INTEGRATION OF ARTIFICIAL INTELLIGENCE AND DIGITAL INFORMATION TECHNOLOGIES IN NUCLEAR PHYSICS EDUCATION

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Annotatsiya: *Ushbu maqola zamonaviy axborot texnologiyalarini sun'iy intellekt (SI) bilan integratsiyalash jarayonlari, fizikaning yadro fizikasi bo'limi ta'limi jarayonlarida kompyuter texnologiyalari dasturlaridan foydalanish orqali o'qitishning samarador natijalariga erishish mumkinligi ko'rsatib berilgan. Shuningdek, yadro fizikasi mavzularini texnologik yutuqlar bilan boyitilib, namoyishli tarzda o'qitilishi o'quvchi dunyoqarashini zamonga mos xolda shakllanishiga yordam berishi asoslab berilgan.*

Kalit so'zlar: *sun'iy intellekt (SI), xborot texnologiyalari, raqamli infratuzilma, yadro fizikasi, modellashtirish, yadro jarayonlari.*

Аннотация. *В данной статье рассматриваются процессы интеграции современных информационных технологий с искусственным интеллектом (ИИ), возможности достижения эффективных результатов обучения посредством использования компьютерных программ в образовательном процессе кафедры ядерной физики. Также утверждается, что обогащение тем ядерной физики технологическими достижениями и их наглядное представление помогут сформировать у студента современное мировоззрение.*

Ключевые слова: *искусственный интеллект (ИИ), информационные технологии, цифровая инфраструктура, ядерная физика, моделирование, ядерные процессы.*

Abstract. *This article examines the integration of modern information technology with artificial intelligence (AI) and the potential for achieving effective learning outcomes through the use of computer programs in the educational process at the Department of Nuclear Physics. It also argues that enriching nuclear physics topics with technological advances and their visual presentation will help develop a modern worldview in students.*

Keywords: *artificial intelligence (AI), information technology, digital infrastructure, nuclear physics, modeling, nuclear processes.*

In recent years, the fundamental foundations of nuclear knowledge have been significantly advanced in the fields of atomic nucleus and elementary particle physics, nuclear structure theory, and the fundamental aspects of high-energy physics. In the field of technologies related to nuclear processes, many globally significant achievements have been made, such as Generation III+ reactors, the advancement of the theory of neutrinoless beta decay, neutrino oscillations, and the experimental discovery of the Higgs boson. In order to understand and study the role of these achievements in human life and their impact on progress, it has become essential to study nuclear physics at the level required by modern global standards and contemporary demands.

Worldwide, large-scale research is being conducted to improve the effectiveness of teaching physics, to create modern methodological support oriented toward professional fields on the basis of a competency-based approach through the use of modern information and pedagogical technologies, to ensure the quality of education, and to develop comprehensive and accessible content related to nuclear processes. In particular, the widespread use of websites such as Crocodile.com, Yenka.com, Physics.com, and Physicon.ru, as well as various approaches aimed at increasing the effectiveness of teaching the nuclear physics section, can be cited as evidence of this trend. Although the learning efficiency of this section has been increasing year by year as a result of these studies, it is clearly evident that there remains a need for further development of research in this direction.

The reforms being implemented in the field of education in our country require the training of mature, highly intellectual personnel who meet international standards. This issue is also specifically addressed in Resolution No. PQ-5032 of the President of the Republic of Uzbekistan, “On Measures to Improve the Quality of Education in Physics and Develop Scientific Research.” This, in turn, requires raising teaching to a higher level both in terms of content and methodology.

What, then, is the role of nuclear physics in fulfilling these requirements? To answer this question, it is first necessary to understand the main problems in teaching nuclear physics and the causes of their emergence.

Nuclear physics is one of the most complex subjects taught in higher educational institutions, since its content is closely related to advanced mathematical formalism, abstract physical concepts, and experimental processes. Practice shows that a number of systemic problems exist in teaching this subject, which directly affect the quality of education and the level of students’ knowledge.

