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Methodology of Teaching "Atomic and Nuclear Physics Subjects" Using Digital Technologies in Secondary Schools (In the Example of the Subject "Composition of the Atomic Nucleus. Bonding Energy. Mass Defect")

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Abstract: In the process of organizing the traditional process in secondary schools, it is advisable to use digital technologies to increase interest in science. The educational process based on digital technologies is becoming one of the requirements of our time. The organization of physics lessons in general education schools based on digital technologies ensures competitiveness, logical thinking of students, and harmony with new times.

Key words: educational process, digital technologies, quest technologies, training methodology.

1. Introduction

"Education as the main factor ensuring sustainable development" is recognized on a global scale, and in the concept of international education until 2030 adopted by UNESCO," creating opportunities for quality education throughout life" is defined as an urgent task [1]. The practical application of innovative scientific achievements in the educational system is the basis for the creation of effective mechanisms for the training of highly qualified, up-to-date personnel, the adaptation of the assessment of the quality of education to international standards, and the achievement of high results in the modernization of the educational system [2, p.112].

2. Literature review

The reforms carried out in the field of education in our country require the training of mature and high-level thinking personnel in accordance with the world standard. This requires raising the teaching to a higher level, both in terms of content and style.

In pedagogy, play, study and work activities are distinguished as the main types of activities. In order to improve and activate the educational process, to make it more effective, rich, creative and interesting, it is appropriate to use different methods at different stages of lessons. One of the modern methods is inextricably linked with digital technologies.

For the development of society, humanity has joined the general historical process in which modern digital technologies are used. Digital technologies are developing at a very fast pace. Experts are talking more about transferring the school curriculum to an electronic format. When this idea comes to life, not only the educational system will change, but also its content and purpose. The modern formation of school education is fundamentally different from the old one.

With the help of technical and software tools, digital technologies individualize the progress of the educational process, the pedagogical (student and teacher) relationship and ensure the educational independence of students [9]. This, in turn, allows improving the quality of education, full implementation of educational programs by students, organization of lessons based on personal interests and needs of students, and a liberal approach to the process of knowledge assessment.

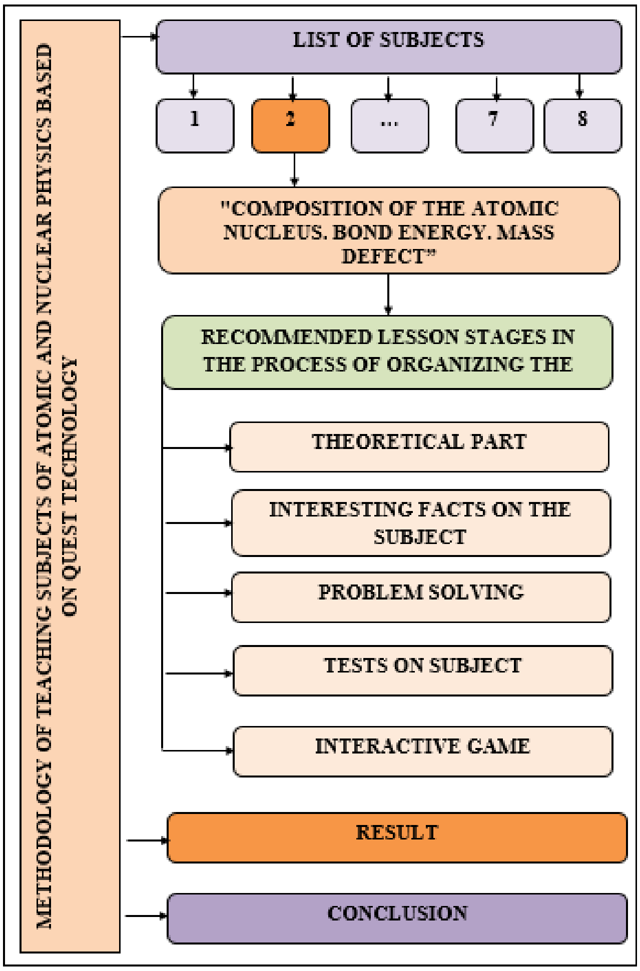
To increase the effectiveness of teaching physics, to create modern methodological support for professional fields based on the competence approach by using modern information and pedagogical technologies and the possibilities of educational technologies in the educational process, to ensure the quality of education and nuclear processes; research work aimed at developing comprehensive and perfect content is being conducted on a large scale.

