methods and Means of Training

The objectives of the disciplines of computer graphics and digital design are to acquire basic knowledge of design and graphics for mastery, fluency in all theoretical and practical knowledge and skills in the independent development of various graphic projects.[25] The main form of studying the course is creative work on comprehending the lecture material and performing practical tasks according to the curriculum.[26] When studying the discipline "Fundamentals of Computer Graphics", higher education students must independently solve complex tasks related to the verification of the results of existing published visual research and compare them with the results of their own research on visual practices based on communication analysis methods.[27]

In order to achieve the planned result, namely, the formation of a set of subject competences in the study of the discipline "Fundamentals of Computer Graphics", it is proposed to introduce some methodological approaches into the practice of teaching this discipline. Firstly, laboratory work should contain tasks that are differentiated by two levels of difficulty and are assessed by different numbers of points. This methodological approach allows for individualisation of the learning process and increases students' motivation to learn the subject. In the tasks of the first level of difficulty, students are asked to complete the work according to the proposed algorithm. In doing so, they learn how to create and edit graphic images. Students develop skills in working with certain software tools that allow them to transform graphic images, as well as gain an understanding of the end result of using these tools.

The tasks of the second level of difficulty involve the student's independent selection of decorative elements of the composition, colour scheme, font, etc. In the process of performing tasks for which no clear algorithm of actions is provided, the student develops imagination, spatial imagination, artistic taste, and creative abilities.[21] In addition, the organisation of student learning involves mainly the preparation of differentiated tasks of different levels, provided that they are traditionally divided into academic groups.[17] The peculiarity of the discipline "Fundamentals of Computer Graphics" is that it consists of two interrelated components: mastering the tools and methods of creating various types of graphic images and using a creative approach to perform educational projects that can be applied in other fields of knowledge.

That is why the second important approach to teaching this discipline is to include non-trivial, creative tasks with a mandatory discussion of the results, since the development of students' creative potential is one of the conditions for the process of professional development, since its effectiveness is primarily associated with creative activity, with the intensity of intellectual and volitional efforts.[28] For successful implementation, performance of actions, future graphic and design specialists need to compare the idea of the object itself, the process and its result (including intermediate), take into account the presence of conditions and their changes, identify deviations and get rid of them.[29]

Styles of interaction between subjects of the educational process: democratic and tolerant; career guidance and activity; artistic and creative.[30,31] Forms, methods and means of teaching are implemented with the extensive use of ICT. In particular, the forms of organisation of training sessions include lectures conducted in the form of multimedia presentations; laboratory classes with the use of ICT; independent extracurricular work performed using computer technology; final forms of control - written tests, module tests, exams conducted in the form of computer testing. In addition to traditional teaching methods (narration, explanation, demonstration, discussion), active methods are used, which are implemented with the help of ICT (interactive communication, e-mail, project method). Teaching aids include PCs, video and audio equipment, network equipment, general and special purpose software.[21]

Every year, more and more narrow specialisations appear in the design industry, and design trends are changing even faster. Therefore, a modern designer cannot become a full-fledged professional without practice and readiness for constant change. This is especially true for the development of future designers' ability to perform exploratory mock-ups, which is the final stage of the design and creative process of form-making.[32] Based on cultural and historical experience, it is easy to predict the emergence of new technologies in the future. The only question is whether this is a short-term or long-term perspective of civilisational development.[33]

The development of digital technologies has led to a diversity of learning modes that encourage rethinking the content of computer graphics and design education. Modern trends in the development of digital art are as follows: virtual art, 3D printing, open source software, artificial intelligence, a combination of 2D animation and modern technologies, 3D painting, game design.[5] Thus, with the spread of 3D animation technologies, 2D animation began to decline, but the combination of 2D animation and modern technologies gave it a new lease of life. Yes, Nexa3D is another company looking to change the current landscape with its high-speed, industrial-grade stereolithographic 3D printers.[34] Artificial intelligence art (neural network art) is a new art form created

with the help of smart algorithms. It began to develop rapidly and raise interesting philosophical questions about what is meant by art.[35]

Nowadays, computer graphics and digital design specialists should not only be able to retouch and draw images in a graphic editor, make 3D models and realistic visualisations, work with object photography, develop creative concepts and show their ideas in sketches, but also have the means to program graphics, develop VR and AR projects, virtual and 3D drawings, and 3D printing technologies.[5] The following modern information technologies are among the critical potential ways to increase competitiveness in the digital market.[36]

CONCLUSIONS

This study explored the impact of teaching computer graphics and design on the creative potential of higher education students, focusing on the development of graphic competence.

The essence of key concepts such as "graphic abilities," "computer graphics," "digital design," and "graphic competence" was clarified, providing a foundational framework for understanding the components of graphic competence in higher education.

The core components of graphic competence were identified, including motivation, spatial imagination, reflection, empathy, systemic thinking, creativity, and aesthetic taste. These components directly influence students' professional readiness and creative potential.

Three distinct stages in the professional training process—search and research, practical and artistic, and formative—were defined, offering a structured pathway for developing graphic skills and creativity.

The study demonstrated that integrating modern teaching methods, interactive techniques, and contemporary software significantly enhances the ability to form graphic competence and stimulates creative thinking among students.

The methods and tools employed, including project-based learning, role-playing, and interdisciplinary collaboration, were shown to promote not only technical proficiency but also innovation and self-expression in graphic design.

By addressing the stated objectives, this research highlights the importance of a structured, methodologically sound approach to teaching computer graphics and design, ensuring that students emerge as creative professionals capable of meeting the evolving demands of the digital design industry.

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