

CREATIVE LESSON ON THE GENERAL COURSE OF PHYSICS ON THE TOPIC  
"ZEEMAN EFFECT"

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**Annotation.** This article provides the content of the creative lesson of the atomic physics section of the general physics course on the topic "Zeeman effect" for students of higher educational institutions.

**Key words:** creativity, creative lesson, Zeeman effect, normal Zeeman effect, anomalous Zeeman effect, J. Gilford, E.P. Torrance, Larmor frequency, educational institutions.

In order to improve the methodology for teaching the topic "Zeeman effect" of the general course of physics in higher educational institutions of the Republic of Uzbekistan, the first task is to organize a creative lesson on this topic. Thanks to such a lesson, students of higher educational institutions can develop their creative thinking and abilities on this topic. What is meant by creative thinking and student abilities? The development of creative thinking and abilities is the guiding principle of learner-centered learning. In this case, the student is an active subject of his self-expression within the framework of professional interests and needs through independent learning activities in the context of specific personal-creative technologies of developing education.

The term "creativity" first appeared in the late 50s in Western psychology and meant the ability of a person to create new concepts and develop new skills. The concept of creativity, universal creativity as a cognitive ability became popular after the publication of the work of J. Gilford. Therefore, creativity, that is, creative thinking and abilities, is rather a collection of different thinking and abilities that a person can acquire at different levels. In a broad sense, creativity is a non-trivial and skillful solution to a problem. Creative abilities of students is a psychological and pedagogical phenomenon. The concept of creativity as a universal cognitive creativity gained popularity after the publication of the works of J. Gilford.

E.P. Torrance continued Guildford's research and developed his own program for the development of students' creative abilities. It included several stages. At the first stage, he developed convergent thinking according to Gilford, and at the second stage, divergent thinking.

E.P. Torrance understands creativity as a person's ability to perceive shortcomings, gaps in knowledge, disharmony, etc. In his opinion, the creative act is divided into the perception of the problem, the search for a solution, the emergence and formulation of hypotheses, their verification, modification and finding the result.

Based on this, he gives the following description of the main criteria of creativity: ease - the speed of performing test tasks, i.e. test norms are similar to the norms of the speed intelligence test; flexibility - the number of switches from one class of objects to another in the course of responses; originality - the minimum frequency of a given answer to a homogeneous group. Accuracy in Torrance tests is evaluated by analogy with intelligence tests.

This lesson can be carried out in the form of a fairy tale, because any fairy tale is unusual for schoolchildren and children of school age, and they, and even adults, always perceive it with great interest. They sympathize with the heroes of fairy tales. Most importantly, they repeat the learning material on the topic. It develops their creative thinking and imagination.

**Block 1.** Professor-teacher: «Dear students! Today's lesson will be in the form of a fairy tale. I know that we all love stories told or read by our grandparents or parents. This is how we remember our youth. So I will tell you a story. Listen carefully. In the process of listening to a fairy tale, some problems arise in front of its heroes. In solving these problems you will help the heroes of the fairy tale, answer the questions that arise before them. To do this, you need to know the quantum theory of light and the Zeeman effect. Prepare drawing books, you will need them to solve the problems of fairy-tale characters. If not, then we've started. Thus, there lived a king of a certain country. His daughter, the princess, who has no equal in beauty, intelligence and hard work, also lived with the king. It is interesting to note that the princess was well versed in physics, especially atomic physics and quantum atomic physics and the related Zeeman effect. She did some physical experiments in her room and worked on problems related to physics, especially quantum atomic physics. One day the princess was carried away by a black raven. Then the king addressed the people of his country: «Whoever saves my daughter, to him I will give my daughter and half of my wealth». Among the people there was a daredevil to save the princess. His name was Abdulvali, and he was the son of a peasant. The king told him that whoever knows physics, especially quantum atomic physics, should go to save the princess. Abdulvali told him: «Let your heart be satisfied, my king, I know physics, especially quantum atomic physics». After that, the king sent him to search for the princess.

Abdulvali went where his head led. He walked, walked a lot, and, finally, on the way he met a hut. An old woman met him at the hut. The old woman asked him in which direction he was going. Abdulvali told her everything. The old woman asked Abdulvali the question that the king asked. And Abdulvali repeated his answer, which answered the king's question. After that, the old woman gave him a ball and said: «If you answer one of my questions, this magic ball will take you to the right place». Abdulvali told her: «Ask your question». The old woman asked him the following question: «What do you know about the Zeeman effect?» Abdulvali immediately correctly answered this question. The professor turned to the students: «What do you think, dear students, what did Abdulvali say to the old woman?» The teacher examines the answers of the students and chooses the correct one from them. Encourages the student who gives this answer. Students who give close to correct answers are also rewarded.

