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HOW E-LEARNING DEMONSTRATES THE FORMATION OF STUDENTS' COGNITIVE ACTIVITY IN THE TEACHING OF QUANTUM PHYSICS

Abstract. The aim of this article is to prove the advisability of using the e-learning of quantum physics in the Moodle environment to help students achieve better success in this difficult subject area. The possibilities of Moodle in a distance learning environment have been analysed. E-learning tool of quantum physics in the Moodle environment has been described, and its educational opportunities have been determined. The need for material models and thought models for teaching of quantum physics has been proven. Modeling method and thought experiments explain phenomena of physics help to better understand real experiments and the essence of physics theories. The method of creation of computer models using Easy Gif Animator has been discussed. The requirements for material models have been identified, and an example of material model of Large Hadron Collider has been demonstrated. Results showed that e-learning of quantum physics increases the level of students' cognitive activity. This technique can be used for teaching other sections of physics and other natural sciences.

Keywords: cognitive activity of students; e-learning; Moodle environment; learning models; quantum physics.

1. INTRODUCTION

The use of information technologies has become affordable and convenient in current education [1] – [3]. Yildiz and Selim [4] have analyzed the advantages and disadvantages of distance learning compared with traditional forms of education. Kotluk and Kocakaya [5] have considered the using of digital storytelling in physics instruction as a distance education tool. Teoh, Lin, and Belaja [6] have studied language learning courses and made recommendations for designers and instructors of those courses for distance delivery. These recommendations can be applied to develop e-learning in other subjects as well.

Rajesh [7] has focused on new technologies such as WebCT/Blackboard, Moodle, Ning, Wiki, A-View, Wiz-IQ, which are relevant to the field of education, and distance education in particular. Şahin and Uluyol [8] have identified many types of personal learning environments: homepages, encyclopedias, search engines, networks, documents, email, graphics, blogs, microblogs, chats, presentations, calendars, videos. Researchers have also analyzed the advantages of personal learning environments, such as open access, multithreading, convenience and usability, individualization, usefulness, sociability, prevalence and their limitations, such as phishing, advertisements, cyber bullying. The effectiveness of any educational technology is directly dependent on its application to teaching. According to Sarmadi, Farajollahi, Saeidipour, and Ahmadifar: “Teachers should create a learning environment in which students with different thinking styles can capitalize on their strengths and compensate for their weaknesses of thinking and learning” [9, p. 105]. In accordance with this approach, we explore the possibilities for learning of quantum physics offered in the Moodle environment.

Moodle (Modular Object-Oriented Dynamic Learning Environment) allows learners to study at a distance. In Moodle there are several user roles that have different degrees of access to the system: administrator, lecturer, and student. All users are able to set their time zone and to choose their language. This platform provides students with access to numerous

educational opportunities. Lecturers can monitor the learners' work during class, send new messages to students, distribute resources and information, collect assignments and grade students' works. Learners can communicate with each other in discussion forums and chats. Forums provide places for discussion of issues and for consultation. Posts to the forum can be distributed automatically via e-mail to students.

Physics is a natural science, which uses sophisticated mathematical apparatus. Many students are not able to understand most physics concepts, laws and theories without engaging in full-time study. We came to this conclusion while teaching quantum physics at the University. Therefore, we consider the e-learning only as a subsidiary form to full-time study.

The teaching of physics is more difficult if students are not engaged cognitively. The results of a pre-test showed that learners' cognitive needs are determined by their internal motivations. Learners will not be able to understand the educational material if they are not motivated to study it. The purposeful work of lecturers is required to assist in the formation of students' cognitive activity [10] – [12]. The aim of our research reported here is to prove the advisability of using the e-learning of quantum physics in the Moodle environment to help students achieve better success in this difficult subject area.

2. METHOD

2.1. Learning models in the teaching of quantum physics

Students' knowledge of physics would be incomplete without the study of quantum physics. Learners learn the properties and laws of the microworld in this section of physics. Many of these ideas are contrary to the ideas of classical physics (e.g., magnification of body's mass, if body moves with the speed which is compared with the speed of light). Learners must have a high level of abstract thinking for the assimilation of quantum physics. Thereby, learning models should be used in the teaching of quantum physics.