The main form of organization of education in a modern school is a lesson. Organizing any lesson process in the usual way will not lead to a high result. This is especially reflected in the science of "Physics". It is not always possible to explain all topics of physics to the student with the help of handouts and experiments [9, p. 2961]. Therefore, the use of digital technologies in physics lessons creates an opportunity to get a high result from the lesson.

A modern physics lesson includes technical tools such as "Computer" and "Projector" for a long time in the educational process, but the teacher should not forget that it is not just "Electronic version of Visualization". Taking into account that today students live in the electronic world of various gadgets and digital devices, it is necessary to use such tools [10, p. 2967]. Today, even an electronic magazine consists of photos and SMS messages, and explanations and advice can be obtained through Skype, zoom, various electronic applications and social networks. In this regard, great expectations are placed on digital technologies [2, p. 109].

In the process of using digital technologies in physics lessons, the use of game technology gives good results. Game technologies increase the efficiency of the educational process, reduce the time of studying the educational material, and turn the educational process into a creative and interesting activity. Unlike games in general, a pedagogical game has an important feature - a clearly defined goal of learning and a pedagogical result corresponding to it, which can be justified, defined and characterized by a cognitive orientation of education [4, p. 8].

Analysis

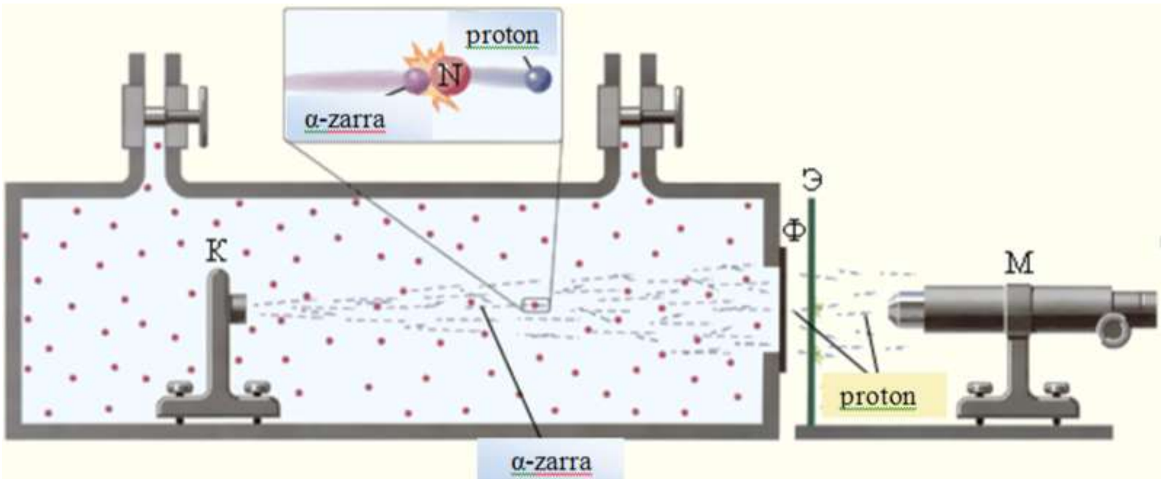


Picture 1. Methodology of teaching atomic and nuclear physics topics based on quest technology

Delivering the subjects of the "Atomic and nuclear physics" department of physics to students creates a number of difficulties. There are almost no visual aids related to the topics of this department in educational institutions. Taking this into account, the use of innovative (digital) technologies by general secondary school teachers in the process of explaining the topic leads to the expected result.
As an example, we will consider the organization of the topic "The composition of the atomic nucleus. Binding energy. Mass defect" of the "Atomic and nuclear physics" department of physics based on digital technologies. It is recommended to use Dreamweaver and FrontPage platforms and HTML, Java Script and CSS programming languages in the process of covering this topic.
"Dreamweaver" and "FrontPage" platforms were used to create the program structure, while "HTML, Java Script" programming languages were used in the process of creating interactive assignments and tests. In addition, Gif-animations were used in the process of covering the topic, and "Flash and Pencil 2D" programs were used to create them [5, p.68].
In the program, a lot of information is included and voiced not only from textbooks intended for general secondary schools, but also from external sources. The organization of the topic "The composition of the atomic nucleus. Binding energy. Mass defect" based on digital technologies can be organized on the basis of the following structure (Pic. 1).
From Rutherford's experiments, it was determined that the nucleus is a positively charged particle that embodies the main mass of an atom. The question arose as to what kind of particles the Positive Nucleus is composed of; in 1919, Rutherford discovered the proton, the next elementary particle after the electron (Pic. 2). The mass of a proton is 1836.1 times greater than the mass of an electron, i.e

$$m_p=1836m_e \quad (1)$$

and a stable elementary particle with a positive charge, whose electric charge is equal to the electron charge, and whose spin is equal to that of $s = 1/2$.