After that, the professor-teacher continued the tale: «The ball rolled. Abdulvali ran after him. The ball rolled and carried Abdulvali to the trees. Abdulvali saw that green ribbons were hanging on them instead of green leaves. Abdulvali was about to pass, when he suddenly heard a voice: «Help us, O Abdulvali!» Hang the ribbons correctly on two trees: on the first tree - let there be a ribbon with the answer to the question «What is the normal Zeeman effect?», and on the second let there be a tape with the answer to the question «What theory explains the normal Zeeman effect?». Abdulvali set to work. After completing the task, green leafy trees appeared in front of him and began to make noise. Then the next voice appeared again: «Thank you for resurrecting us!» The professor-teacher again turned to the students: «Well, which of you students can complete this task?» At will, two students are called to the board. One of them answers the question written on the first ribbon of the tree. The second answers the question written on the second ribbon of the tree. The professor motivates these students based on their answers.

**Block 2.** The professor-teacher continued the tale: «The ball rolled again. And Abdulvali followed him. The ball went and stopped in front of an old man who was sitting on a stool. Abdulvali was about to pass in front of him, the old man stopped him and asked: «My son, do not

hurry. I know where you're going. You must answer my three questions in order to continue on your path. If you don't answer, you won't make it to your final destination». Abdulvali said to the old man: «Ask» and listened to his three questions: 1) explain the content of the normal Zeeman effect; 2) write down the Larmor frequency formula and explain the quantities included in it; 3) what theory explains the anomalous Zeeman effect?. Abdulvali answered all three questions correctly. Here the professor-teacher again addresses the students: «What do you say, how would you answer these questions?». At will, three students are called to the board. One of them answers the first question. The second student answers the second question and the third student answers the 3rd question. Thereafter, the professor-teacher evaluates these students based on their responses. After that, the professor-teacher continued the tale: «The ball rolled so fast that Abdulvali ran after it and barely caught it. The ball suddenly stopped in front of a swamp that appeared on the road. There was no way through this quagmire».

Abdulvali's head froze, and he sat down on a stone in front of the swamp. At that moment, it was as if someone called him. He looked up and saw a small bird perched on a tree branch opposite. «Pick up the stone you are sitting on. Below it is the letter you need. It contains several tasks related to the Zeeman effect. If you find their answer, an invisible path through the swamp will open for you, otherwise you will not be able to pass through the swamp and you will not be able to find the princess» said the bird. Abdulvali pushed the stone and saw that there really was a letter with a written task under it. He began to read these tasks: 1) if an atom of some element is introduced into an external magnetic field, then.....; 2) the Zeeman phenomenon was observed for the first time.....; 3) phenomenon explained on the basis of electron theory is.....; 4) write down an expression associated with the theory that Lorentz used to explain the Zeeman phenomenon; 5) a student determined a magnitude twice as large as the normal shift while solving problems related to the Zeeman effect in a practical exercise in atomic physics. What did the student identify?

As soon as Abdulvali completed these tasks correctly, he saw a path through the swamp. In this way he quickly crossed the swamp. Again, the professor-teacher addresses the students: «How do you think you would complete these tasks?» Students are called to the board at will. They tell the answers to these tasks. The professor-teacher then evaluates these students based on their responses.

**Block 3.** Several photos related to the topic of the lesson are shown to slightly distract students from the topic and relax them. These pictures depicting scientists who carried out scientific research in the field of quantum atomic physics (N. Bohr, M. Planck, P. Zeeman, Paschen, Back and others) will be needed. In this, too, the professor-teacher evaluates active students.

**Block 4.** The professor-teacher continued the story: «The ball rolled along the road, which ended up in a swamp. Abdulvali hurriedly followed him. The ball suddenly stopped. Abdulvali took a closer look and saw that there was a deep ditch in front of him. This ditch cannot be bypassed, it is impossible to jump off it. Abdulvali thought, not knowing what to do. His gaze fell on a large stone lying at the far end of the ditch. The following words were written on the stone: «If you find physical errors in the audio text that will now be given, a bridge will appear over the ditch and you will cross it, otherwise you will not be able to cross the ditch and reach your goal». Again the professor-teacher addresses the students : «Attention, students! Now we are listening to an audio text. Listen to it and find physical errors in the text».



After that, the professor-teacher played the audio text previously recorded on the computer. Voice text turned on and off. This allows students to listen to the text again and makes it easier to find physical errors in the text. The content of the text is as follows: «Two friends met, Murod and Bahodir, who had not seen each other for a long time. After the greeting, Bahodir boasted to Murod that «I know physics, its branch of atomic physics, quantum atomic physics, especially the Zeeman effect». Murod did not come empty-handed: «I also know atomic physics, quantum atomic physics and the Zeeman effect well». After that, they began to show their knowledge. Bahodir said: «When an atom of a substance is introduced into an electromagnetic field, the Zeeman effect occurs». Dilshod answered him: «When an atom of a substance is introduced into a magnetic field, the Zeeman effect occurs». Bahodir asked again: «Do you know that the Zeeman effect can be directly observed with the eyes?».