Scientific model replaces the object during the process of learning and gives the information about the object. The model is used when the direct study of the object presents considerable difficulty or is impossible. Many years ago, Shtoff [13] formulated the requirements for creation of scientific models:

- 1) visibility;
- 2) elements of abstraction;
- 3) elements of science fiction;
- 4) using of analogies;
- 5) elements of hypothesis.

Scientific models are used in physics. In 1687, the English scientist Isaac Newton (1642-1726) gave a theoretical justification of modeling method in *Mathematical Principles of Natural Philosophy* (Book II, Section VII). Studying of quantum physics is impossible without using scientific models. Kalapusha [14, p. 103] argued that scientific models are the result of the creative imagination of scientists, and this provision applies to learning models. In this way, we can assume that the use of learning models will also develop the thinking of students during the teaching of quantum physics. We analyzed the works of scientists [15], [16] and identified the two types of learning models, which can be used in physics teaching (Figure 1).

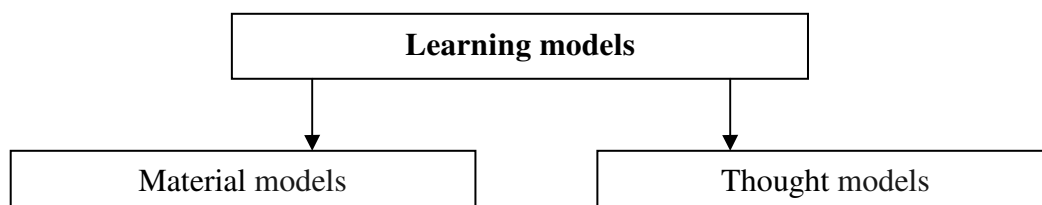


Figure 1. Types of learning models

Material models include material elements which interact appropriately. We identified the following requirements for material models:

- 1) accordance to safety rules;
- 2) simple equipment;
- 3) curiosity;
- 4) coordinated with the curriculum;
- 5) dynamism (ability to demonstrate the phenomenon in motion).

“A thought experiment is a device with which one performs an intentional, structured process of intellectual deliberation in order to speculate, within a specifiable problem domain, about potential consequents (or antecedents) for a designated antecedent (or consequent)” [17, p. 150]. Thought experiment is a method of scientific knowledge of physics as a science. Scientists discovered a number of physics laws using thought experiments. For example, the thought experiments of Italian scientist Galileo Galilei (1564-1642) led to the discovery of the law of Inertia. This law is a fundamental law of classical physics. Visual models facilitate the formation of students' abstract thinking [18]. Computer models enable students to better understand various physics phenomena and they are “a positive supplement to bridge the gap between education and the technological world in which we live” [19, p. 191]. Visual and computer models are the thought models. In this way, thought models help to develop the skills of learners to conduct the thought experiments.

“Although modeling is a central component of modern science, scientific models at best are approximations of the objects and systems that they represent – they are not exact replicas. Thus, scientists constantly are working to improve and refine models” [20]. It is necessary to abstract from non-essential features of the phenomenon during the modeling process. Only the basic signs of phenomenon are displayed. It is difficult to explain any physics phenomenon using only one learning model. Therefore, the issue regarding the creation of new learning models is topical.

2.2. The Quantum Physics course in the Moodle environment

The Quantum Physics course in a Moodle environment is mounted on the website of Ternopil Volodymyr Hnatyuk National Pedagogical University (<http://elr.tnpu.edu.ua>). All registered students have access to the course. The course includes curriculum, teaching materials, reference materials, tests, chat and forum. The requirements for design of the course include an appropriate background and color; and the absence of any excess information which will distract students.

E-learning permits students to engage in the following actions:

- 1) receive messages from the lecturer (block “message”);
- 2) view the course curriculum (block “curriculum”);
- 3) view the learning materials (block “lectures”);
- 4) develop abilities and skills (block “practical exercises”);
- 5) study additional resources and material (block “reference material”);
- 6) control knowledge, abilities and skills (block “control”).

