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USING ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN MODERN SELF-DIRECTED LEARNING ENVIRONMENTS (ON THE EXAMPLE OF GRAPHIC DISCIPLINES)

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ABSTRACT. *The article elaborates the scientific-theoretical foundations of modernizing self-directed learning in graphic disciplines through the integration of artificial intelligence (AI) technologies. Existing scholarly perspectives on AI integration in education are analyzed, and the specific features of its application in graphic education are identified. The study reveals the impact of intelligent tutoring systems, adaptive learning environments, automated analysis and assessment modules, as well as generative dialogue agents on the effectiveness of self-directed learning.*
KEYWORDS: *artificial intelligence, self-directed learning, graphic disciplines, intelligent tutoring systems, adaptive instruction, generative AI, automatic drawing analysis, spatial visualization, personalized learning, normative verification module.*

In the modern educational landscape, the importance of advanced technologies in strengthening students' knowledge, professional competencies and self-directed learning abilities is steadily increasing. The preparation of qualified technical specialists in higher education institutions, vocational colleges and other training centers is recognized as a strategic priority, driven by the growing demands of industry and manufacturing sectors. In this context, the ability to master and effectively apply emerging technologies — particularly artificial intelligence — represents a key factor not only in meeting current industrial requirements, but also in preparing future-oriented specialists capable of responding to new technological challenges. Integrating AI tools into self-directed learning environments enables learners to analyze complex graphic information, model engineering solutions, receive real-time feedback and personalize their learning trajectories, thereby fostering a generation that can adapt rapidly to innovations and contribute to the development of novel engineering-technological solutions.[1]

At present, the role of self-directed learning in mastering graphic disciplines is rapidly increasing for students in technical fields. Ensuring the effectiveness of independent acquisition

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of drawings, graphic tasks aimed at developing spatial visualization, and practical exercises related to solving constructive-technological problems outside the classroom requires the judicious use of modern educational methods. The relevance of this process is determined, first, by the high instructional workload of graphic subjects and, second, by the practice-oriented nature of their teaching.

The purpose of this article is to substantiate scientific–theoretical proposals for improving self-directed learning in graphic disciplines through artificial intelligence technologies and to analytically present the methodological possibilities of this approach.

Artificial intelligence (AI), as a modern scientific domain, is rapidly penetrating everyday life; it is becoming an integral part of e-commerce, marketing, manufacturing, medicine, automotive engineering, and is assuming an increasingly important role in education, including the teaching of foreign languages. The future of higher education is closely linked to the development of new technologies and the computational capacities of intelligent machines. While AI breakthroughs open new opportunities in this direction, they also generate a number of challenges that may fundamentally transform the governance and internal structure of higher education institutions.

Research on artificial intelligence began in the 1950s. In 1956, J. McCarthy, a renowned expert in computer science, proposed one of the earliest and most notable definitions of AI, according to which the study of AI should consist in describing every aspect of learning or other characteristics of intelligence in such precise terms that a machine can be created to simulate it.[2]

In recent years, the number of scientific studies on the integration of artificial intelligence — particularly generative dialogue systems — into the educational process has increased significantly. Research conducted by various authors shows that GAI chatbots are being used not only as communication tools, but also as guiding, explanatory, and evaluative intelligent assistants in self-directed learning environments. Although some studies do not report a significant impact of chatbots on learning outcomes, their role in enhancing learners' self-regulation, providing personalized instruction, and simplifying the delivery of complex concepts is highly valued.

The trends observed in higher education are also relevant for graphic disciplines. In particular, in descriptive geometry, engineering graphics, and computer graphics, AI technologies provide users with interactive explanations, visual transformations, and step-by-step clarification of complex graphic tasks in a way that differs from traditional textbooks. This process shifts the learner from a passive recipient to an active analytical subject.

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At the same time, several publications emphasize that increasing reliance on AI tools necessitates consideration of issues such as academic integrity, the ability to independently perform graphic competencies in real practice, and the deep formation of intellectual preparedness. Some studies note that students frequently use AI chatbots as "personal tutors," and although this can enhance learning motivation, it may also reinforce reliance on ready-made answers rather than fostering a deep understanding of fundamental theoretical principles.