Dilshod answered him: «Of course, you can observe with the naked eye, because everything can be seen with a telescope, but did you know that the Zeeman effect occurs in an arbitrary magnetic field?». Bahodir replied: «Don't you know that everyone knows this». «Did you hear Murod that the hydrogen atom was used in an experiment to study the Zeeman effect?». Dilshod smiled saying, «Of course I heard. I even know the properties of the hydrogen atom. It will have a certain volume, but will not have a specific crystal lattice. Bahodir said: «Oh, stop, it seems to me that you got everything mixed up». «I didn't mix anything up, I know the Zeeman effect and the experience of detecting this effect like two and two are four». Bahodir told him: «Okay, then answer my other question: “Does the Larmor frequency change during the anomalous Zeeman effect?” Think first». «What should I think? I say without hesitation that the frequency will not change». It is worth noting that when the audio text is played, it is necessary for students to write down the questions and answers given in it in their notebooks, since these questions and answers may be lost from their memory. Again, the professor-teacher addresses the students: «What do you say, how would you answer these questions?». Students are called to the board at will. They will answer these questions. The professor-teacher then evaluates these students based on their responses.

**Block 5.** The tale continued: «Abdulvali clearly pointed out all the errors in the text. After that, a bridge appeared across the stream, and Abdulvali crossed it and continued on his way, walking for a long time. Finally he reached the castle where the princess was hiding. He saw with his own eyes that all the surroundings of the castle were empty, and the walls were built so high that they were impenetrable. He tried to bring down the walls, but their strength did not allow. Abdulvali was delighted to see a small door in these walls. But his joy did not last long, because there was a large padlock on the closed door. He again fell into depression, but this process did not last long. Suddenly a voice was heard: «Don't be so sad. If you answer the following questions correctly, the door will open by itself and you will achieve your goal, otherwise you will not see the princess again: 1) was there any reward for the Zeeman effect?; 2) where is the Zeeman effect used?; 3) what theory explains the anomalous Zeeman effect?; 4) why was the emission spectrum of sodium vapor used in the Zeeman experiment?». Here again, the professor-teacher addresses the students: «What do you say, how would you answer these questions?». Students are called to the board at will. They will answer these questions. The professor-teacher then evaluates these students based on their responses.

**Block 6.** The appearance of this block for the Zeeman effect theme can be as follows.

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### VOLUME-4, ISSUE-6

The professor-teacher continued the tale: «With the last words of Abdulvali, the lock on the castle door opened and fell to the ground, and the door opened. The princess was standing in front of him. She said: «Good Abdulvali!». You overcame all the difficulties and trials that preceded you and arrived here. But I can't go with you because my spell hasn't been broken yet. In order for it to be removed, you must correctly answer the following questions, otherwise my spell will not be solved and I will not be able to go with you: 1) why is it called the anomalous Zeeman effect?; 2) why is it called the normal Zeeman effect?; 3) what rotating particle is used to explain the normal Zeeman effect? For what?; 4) What type of energy operator is necessary to calculate the atomic energy introduced into an external magnetic field? Abdulvali fulfilled this task. The evil spell has been broken. The abandoned castle is gone. Abdulvali and the princess appeared in the king's palace. He was very happy to see his daughter. He gave Abdulvali the promised half of the wealth and a daughter. Here the tale ends. «Blessed is he who listened to him and repeated quantum atomic physics and the Zeeman effect». Here again, the professor-teacher addresses the students: «What do you say, how would you answer these questions?». Students are called to the board at will. They will answer these questions. The teacher-professor then evaluates these students based on their responses.

**Block 7.** The appearance of this block on the topic «Zeeman effect» could be as follows: the professor-teacher shows students through the computer animation and experiments related to the topic «Zeeman effect». He asks them to explain.

**Block 8.** This block provides feedback to the students in the lesson and gives a qualitative and emotional assessment of the lesson itself to the students. The appearance of this block for the Zeeman effect theme can be as follows.

**Creation of syncwine on the theme «Zeeman effect».** Syncwine is a unique non-rhyming poem, consisting of five lines, which contains information about the concept (event, event, topic) being studied, expressed in the words of the reader in different versions and from different points of view. Syncwine is an important skill for expressing complex ideas, intuitions and feelings in just a few words. The process of creating a syncwine helps to better understand the topic. The rule for compiling a syncwine: 1) In the first line, the subject (task) is depicted in one word (usually with a noun); 2) The second line consists of two words, and these words must consist of adjectives. Words should reveal the main theme. 3) In the third line, the actions within the subject are expressed in three words. 4) In the fourth line, an opinion (intuition) is written, consisting of four words, which means attitude to the subject. 5) In the last line, write one word that repeats the essence of the topic and is close to it in meaning.

The syncwine for the Zeeman effect theme looks like this:

Zeeman effect			
normal Zeeman effect		anomalous Zeeman effect	
splits		invented	explained
effekt	radiation spectrum	sodium vapors spectral line	Nobel prize

Students who have compiled a syncwine are called to the board at their own request. They will read and explain their syncwines. The teacher-professor then evaluates these students based on their responses. At the end of the lesson, the professor-teacher summarizes and announces the final grades of the encouraged students.

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