2.2.1. Block “lectures”

Each lecture includes (Figure 2):

- 1) relevant content of the lecture (e.g., Lecture 1);
- 2) animations (e.g., Absolutely black body);
- 3) demonstrations (e.g., Video 1 Rays of cold).

Students can download the required lecture file. Information about the founders of quantum physics is included in lectures [21]. The problem method of teaching is used to

present lectures. For example, the study on the topic “thermonuclear reactions” begins with the formulation of the problem. The Sun is the energy source on Earth. This energy reaches our planet during radiation. The mass of the Sun is reduced about by 4.2×10^9 kg during 1 s. But the next day, the Sun continues to shine. Why is the mass of the Sun not reduced?

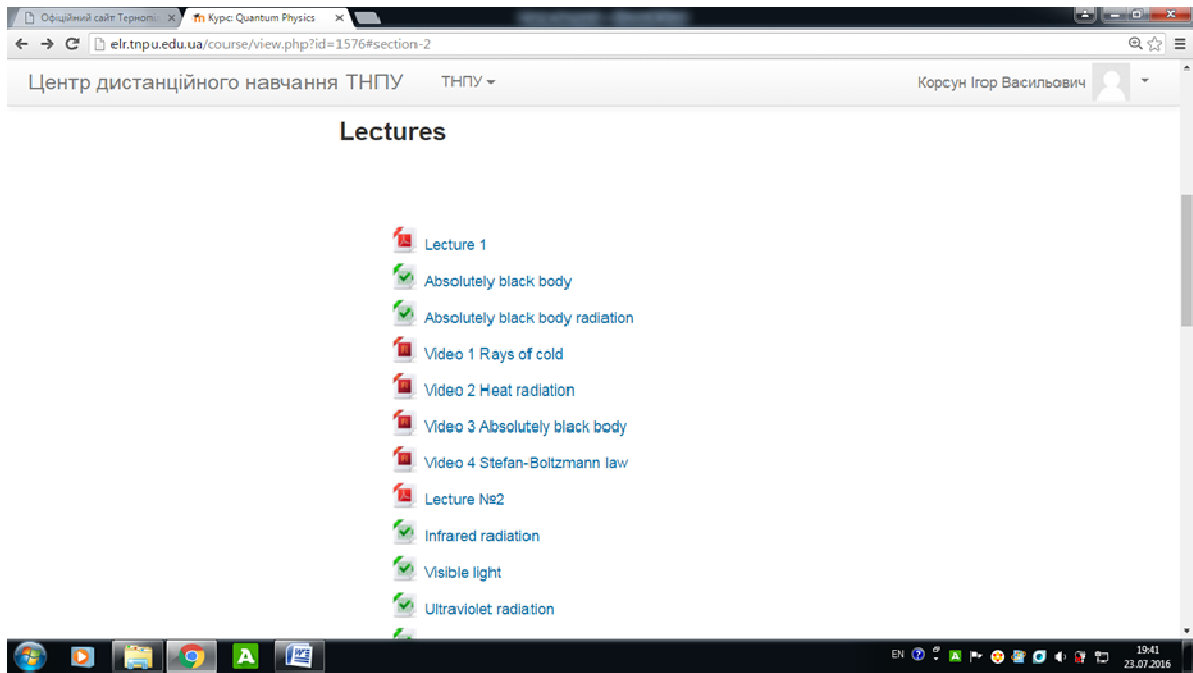


Figure 2. Block “lectures”

Animations that reveal the content of physics concepts (absolutely black body, absolutely black body radiation, infrared radiation, visible light, ultraviolet radiation, external photoelectric effect, de Broglie waves, planetary model of the atom, quark model of the nucleus) and computer models that explain the principle of physics devices' work (radiometer, Large Hadron Collider) have been created in e-learning of quantum physics.