Picture 2. Experimental scheme for the discovery of protons in nuclear fission. K - lead container with a radioactive source, F - metal foil, E - screen covered with soul sulfide, M - microscope.

3. Discussion

In 1920, Rutherford predicted the existence of a neutral particle whose mass is equal to the mass of a proton, and it was discovered in 1932 by the English physicist D. Chadwick.

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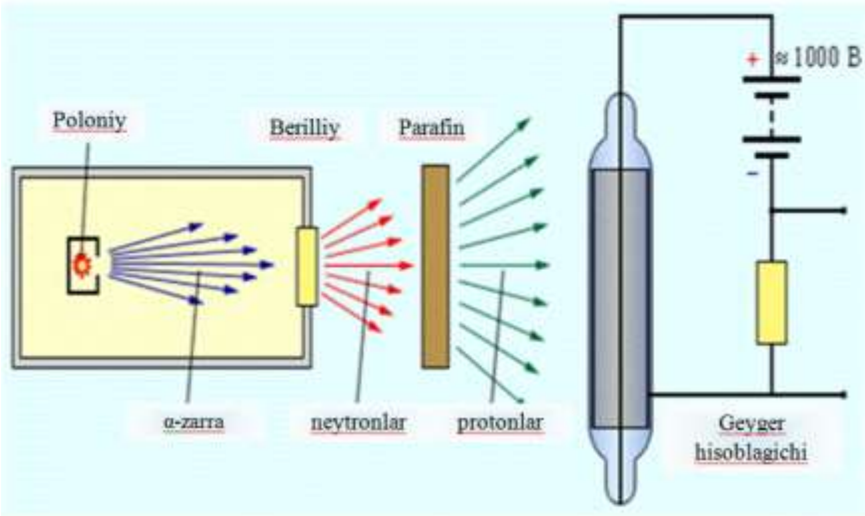


Picture 3. Neutron detector

This particle was called a neutron. In 1932, the Russian scientist D.D.Ivanenko and later the German scientist V.K.Heisenberg put forward the idea that the nucleus consists of a positively charged particle called a proton and an uncharged particle called a neutron. This model of the nucleus is called the proton-neutron model.



D.D.Ivanenko (1904-1994) V.K.Geyzenberg (1901-1976) J. Chedvik (1891-1974)

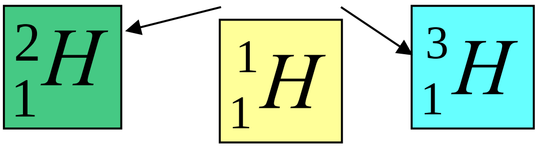
Proton (p)–the nucleus of the hydrogen atom, discovered in 1919 by Rutherford and his colleagues. has a positive charge equal to the charge of an electron [6, p.162].
Neutron (n) – in 1932 was discovered by the English physicist J. Chadwick . An electrically neutral particle. D. Chadwick was awarded the Nobel Prize in 1935 for the discovery of the neutron. Later, the atomic nucleus was made up of protons and neutrons, which were collectively called nucleons.
The number of nucleons in the nucleus A is the mass number of the nucleus, and the number of neutrons are found from

$$N = A - Z \qquad (2)$$

where Z is the number of protons.

The nucleus is defined in the same way as a neutral atom. To designate the kernel - $_ZX^A$ designation is used. Here:
X-chemical element symbol
Z- atomic number (the number of protons in the nucleus)
A-mass number (the number of nucleons in the nucleus)

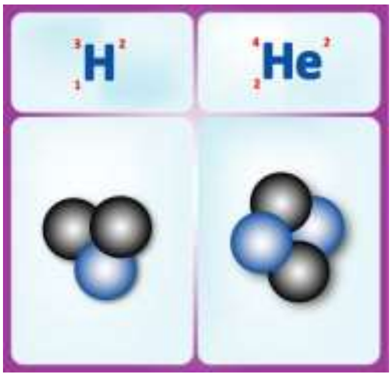
A group of nuclei in which the number of protons in the nucleus does not change is called isotopes (Pic. 4). For example, there are three isotopes of hydrogen, which are:



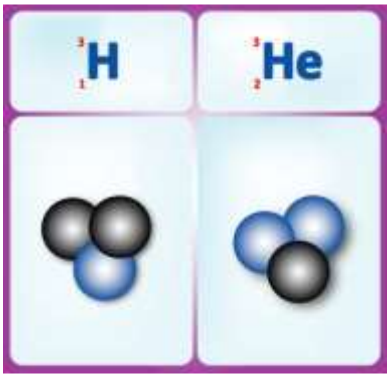
Picture 4. Hydrogen isotopes: ${}_1H_0^1\,(protiy),\ {}_1H_1^2\,(deyteriy),\ {}_1H_1^3\,(tritiy).$

Isotopes can be divided into 2 types:
1. Natural isotopes
2. Artificial isotopes

A group of nuclei in which the number of neutrons in the nucleus does not change is called **isotons**. For example: ${}_1H^3$, ${}_2He^4$ (Pic. 5)
A group of nuclei whose mass number remains unchanged is called **isobars**.
For example: ${}_1H^3$, ${}_2He^3$ (Pic. 6)



Picture 5. **Isotones**



Pictura 6. **Isobars**

The results of the most accurate measurements of the masses of the nucleus show that the rest mass M of the nucleus is always smaller than the sum of the rest masses of the protons and neutrons that make up it:

$$M < Zm_p + Nm_n = Zm_p + (A - Z)m_n \quad (3)$$

The energy required to completely split a nucleus into individual nucleons is called the **binding energy of a nucleus**.
The binding energy of a nucleus is found from the following expression:

$$\Delta W = \Delta Mc^2 \quad (4)$$

where Δ**m** is called **the mass defect** and this will found from

$$\Delta M = Zm_p + Nm_n - M = Zm_p + (A - Z)m_n - M \quad (5)$$

We can see the binding energy of some chemical elements from the following table (table 1):

Table 1

A particle or chemical element	Mass (u)	Energy (MeV)	Chemical element	Mass (u)	Energy (MeV)
Electronic(${}_{-1}^{0}e$)	0,0005486	0,51102	Lithium (${}_3^6Li$)	6,941	6465,542
Proton (${}_1^1p$)	1,0072765	938,28	Carbon (${}_6^{12}C$)	12,0	11178

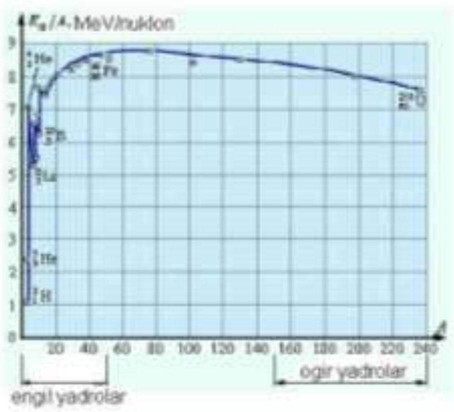
Neutron ($^{1}_{0}n$)	1,008665	939,57	Carbon ($^{13}_{6}C$)	13,003354	12112,624
Hydrogen ($^{1}_{1}H$)	1,007825	938,79	Uranus ($^{235}_{92}U$)	235,04418	218943,654
Deuterium ($^{2}_{1}H$)	2,014102	1876,136	Uranus ($^{238}_{92}U$)	238,05113	221744,6276
Tritium ($^{3}_{1}H$)	3,016062	2809, 462	Neptune ($^{239}_{93}Np$)	239,05320	222678,0558
Helium ($^{4}_{2}He$)	4,002603	3728,425	Plutonium ($^{239}_{94}Pu$)	239,05242	222677,3292

$$\Delta W = \left[Zm_p + (A - Z)m_n - M \right] c^2 \qquad (6)$$

The binding energy of a nucleus corresponding to one nucleon is called the **relative binding energy of a nucleus** (ε).

$$\varepsilon = \frac{\Delta W}{\mathrm{A}} \qquad (7)$$

The larger the value of ε, the more energy is required to separate the nucleon from the nucleus. This in turn means that the core is stronger. The values of ε for different kernels are shown in Pic. 7 described.

