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METHODOLOGICAL FOUNDATIONS FOR TEACHING ARTIFICIAL INTELLIGENCE IN GENERAL SECONDARY SCHOOLS

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Abstract. *This research focuses on developing the theoretical and methodological foundations for teaching artificial intelligence elements in general secondary education schools. The study analyses the concept of artificial intelligence and core components, identifying seven structural elements. Four progressive levels of AI literacy for students have been developed and international experience in AI education has been examined.*

Keywords*: artificial intelligence, machine learning, AI literacy, computer science education, didactic structure, deep learning, natural language processing, computer vision, teaching methodology, cognitive levels.*

Annotatsiya. *Ushbu tadqiqot umumiy o'rta ta'lim maktablarida sun'iy intellekt elementlarini o'qitishning nazariy-metodologik asoslarini ishlab chiqishga qaratilgan. Tadqiqotda sun'iy intellekt tushunchasi, asosiy elementlari tahlil qilinib, yettita tarkibiy komponent aniqlangan. O'quvchilar uchun sun'iy intellekt savodxonligining to'rtta progressiv darajasi ishlab chiqilgan hamda xalqaro tajriba o'rganilgan.*

Kalit so'zlar*: sun'iy intellekt, mashina o'rganishi, sun'iy intellekt savodxonligi, informatika ta'limi, didaktik tuzilma, chuqur o'rganish, tabiiy tilni qayta ishlash, kompyuter ko'rishi, ta'lim metodikasi, kognitiv darajalar.*

Аннотация. *Данное исследование направлено на разработку теоретико-методологических основ обучения элементам искусственного интеллекта в общеобразовательных школах. В работе проанализированы понятие искусственного интеллекта и основные компоненты, выявлены семь структурных элементов. Разработаны четыре прогрессивных уровня ИИ-грамотности учащихся, а также изучен международный опыт в области обучения искусственному интеллекту.*

Ключевые слова*: искусственный интеллект, машинное обучение, грамотность в области ИИ, обучение информатике, дидактическая структура, глубокое обучение, обработка естественного языка, компьютерное зрение, методика преподавания, когнитивные уровни.*

INTRODUCTION

In today's information society, artificial intelligence technologies are permeating nearly every sphere of human life. The growing use of artificial intelligence in education, healthcare, the economy, industry, and other strategic sectors is making a deep understanding of this technology a vital necessity. Consequently, the issue of teaching the fundamentals of artificial intelligence in general secondary schools necessitates special attention and research within the scientific and pedagogical community.

Raising the quality of education in the Republic of Uzbekistan to a new level, preparing students to live and work in the age of digital economy and information technologies, has been identified as one of the priorities of state policy. In particular, pragmatic actions have been identified, such as the introduction of the national program "Artificial Intelligence Day" aimed at training students of secondary educational institutions in artificial intelligence, improving their knowledge and skills, and the development of textbooks and manuals for teachers within the framework of the program, the inclusion of topics related to teaching the basics of artificial intelligence and basic skills in school programs on "Informatics and Information Technologies" starting from the 2026/2027 academic year, the expansion of the "One Million Artificial Intelligence Leaders" project, which is a continuation of the "One Million Programmers" project, and the holding of a national competition to award young people, teachers, and educational organizations that have shown the highest results at the end of the year [1]. Also, special attention is paid to assessing students' knowledge using the function of artificial intelligence in the general education system [2]. These aspects indicate that there are basic legal solutions in Uzbekistan.

In this context, enriching the content of the subject "Informatics and Information Technologies" of general secondary schools with elements of artificial intelligence and forming appropriate literacy among students is of urgent scientific and practical importance.

This scientific thesis is prepared on the basis of the scientific analysis, conclusions, and developed methodological approaches presented in the first chapter of the dissertation entitled "Theoretical and methodological foundations of teaching elements of artificial intelligence in general secondary schools". During the research, international scientific literature on the concept of artificial intelligence, research of leading scientists, practical experience of developed countries, and program documents of international organizations were extensively studied and analyzed.