Consider the thought model of the absolutely black body. The absolutely black body (black body) is an idealized model of the body, which completely absorbs all incident light radiation by any wavelength at any temperature. The model of the black body is a cavity of arbitrary shape, which contains a small hole and has nontransparent walls. Light beams that hit the cavity are completely absorbed during the multiple reflections from the walls of the cavity.

The programs Corel DRAW X6 and Easy Gif Animator have been used to create animation of the black body. Designed animation comprises a set of images (Figure 3) that are reproduced over a certain period of time. The cavity is unchanged in each picture. A ray of light that falls into the cavity is always shifted by the same distance closer to the hole (red light beam in Figure 3). When the beam enters the cavity, after multiple reflections, its thickness reduces as each reflection beam becomes thinner. After that, all images were loaded into the program Easy Gif Animator. We set the size of the animation in percentage. Then we set a few milliseconds between each picture transition. We saved it with the extension Gif. Animations can be saved with the extension AVI – video format.

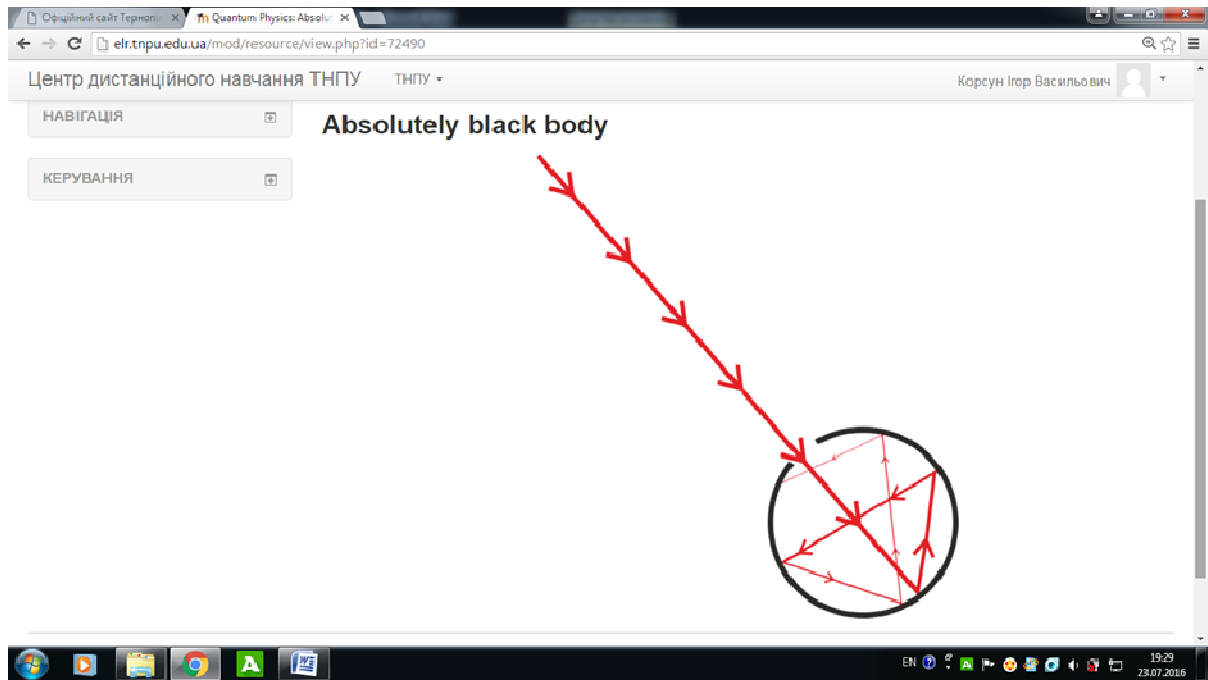


Figure 3. Animation of absolutely black body

The model of black body was heated to a high temperature. The small hole in the cavity will be as a black body radiation (e.g., the Sun is a black body). The computer model of black body radiation has been created in a similar way as the model of black body. The light beam which comes from the cavity undergoes multiple reflections (Figure 4). Its thickness increases after each reflection (light beam is shown in red). When the beam emerges from the hole, its thickness is greatest. Computer models of black body and black body radiation enable students to better understand the laws of thermal radiation.