Thus, the literature review indicates that artificial intelligence technologies hold great potential for modernizing graphic education; however, their implementation should be assessed not only in terms of effectiveness, but also against the criteria of pedagogical safety and cognitive independence.

In recent years, the system of self-directed education — previously relying mainly on traditional information technologies — has moved to the stage of artificial intelligence technologies. In addition to interactive multimedia, distance learning platforms, and electronic textbooks, AI-based adaptive learning systems, automated analysis and assessment tools, and intelligent tutoring programs have emerged, forming new methodological opportunities for graphic disciplines.

In Uzbekistan, strategic plans are also being developed to advance artificial intelligence technologies and integrate them into the education system. In particular, a presidential decree was adopted to establish a systematic framework for national research and development in AI, to effectively reform the education system, and to integrate digital technologies into the economy and social life.

According to the decree, the strategy consists of three major phases:

• Phase I (2021–2022): Establishing and systematizing the fundamental foundations for the development of artificial intelligence.

• Phase II (2023–2025): Training qualified specialists in AI and strengthening scientific capacity.

• Phase III (2026–2030): Forming a highly developed digital society in Uzbekistan.

The strategy clearly defines the priority directions for the development of AI technologies. First and foremost, it emphasizes the need to develop and regulate legal frameworks and ethical standards for the use of AI. Furthermore, the role of AI in the development of the digital economy and the formation of an information-based society is specifically highlighted. Alongside this, the modernization of AI-related educational programs, support for scientific research activities, and enhancement of human capital are identified as strategic tasks. Finally, the development of digital products and the gradual implementation of "smart" technologies across various

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sectors of the economy are noted as key priority directions of the strategy.[3]

The need to scientifically justify the use of artificial intelligence is determined by several factors:

• the ability of AI tools to adapt the quality of self-learning in real time and ensure individualized, differentiated instruction;

• strengthening the reflective mechanism of learning by automatically analyzing students' errors in graphical tasks;

• the need to increase educational quality while ensuring time and resource efficiency.

These factors indicate that the use of AI technologies should not be arbitrary, but rather grounded in a methodologically and scientifically justified approach.

Recent academic works on the role of artificial intelligence in education interpret AI technologies as a transformational instrument that enables the adaptation and differentiation of the learning process, the automation of assessment, and the provision of personalized instruction. Studies note that AI-based instructional systems are able to diagnose the learner's knowledge level in real time and adjust the learning trajectory accordingly — a quality indicator that fundamentally distinguishes them from traditional information-computer technologies.

Theoretical developments regarding AI systems supporting independent learning are primarily focused on the modeling of intelligent tutoring systems (ITS), adaptive learning environments, automated skill-analysis assessment modules, natural-language-processing-based assistant agents, and generative AI-based advisory systems. The scientific model of these systems is based on the cycle "diagnosis — adaptation — feedback — assessment — repeated instruction," and this very model constitutes the methodological foundation for supporting self-directed learning.

In the context of graphic disciplines, prevailing perspectives on AI application are concentrated in the following directions:

a) expert systems for automatic detection and correction of errors in drawings;

b) models for developing spatial thinking through automatic AI-based generation of three-dimensional visualizations;

c) algorithmic reconstruction of drawings through image-based recognition of construction elements from sketches;

d) intellectual monitoring approaches that track a student's sequential actions in graphic tasks and evaluate their conscious strategy.

These approaches demonstrate the existence of scientific research focused on the real integration of AI into the methodology of graphic disciplines.

However, the shortcomings observed in existing approaches lie in the

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fact that most studies are limited to technically demonstrating the use of AI, without sufficiently elaborating its methodological model, didactic justification, or pedagogical validation. Furthermore, the impact of AI tools on the self-learning component of graphic disciplines has not been systematically assessed; the results are often fragmentary and localized. This situation generates a scientific necessity — namely, to methodologically substantiate the application of AI in graphic disciplines, to develop scientific-theoretical approaches toward its integration, and to prepare conceptually grounded proposals oriented toward educational practice.

In the present era, the rising trust in technology and the expansion of digital transformation processes are sharply increasing the global demand for specialists in the field of computer science. This trend is compelling the education system to undergo a fundamental renewal: learners are now required not only to acquire knowledge but also to develop competencies for approaching real-world problems with innovative, creative, and critical thinking. This new paradigm of education abandons the traditional reproductive approach and instead demands the formation of competencies based on independent analysis, algorithmic thinking, and constructive decision-making.