The rapid development of artificial intelligence (AI) technologies also requires fundamentally new approaches in the field of education. As S. Russell and P. Norvig noted, "artificial intelligence is the creation and understanding of intelligence not as a

specific property of a person, but as a general property of systems" [9]. This definition encourages us to take AI out of its narrow technical boundaries and consider it as a universal cognitive paradigm. This approach is also important in the field of education. If AI is interpreted not as an alternative to human intelligence, but as a general property of systems, then teaching it to schoolchildren will serve not only to form technological literacy, but also to develop systematic and algorithmic thinking. Therefore, teaching AI elements in general secondary schools should be considered a pedagogical necessity that directly affects the intellectual development of students.

In justifying the relevance of AI education at the international level, UNESCO's report "K-12 AI Curricula: A Mapping of Government-endorsed AI Curricula" occupies a special place. This document emphasizes that teaching artificial intelligence in school education is a strategic necessity aimed at "preparing students not only as consumers of technology, but also as creators of future innovations" [12]. This concept shows that AI education is not limited to providing programming skills, but is aimed at developing a wide range of digital potential in students - problem identification, data analysis, model creation and ethical evaluation skills. In this regard, the issue of integrating AI elements into the educational process in school education of our republic should be interpreted as one of the priority tasks of not only national, but also global educational policy.

An important theoretical basis for the development of students' AI literacy is provided by the research conducted by D. Long and B. Magerko. The researchers define AI literacy as "a set of competencies necessary to critically evaluate artificial intelligence systems, effectively communicate with them, and use them in a socially responsible manner" [11]. This definition shows that AI literacy is a much broader concept than simple technical skills, and includes cognitive, social, and ethical dimensions. Therefore, when designing the process of teaching AI elements in school education, it is not enough to rely solely on the paradigm of knowledge transfer - a didactic approach is required that simultaneously forms systematic thinking, critical thinking, and ethical responsibility in the student. This, in turn, provides a methodological basis for developing a system of progressive levels of AI literacy. The study of D. Touretzky and co-authors is also of particular importance in determining the content of AI education for schoolchildren. They put forward the concept of "Five main ideas necessary for the study of artificial intelligence in K-12 education" and systematized AI education by dividing it into certain theoretical and practical blocks [10]. This approach scientifically proves the need to maintain a didactic hierarchy when integrating AI elements into the educational content - that is, to apply the principle from simple to

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complex, from concrete to abstract. In this regard, the four progressive levels of AI literacy developed in our study — conceptual understanding, purposeful use, critical analysis and ethical evaluation, and creation — are based on the same methodological principle, taking into account the age and cognitive development characteristics of students, and constitute a scientifically based didactic model for teaching AI elements in school education.

This article describes the conceptual essence of artificial intelligence, its types, main features and structural elements on a scientific basis. It also analyzes the cognitive levels, didactic structures and methodological approaches necessary for the formation of students' AI literacy. The thesis consists of an introduction, main part and conclusion, and the main part provides a structured scientific presentation of the research results.

2. Materials and Methods

There are various approaches to the concept of artificial intelligence (AI) in the scientific literature, each of which highlights a certain aspect of technology. S. Russell defines artificial intelligence as "the creation and understanding of intelligence not as a specific property of a person, but as a general property of systems". R.E. Bellman describes it as "an activity that automatically connects human thinking with intelligence". In H. Lee's approach, artificial intelligence is considered as a tool that "provides machines with human abilities that rely on thinking, such as listening, speaking, reading, writing, remembering and learning".

Local scientists H.N. Zaynidinov defines artificial intelligence as "a property of automatic and automated systems that embody some of the functions of human intelligence". However, the analysis carried out during the study showed that none of these definitions can fully reflect the capabilities of artificial intelligence. In some definitions, the current capabilities of technology take precedence, in others, the future prospects, while in others, the interaction between human and machine intelligence is raised as the main issue, which makes it difficult for students to form a clear and holistic picture.