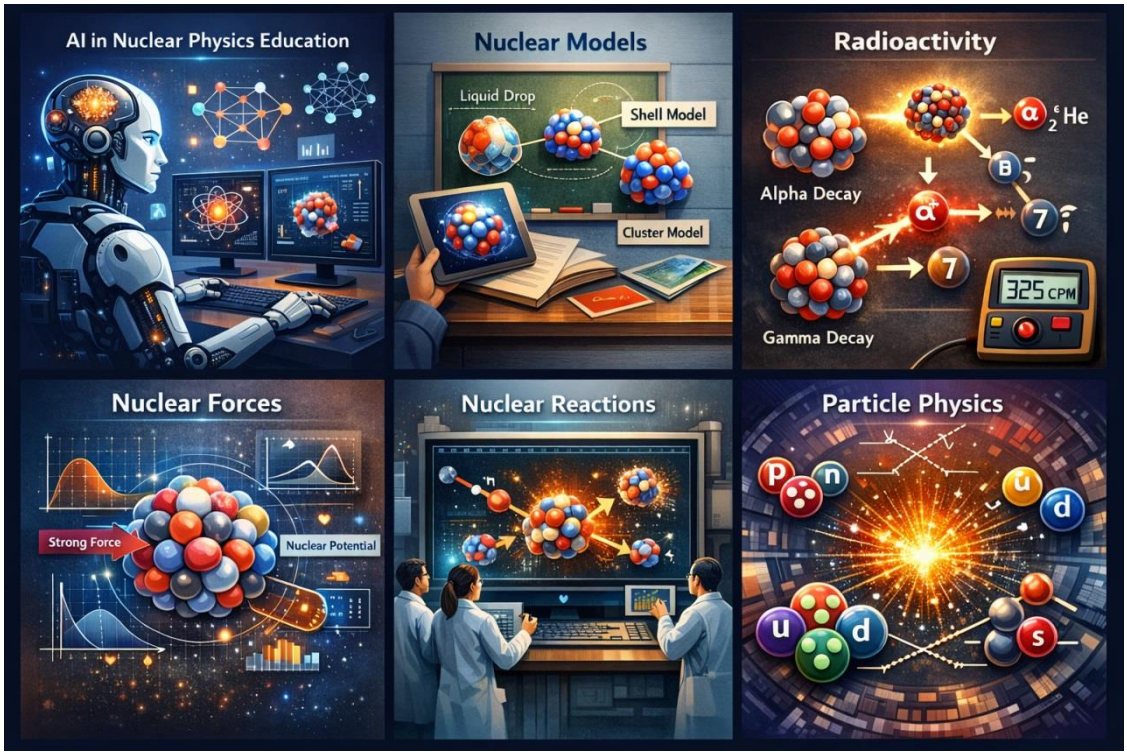
The first problem is related to the abstract nature of nuclear processes and the difficulty of visualizing them. The impossibility of directly observing phenomena occurring at the level of the atomic nucleus makes it difficult for students to form theoretical concepts.

The second problem is the limited opportunity to conduct experiments. Nuclear physics experiments require high-energy sources, special protective equipment, and complex laboratory infrastructure. The absence of such conditions in many educational institutions hinders the adequate coverage of the practical aspects of the discipline.

The third problem is the dominance of traditional teaching methods. Approaches based on lectures and static presentations are not sufficiently effective for deep mastery of complex mathematical models and statistical processes.

The fourth problem is the difficulty of taking into account students’ individual levels of preparation and cognitive differences, which creates the need to deliver knowledge in a differentiated manner.

It should be noted that in the higher educational institutions of our republic, the methodology for teaching the elementary particle physics section of the subject “Atomic Nucleus and Elementary Particle Physics” has been recommended by scholars in a sufficiently modernized form appropriate to contemporary requirements. However, in teaching the nuclear physics section, most studies have been devoted to virtual methods of conducting physical laboratory work, while the traditional nature of teaching methods remains dominant. Moreover, the comprehensive improvement of teaching methodology through modern information technologies in accordance with present-day requirements has not been thoroughly studied, which has necessitated scientific research in this field.