Demonstrations for lectures are in video format. Students can download each video. Analysis of demonstrations allows students to better understand the theoretical material.

2.2.2. Block “practical exercises”

Block “practical exercises” allows students to form skills for solving tasks. Examples of solving typical problems for all course sections are presented in this block. As most students do not understand the practical use of physics laws, physics tasks must relate to real life. For example, we consider the task about radiocarbon dating: Nitrogen atoms are constantly in the Earth's atmosphere (78.082% by volume of dry air). Nitrogen nuclei are transformed into radioactive Carbon nucleus under the influence of cosmic radiation. Carbon enters into plants but the amount of this radioactive isotope decreases gradually when the plant dies. Since the archaeological finding is made from wood, scientists can determine the amount of Carbon in archaeological finding using the radiocarbon dating. This value is compared with the amount of radioactive Carbon in the tree, which has just been cut down. Students determine the age of archaeological find using the law of radioactive decay.

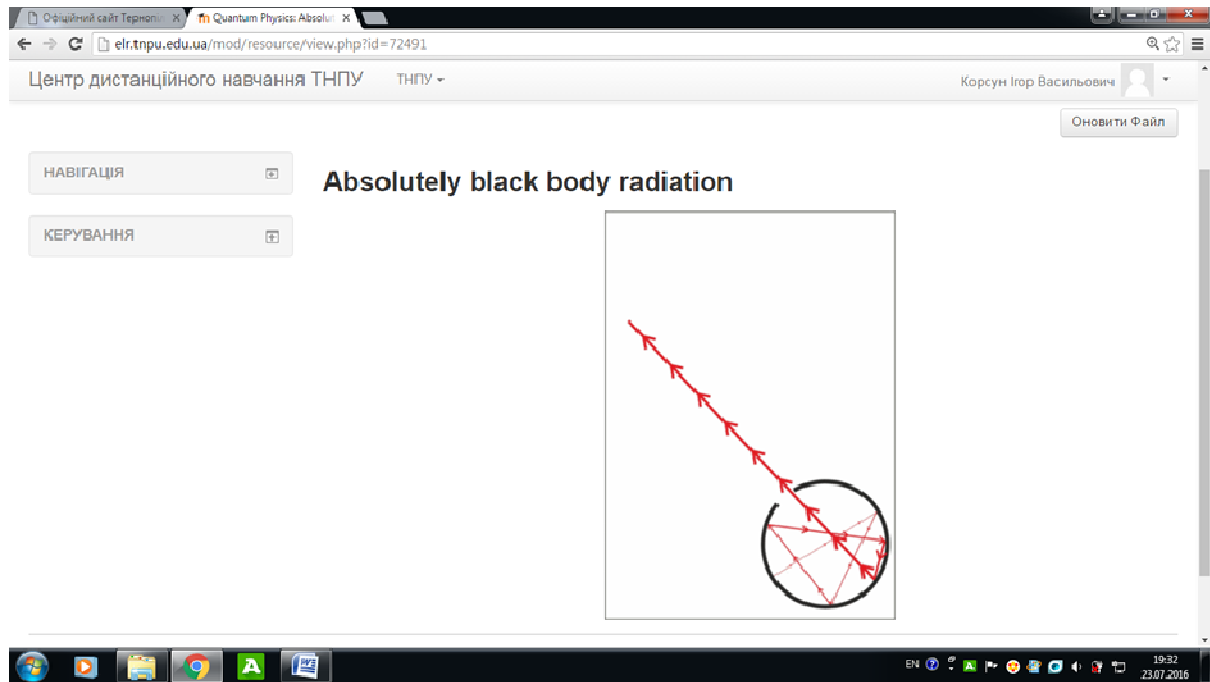


Figure 4. Animation of absolutely black body radiation

2.2.3. Block “reference material”

An analysis of Nobel prizes in Physics in recent years shows that quantum physics is one of the most popular areas of current science [22]. Block “reference material” provides information about current research in quantum physics. The Large Hadron Collider (LHC) is the largest experimental setup in the world. It lies near Geneva, Switzerland, in a tunnel 27 kilometres in circumference and runs underground at a depth of 175 metres. The aim of research is to test the predictions of different theories of particle physics, high-energy physics and other unsolved questions of physics. LHC is an accelerator of charged particles (e.g., protons). Scientists record the process of particle's collision. In 2012, scientists discovered a particle similar to the Higgs boson (the only missing link so-called Standard Model, whose existence is predicted half a century ago). Data from collisions have been analyzed with a grid-based computer network infrastructure connecting 140 computing centers in 35 countries. The Worldwide LHC Computing Grid is the world's largest computing grid [23].

Photos of experimental setups, material models and recommendations for correct demonstrations are presented in block “reference material”. For material model of LHC we need the following equipment: two tripods, two long glass tubes with thick walls (models of LHC interconnection), two metal balls (models of particles), a jar with sand (model of particle detector). Two students performed the demonstration. They released the balls simultaneously. One tube is longer and therefore is raised higher. In this case, times of movement are the same. The traces of balls' collision on sand has been recorded (Figure 5).

The expediency of engaging students in the performance of demonstrations in lectures has been proven in our works [24], [25]. Students should be able to conduct demonstrations. This contributes to conscious assimilation of knowledge and the development of relevant abilities and skills. In this way, the course has been designed with the future in mind – for students' future work as teachers of physics.

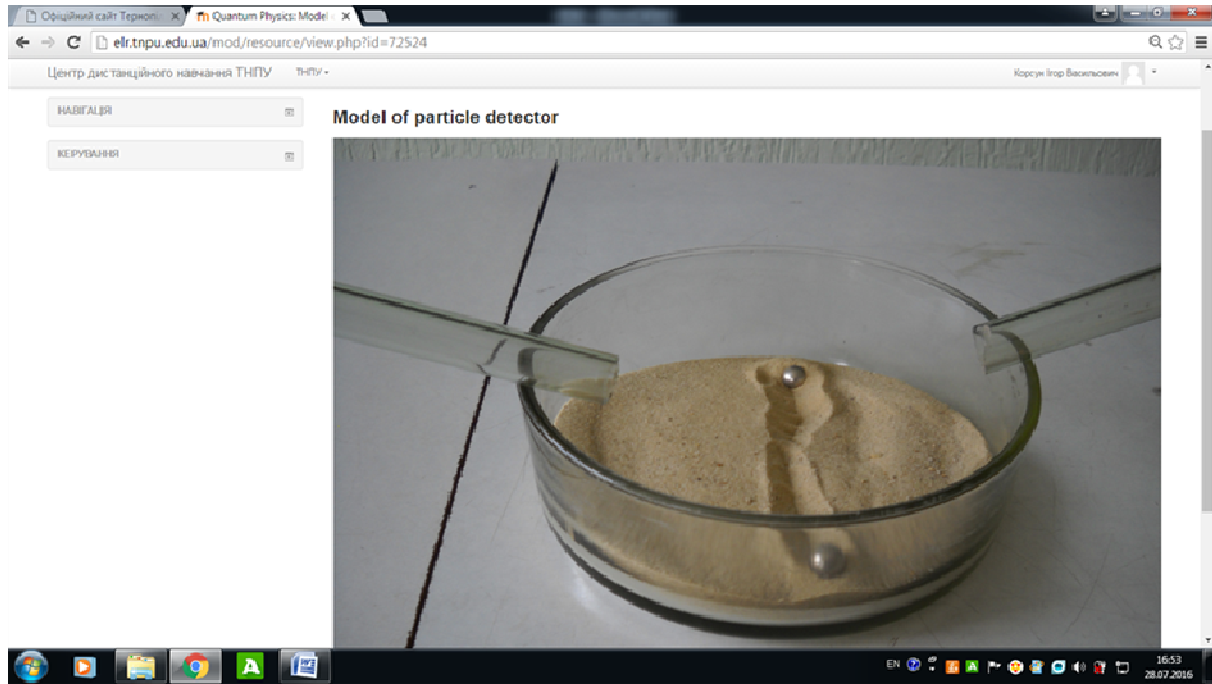


Figure 5. Model of particle detector

2.2.4. Block “control”

The criterion for evaluation and a list of questions for modules and final evaluation are contained in the block “control.” Testing provides a demonstration of students' knowledge, abilities and skills. Students can have several attempts at the test. A journal of assessments allows learners to see the results of their work, thereby promoting students' self-improvement.