Based on the scientific analysis conducted, an author's definition was developed in the study. This definition was expressed as "artificial intelligence is a computer system capable of performing tasks that usually require human intelligence, such as speech recognition, visual perception, independent decision-making, and others." This definition was accepted as a conceptual basis that is clear, understandable for students, and fully reflects the practical essence of technology.

Artificial intelligence is widely considered in the educational process in two directions. First, as a means of AI, it is a technology used to improve the quality of education, and secondly, as a subject of AI, it is a field of knowledge and skills that students must master. The

second direction, namely the development of a methodology for teaching AI elements, is identified as the main research object in this study. This represents a strategic approach aimed at preparing students not only as consumers of AI products, but also as specialists who will create and improve them in the future.

Basic elements of artificial intelligence

During the research, the classification of artificial intelligence accepted in the scientific literature was studied, and three main types were distinguished: narrow artificial intelligence (ANI), general artificial intelligence (AGI), and super artificial intelligence (ASI). Narrow artificial intelligence refers to systems that are currently widely used in practice and show high efficiency in a specific field or task, and provide results superior to humans in areas such as image recognition, speech recognition, and game playing. General artificial intelligence is being studied theoretically as a system with the ability to think flexibly and solve problems in various fields, like humans. Super artificial intelligence, on the other hand, represents a system that is significantly superior to human intelligence in all fields and is currently being discussed at a scientific and hypothetical level.

The following main characteristics of artificial intelligence were identified and summarized in the study: reasoning, learning, problem-solving, perception, linguistic intelligence, and moral characteristics. Each of these features can serve as a basis for the formation of didactic content that can be taught to students using understandable examples and practical exercises. Regarding the main elements of artificial intelligence, the study identified, systematized, and integrated into teaching methodologies the following seven main elements based on an analysis of scientific literature, scientific research, and the current level of development of technology.

Table 1. Key Elements of Artificial Intelligence and Their Role in Education[15]

AI Elements (Uzbek)	English Terminology	Practical Application in Education
Mashina oʻrganishi	Machine Learning	Predictive models based on data analysis
Chuqur oʻrganish	Deep Learning	Solving complex tasks using neural networks
Tabiiy tilni qayta ishlash	Natural Language Processing	Text analysis and linguistic interactions
Robototexnika	Robotics	Automated movement and control in physical environments
Ekspert tizimlari	Expert Systems	Decision-making based on

AI Elements (Uzbek)	English Terminology	Practical Application in Education
		domain-specific knowledge
Noaniq mantiq	Fuzzy Logic	Processing and operating with imprecise data
Kompyuter ko'rishi	Computer Vision	Image recognition and visual analysis systems
Phase-based Learning Approach		
Theoretical Concept	Practical Skill	Creative Project

*Source: Normatov S. A. TA'LIMDA SUN'IY INTELLEKT ELEMENTLARI VA XUSUSIYATLARI //Inter education & global study. – 2024. – №. 8. – C. 35-48.

The AI elements listed in the table must be arranged didactically from simple to complex and serve as the foundation for a curriculum designed to gradually develop students' knowledge and skills. It is recommended that each element be taught in three stages: theoretical understanding, practical skills, and creative design.

3. Results. The study developed four progressive levels of AI literacy for secondary school students. These levels are based on the principle of simple to complex and are structured in accordance with the stages of cognitive development of students:

– Level One – Conceptual understanding of AI. The student will gain an understanding of what AI is, its types and main elements. At this stage, the skills of recognizing AI technologies in everyday life and explaining their main features are formed.

– Level Two – Purposeful use of AI. The student will be able to consciously and effectively use AI tools to achieve specific goals. Skills in the purposeful use of AI capabilities when working with images, sound, text, video and illustration materials are developed.