Integration of Artificial Intelligence and Digital Technologies in Nuclear Physics Education

Since nuclear physics topics possess a high degree of abstraction and are considered among the most complex areas of physics, it is important first to identify the difficulties arising in understanding changes occurring in nuclear processes and then determine ways to solve them. Therefore, when selecting the educational content of the subject, it is necessary to ensure that the scientific validity and consistency with fundamental laws of such concepts as physical phenomena, physical quantities, models, ideas, theories, the atomic nucleus, mass defect, binding energy, radioactivity, and ionizing radiation are maintained. In this sense, when presenting the content of nuclear physics, there is a need to develop innovative technologies appropriate to the subject matter that fully cover broad topics such as the atomic nucleus, nuclear transformations, nuclear power engineering, and the effects of ionizing radiation on living organisms. Through this, it becomes possible to improve teaching methodology by forming and developing modern conceptions of nuclear processes in students’ minds.

For this purpose, within the process of nuclear physics education, it is necessary—based on an analysis of the current state of teaching nuclear physics in higher education—to identify the conditions for improving teaching effectiveness through refinement of the content of nuclear physics topics. It is

also necessary to determine the possibilities of applying modern innovative computer technologies used in physics teaching methodology to the teaching of the nuclear physics section, to develop methods for students’ intellectual growth through the cooperation of additional modern technologies and general pedagogical principles, and to create educational-methodological support through innovative didactic tools, electronic textbooks, presentations, учебные manuals, and methodological guidelines. These materials should be directed toward the development of students’ scientific worldview, professional competencies, and creative-cognitive abilities, while demonstrating dynamic and static representations of nuclear processes and ensuring the integration of pedagogical and information technologies. It is also necessary to solve such tasks as forming an adequate attitude toward atomic energy among students through innovative teaching of nuclear physics, including the physical foundations of nuclear power engineering and the socio-economic significance of energy sources.

In achieving these goals, the integration of artificial intelligence and digital information technologies into nuclear physics education is of great importance and opens broad opportunities for the application of ICT and modern educational technologies in teaching nuclear physics.

In particular, the introduction of information and communication technologies (ICT) and modern educational technologies serves as an effective tool in solving the above-mentioned problems. Digital technologies make it possible to organize nuclear physics education in a visual, interactive, and learner-centered form.

First, nuclear processes can be represented in a virtual environment using computer modeling and simulation technologies. Processes such as neutron scattering, radioactive decay, or the energy dependence of nuclear reactions can be clearly demonstrated to students through interactive models.

Second, adaptive learning systems based on artificial intelligence can analyze students’ knowledge levels and form individualized learning trajectories. This approach facilitates the step-by-step mastery of complex mathematical formulas and models.

Third, virtual laboratories and remote experiments make it possible to conduct real nuclear experiments in a safe and economically efficient manner. On such platforms, students can independently modify parameters and observe the results in real time.

Today, the integration of artificial intelligence algorithms into the educational process creates a qualitatively new stage in teaching nuclear physics. By means of machine learning methods, it

becomes possible to assess students’ knowledge, analyze errors, and adapt teaching strategies accordingly.

In addition, based on big data analytics, the effectiveness of the educational process can be evaluated, making it possible to continuously optimize educational content. The development of digital infrastructure for teaching nuclear physics is based on cloud technologies, high-performance computing systems, and distributed educational platforms. This infrastructure ensures:

- the use of open databases in nuclear physics;
- integration with international virtual scientific laboratories;
- close linkage between scientific research and the educational process.

As a result, nuclear physics education is transformed into a comprehensive system that not only provides theoretical knowledge, but also develops scientific research skills in students.

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