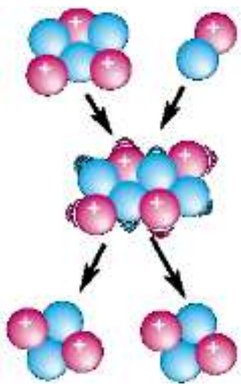


Picture 7. Relative binding energy for different nuclei

The mass number A of the nuclei is along the abscissa axis, and the energy values are placed on the ordinate axis. As can be seen from the figure, the value of ε reaches a maximum (~8,8MeV) at A =50÷60. The smallest value is observed in the case of $_1H^2$ (~1MeV). When two nuclei or nuclei and elementary particles come close to each other at a distance of 10^{-15} m, they intensively interact with each other due to nuclear forces, and the process of changing the composition of nuclei is called **nuclear reactions**.
General nuclear reactions,

$$A + a \rightarrow B + в \quad (8)$$

can be written as For example, the scheme of the reaction of lithium-6 with deuterium (Pic. 8)



Picture 8. Reaction of lithium-6 with deuterium

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During nuclear reactions:
1. Law of conservation of electric charge;
2. The law of conservation of the number of nucleons;
3. Law of conservation of energy;
4. The law of conservation of momentum is fulfilled.

One of the neutrons released during nuclear fission can in turn disintegrate the neighboring nucleus, and this nucleus can also emit neutrons that can disintegrate the neighboring nucleus [7, p.302]. As a result, the number of fission nuclei increases dramatically, and a self-perpetuating reaction occurs. This reaction is called a **chain nuclear reaction**.
Derivation of formulas related to the topic, their interpretation will be explained in the course of the lesson.
Physics science by students "The composition of the atomic nucleus. Binding energy. After the theoretical part of the topic "Mass defect" has been fully mastered, the application of interesting facts on the topic to the lesson process will increase students' interest in science (Pic. 9). This process can be implemented because of digital technologies.
It is advisable to give students 10-15 interesting facts on each topic.
After the lesson is enriched with interesting facts, students can be given the opportunity to test their knowledge through test tasks. In this case, the student can use the set of tests included in the program. The program includes 10 tests on the topic, and for each correctly selected answer, the student is assigned a certain number of points. After the test process is completed, the student can see on the screen how many points he managed to collect and which test questions he allowed to be even. This forces the student to work more on himself.

FUN FACTS (2 QUESTS).
COMPOSITION OF THE ATOMIC NUCLEUS. BOND ENERGY. MASS DEFECT

1. The number of atoms in the human body.

A human body weighing 70 kg consists of 7 × 10 27 atoms. Three atoms (hydrogen, oxygen, and carbon) make up 99 percent of the total atom. The most interesting thing is that 98% of these atoms are unknowingly renewed every year. The most rapidly changing molecule is water: almost 50% of water molecules in the body are replaced every 8 days.

Picture 9. The composition of the atomic nucleus. Binding energy. Mass defect

After completing the stages of the lesson offered to the student, the student is invited to participate in an interactive game within the topic. In this process, the student will strengthen his knowledge of a new subject and increase his interest in physics.
For example, the following interactive game "Crest-zero" can be offered on the topic of "The composition of the atomic nucleus. Binding energy. Mass defect".
Rules of the interactive game "Crest-zero":
1. Students are divided into two groups.
2. Each team chooses a question to answer depending on the level of difficulty: 1 line - level I; 2nd line - II level; 3 lines - level III.
3. When answering correctly, a group mark or is placed on the form.
4. If the question is not answered, another team will answer it.
5. If the group could not answer the question, in the letterhead of this group "?" will be marked.
6. The group that answered the most questions became the winner of the game.

Picture 10. Interactive game "Crest-zero".

4. Conclusion

The organization of the "The composition of the atomic nucleus. Binding energy. Mass defect" topic, given above as an example, because of digital technologies can be introduced not only in the course of the lesson, but also independently and remotely.
Innovative as the main didactic tool of "Atomic and Nuclear Physics" by giving priority to foreign and digital technologies (TechSmith Camtasia, MX Media Flash, ActivePresenter, EasyQuizzy, AutoPlay MediaStudio, Java script) that allow modeling of technologies and nuclear processes, creating new didactic resources and combining the achievements of modern science, atomic and nuclear physics it is possible to improve the teaching methodology. In addition, the use of digital technologies in secondary general education schools ensures that students keep up with the times. It individualizes the progress of the educational process, the interaction between

the student and the teacher with the help of technical and software tools and ensures the independence of the student.

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