Artificial intelligence (AI) technologies offer effective solutions as both methodological and organizational mechanisms in this process. The integration of AI in modern learning environments enables individualized instruction, the creation of personalized learning trajectories, automated monitoring of learning activities, and adaptive assessment. Studies emphasize that AI-based educational technologies construct teaching modules that are aligned with learners' knowledge levels, interests, and developmental needs; ensure the gradual development of problem-solving competencies; and activate reflective thinking mechanisms within the learning process.[4]

For educators, artificial intelligence emerges not merely as an auxiliary digital tool but as an intellectual assistant that enables time management, reduces assessment workload, supports analytical decision-making, and allows rapid adaptation of curricula. As a result, teacher resources are redirected toward "content-pedagogical management," while learners become more deeply engaged in creative and independent thinking, reflection, and problem-solving activities.

Current empirical evidence and literature reviews show that AI integration in education yields the following positive effects:

—Personalized learning experience (adaptive content based on learner profiles);

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—Automated assessment and diagnostics (real-time detection and analysis of errors);

—Interactive and creative learning environments (virtual assistants, chatbots, VR/AR-based visual solutions);

—Development of analytical and critical thinking (AI stimulates reflective learning through problem-based scenarios);

—Optimization of teacher workload (automation of monitoring, feedback, and adaptation processes).

International practice likewise confirms the large-scale integration of AI technologies into education systems. The People's Republic of China has initiated the inclusion of AI fundamentals and AI-assisted instruction into the national curriculum starting from primary education. The Republic of Korea has adopted a strategy to expand 76 AI-based digital textbooks—initially developed for mathematics, Korean language, English, and informatics—to other subjects by 2028. In the United States, the PASS (Pioneering AI in School Systems) initiative has been launched to establish a systemic mechanism for preparing all stakeholders in education—from administrative bodies to classroom practice—for working with AI.[4]

The literature review shows that AI technologies are currently used predominantly in theoretical subjects, language learning, programming, and test-based instructional settings, whereas the integration of AI into normative–technical graphic disciplines such as projection drawing, spatial modeling, and GOST/ISO-based graphic standardization has not yet been fully established. This gap confirms the existence of a theoretical and methodological demand.

The research substantiates the following scientific propositions:

1. Supporting independent learning via AI in graphic disciplines is feasible through strengthening abstract spatial visualization, real-time error analysis in drawings, and automatic verification of compliance with normative standards.

2. AI should be conceptualized not as a teacher replacement, but as an intellectual assistant providing cognitive scaffolding, thereby enriching the pedagogical ecosystem without disrupting its natural structure.

3. AI integration must be framed not merely as a technical affordance but as a methodological norm, where the objective is not to automate graphic exercises but to provide analytical guidance directing the learner's reasoning trajectory.

For the integration of artificial intelligence into the teaching of graphic disciplines, it is essential first to develop an "intellectual verification module" aligned with normative–technical standards. Such a module would automatically validate drawings against GOST or ISO requirements and register deviations based on normative criteria. Another promising direction is the development of intelligent agents capable

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of solving inverse problems via AI-based 3D reconstruction — for instance, reconstructing a spatial model from an orthographic projection with interactive, explanatory dialogue.

From a methodological standpoint, AI-based dialog agents must not provide ready-made solutions; rather, they should steer the learner toward the theoretical basis through questioning, feedback, and explanatory prompts. At the same time, an AI-supported independent learning model should not be fully autonomous but implemented in a hybrid format under teacher supervision.

A priority direction for future research is the empirical measurement and mathematical modeling of the impact of AI intervention on cognitive load in mastering graphic disciplines. Additionally, the effect of AI-mediated independent graphic exercises on real applied competence must be evaluated through controlled experimental research (experimental–control group design). Another essential direction is the development of pedagogical metrics for AI-based graphic education platforms, where parameters such as error typology, repetition frequency, standard compliance, logical sequencing, and time expenditure function as core indicators.

In conclusion, artificial intelligence should be regarded not as a substitute for graphic education but as an intellectually augmenting methodological enhancer. This approach establishes a theoretically grounded, pedagogically adaptive, and empirically testable platform for further development.

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