– Level Three – Critical analysis of AI. The student is able to analyze the strengths and weaknesses of AI systems, critically evaluate the results produced by AI, understand the limitations of the technology, and see alternative solutions.

– Level Four – Ethical Evaluation and Creation of Artificial Intelligence. The student evaluates AI technologies from the perspective of ethical standards, designs simple AI mini-models, performs the stages of problem identification, data collection, model construction, testing, and analysis of results.

This four-level system provides a systematic and consistent approach to the formation of AI literacy in students. The levels logically complement each other, and each stage creates the necessary knowledge and skills base for the next stage. According to the analysis, the skills of effective interaction with AI and the

design of mini-models are of particular importance in preparing students for the digital world. In the formation of the first level of AI literacy in students - conceptual understanding - the main elements of AI, in particular machine learning, expert systems and computer vision, perform an important didactic function. These elements allow the student to recognize AI systems in everyday life, to understand in general the mechanisms of their operation and to distinguish in which areas the technology is used. At the second level - targeted use - the elements of natural language processing and computer vision are of particular importance: students acquire the skills of conscious and targeted use of AI tools by working with multi-format data such as text, sound, images and video on the basis of practical exercises. At this stage, the functional interdependence of the elements serves as the main support for the student in perceiving the wide-ranging possibilities of technology.

At the third level — critical analysis — the integration of deep learning and fuzzy logic elements into the learning process prepares the student to critically evaluate the strengths and weaknesses of AI systems. In particular, analyzing the data on which deep learning models work, the level of reliability of the results, and in which cases the technology can make mistakes develops algorithmic thinking and critical numerical reasoning in the student. The fuzzy logic element, on the other hand, allows the student to understand how the AI system makes decisions in the face of unclear or contradictory data, creating a methodological basis for understanding its limitations. Such an approach forms a culture in the student not to blindly trust AI technologies, but to evaluate them based on reason and evidence.

At the fourth and highest level — ethical assessment and creation — the integrative complex of all AI elements — machine learning, deep learning, robotics, natural language processing, expert systems, fuzzy logic, and computer vision — is manifested as practical skills in the student's independent design of mini-models. Each stage of this sequential process of identifying the problem, collecting data, building a model, testing, and analyzing the results relies on a specific AI element and turns the student into a creative creator of technology. At the same time, the study of AI elements at this level is not limited to technical literacy, but also encompasses a sense of social, cultural, and ethical responsibility: the student realizes the need to foresee the impact of AI technologies on society and adhere to ethical standards when designing them, which is one of the most important outcome indicators of modern education.

The study examined programs, reports, and consensus documents from authoritative international organizations such as UNESCO, the UN, and the European Union that focus on teaching AI elements in general secondary schools. The documents of international

organizations strongly emphasize the strategic need to develop AI literacy in school education and require national governments to make clear policy decisions on this issue.

In the People's Republic of China, national AI curricula have been developed for schoolchildren and their integration into mainstream schools is being implemented gradually. South Korea has made AI education mandatory for all students from elementary school to high school starting in 2020. In the United States, the practice of conducting AI courses through certified teachers has been widely established. Canada, on the other hand, is distinguished by its approach to integrating AI into the school curriculum, which prioritizes ethical aspects.

Based on the conducted analysis, it was determined that there is a great need to organize an artificial intelligence educational environment in secondary schools of our republic, in particular, to develop a digital educational course that helps to visually study artificial intelligence, to offer special methods for teaching AI elements, and to organize special courses on AI teaching in teacher training courses. This further increases the effectiveness and practical significance of the research. The current content of the "Informatics and Information Technologies" textbook was also analyzed in the study. The analysis showed that the content of the existing textbook contains integrative topics that provide fundamental knowledge and skills in studying AI technologies, but they need to be purposefully linked and expanded with AI elements. To this end, the study developed a consistent methodological sequence of eight stages, which serves as the basis for scientifically creating content and teaching methods for AI elements in the subject "Informatics and Information Technologies".

The Structural Framework of the Artificial Intelligence Teaching Methodology

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This study developed a structural framework to define the didactic potential of the methodology for teaching the fundamentals of artificial intelligence in general secondary schools.
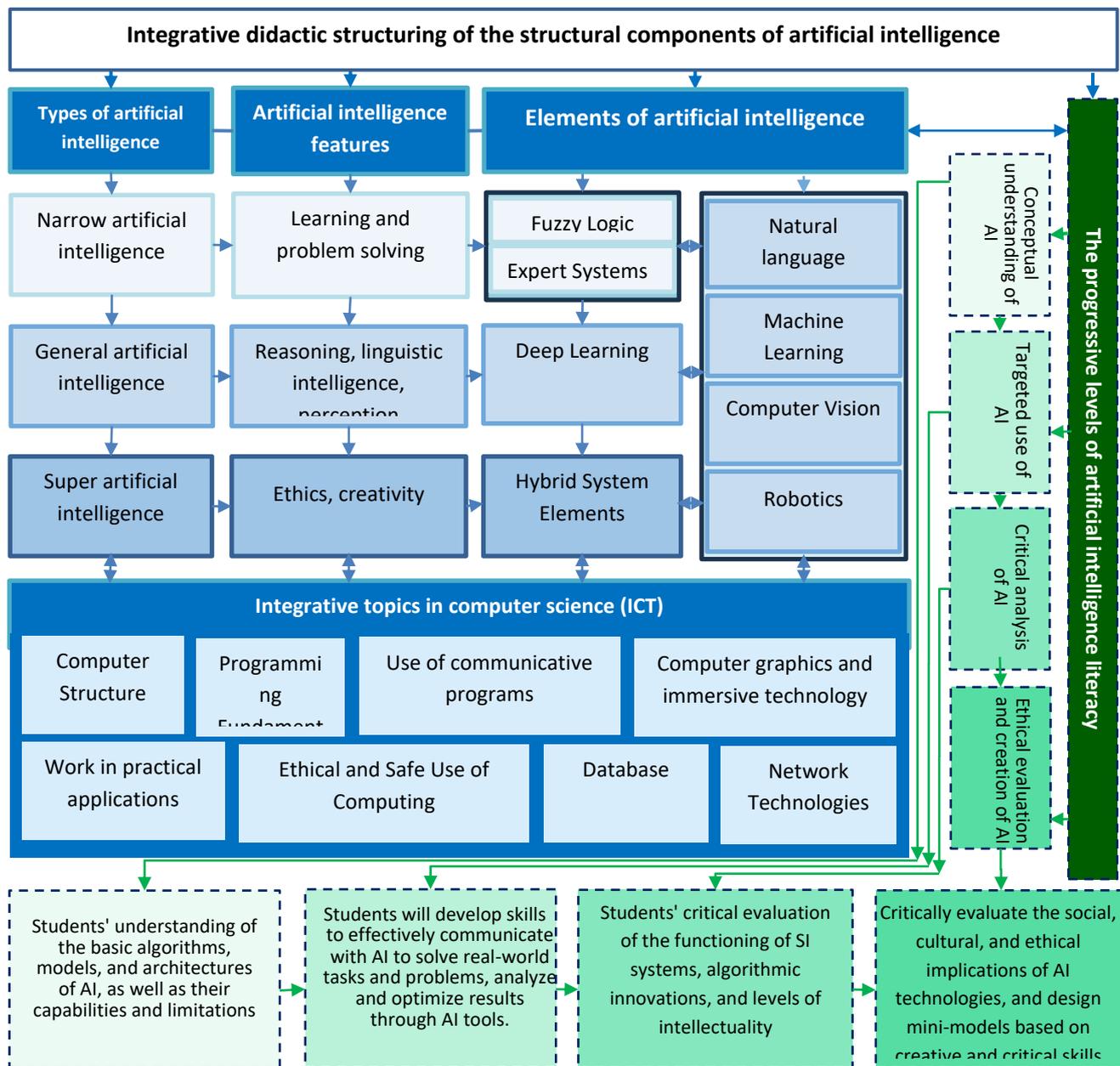

Figure 1. The integrative didactic structure of artificial intelligence components

This framework prioritizes the cognitive levels of AI literacy and is based on the integrative didactic structuring of AI's constituent components. The framework comprises theoretical and activity-based outcome sections. The aforementioned Figure 1 graphically illustrates this structural composition.

4. Discussion. As shown in the figure, the structural layout features three main columns - AI elements - arranged in an interconnected manner. At the bottom of the structure is the block labeled "Integrative topics of computer science

ICT," which encompasses these components and defines topics such as computer structure, programming basics, use of communicative programs, and computer graphics. On the right side of the structure, four progressive levels of students' AI literacy are displayed vertically.

The theoretical part defines the didactic systematization of the conceptual foundations, types, properties, and elements of artificial intelligence and the mechanisms for transferring them to students. The active-resultative part includes such types of activities as design, modeling, experimentation, and analysis, which are designed to develop students' practical skills. The organic unity of these two parts allows students to form not only knowledge, but also practical potential. The structural structure also provides an approach aimed at systematically studying existing AI tools based on their classification when integrating AI types into the curriculum. In particular, tools that are examples of narrow artificial intelligence (such as ChatGPT, DALL-E, Google Translate) are the closest and most understandable for students, and it is advisable to use them first in practical exercises. In general, the structural structure and methodological approaches developed in the study allow equipping students with skills that meet the requirements of the digital economy, forming a critical and ethical attitude towards artificial intelligence in them, and creating a foundation for their future work in the field of AI technologies.

5. Conclusion. The main results achieved in the process of studying the theoretical and methodological foundations of teaching artificial intelligence elements in general secondary schools were scientifically presented. Based on the conducted research and analysis, the following conclusions can be drawn.

First, based on the analysis of various definitions of the concept of artificial intelligence in international and domestic literature, an author's definition was developed and its justification from the point of view of didactic content intended for students of general secondary schools was shown. The author's definition clearly and intelligibly reflects the practical essence of technology and serves to form a holistic idea of AI among students.

Second, the types of artificial intelligence (narrow, general, and super AI), their main characteristics (reasoning, learning, problem-solving, cognition, linguistic intelligence, ethics), and seven key elements (machine learning, deep learning, natural language processing, robotics, expert systems, fuzzy logic, computer vision) were systematized based on an analysis of scientific literature and adapted didactically for teaching.

Third, four progressive levels of students' AI literacy were developed - conceptual understanding, purposeful use, critical analysis, and ethical evaluation

and creation. These levels are structured taking into account the stages of students' cognitive development, with each level creating the necessary knowledge and skills base for the next.

Fourth, based on the analysis of international experience, it was determined that there is a great need in the areas of organizing an AI educational environment in general secondary schools of Uzbekistan, developing digital training courses, offering private teaching methods, and retraining teachers.

Fifth, the structural framework developed in the study - cognitive levels of AI literacy and integrative didactic structuring of AI structural components (Figure 1) - constitutes the methodological basis for teaching AI elements in general secondary schools. A

consistent methodological sequence of eight stages serves as a practical roadmap for creating content and methodology for AI elements on a scientific basis within the subject "Informatics and Information Technologies".

In conclusion, it should be noted that teaching elements of artificial intelligence in general secondary schools is not only a matter of imparting new technological knowledge, but also an important factor in preparing students as responsible, critical thinkers and creative participants in the society of the future. It can be confidently stated that the methodological approaches in the results of this study will make a significant contribution to the modernization of school education and raising student literacy to a new level.

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