2.3. Research Design

The hypothesis of this research on the use of the e-learning for the teaching of quantum physics is that the level of students' cognitive activity will increase. We have used Marianenko's [26] methodology of measuring levels of cognitive activity, which is aimed at diagnosing the structural components of cognitive activity: motivational, content (ability and skills), and emotional. The motivational component of cognitive activity is a positive attitude of learners to learning, a cognitive interest in the discipline, and the desire of students to get knowledge. The formation of thinking and cognitive processes (perception, attention, imagination and memory) is the content of cognitive activity. Positive emotions of diligence, the ability to organize one's own learning, self-control and self-improvement determine the emotional component of cognitive activity.

2.4. Participants

This experiment was conducted in the Physics and Mathematics Faculty of Ternopil Volodymyr Hnatyuk National Pedagogical University in Ukraine during 2015-2016 academic year. Five academic groups of the control group (92 students) and five academic groups of the experimental group (91 students) took part in the study.

2.5. Instrument

In this study, a test with 10 open-ended questions was developed and used. Each student completed the questionnaire, shown in Table 1 below:

Table 1.

List of questions

	Question	yes	no
1.	You can identify the concept of quantum physics (please write example and explanation)		
2.	You know the example of quantum physics in everyday life (please write example and explanation)		
3.	You know the example of quantum physics in technology (please write example and explanation)		
4.	You know the example of current research on quantum physics (please write example and explanation)		
5.	You know the example of real experiment on quantum physics (please write example and explanation)		
6.	You know the example of material model on quantum physics (please write example and explanation)		
7.	You know the example of thought experiment on quantum physics (please write example and explanation)		
8.	You know the example of thought model on quantum physics (please write example and explanation)		
9.	You know the name of physicist, who is a winner of the Nobel Prize on quantum physics (please write the name of scientist)		
10.	You read additional literature on quantum physics (please write the title of book)		

We considered the following evaluation:

0-4 “yeses” indicates a low level of cognitive activity;

5-7 “yeses” indicates an average level of cognitive activity;

8-10 “yeses” indicates a high level of cognitive activity.

2.6. Procedure

The three levels of students' cognitive activity are low, average, and high. According to questioning, the level of each student's cognitive activity in control and experimental groups was determined by a pre-test. During the academic year, the training in the experimental group (EG) was conducted using the developed method (using e-learning); and in the control group (CC), the training was conducted according to traditional methods (without using e-learning). An assessment of students' cognitive activity in both groups was performed in a post-test.

3. RESULTS

3.1. Data Analysis

The results of the experiment are presented in Table 2.

Table 2.

Results of measurements in CG and EG

The level of cognitive activity	Pre-test (%)		Post-test (%)	
	CG	EG	CG	EG
low	29.5	29.0	30.5	16.5
average	46.0	46.1	45.5	54.0
high	24.5	24.9	24.0	29.5

3.2. Statistical analyses

Two statistical hypotheses were formulated for analyzing the results of the experiment:

- 1) a hypothesis about the absence of difference (the null hypothesis);
- 2) a hypothesis about the significance of difference (the alternative hypothesis).

We conducted measurements in a three-level scale of gradation (high, average and low levels of cognitive activity). We used Pearson's criterion χ^2 for the decision about which of the hypotheses (the null or alternative) should be recognized. The critical theoretical value $\chi_{0.05}^2$ for the level of significance 0.05 in the three-level scale of gradation was: $\chi_{0.05}^2 = 0.05$. The empirical value $\chi_{empirical}^2$ of measured levels of cognitive activity in CG and EG for the post-test was: $\chi_{empirical}^2 = 34.30$. Because that $\chi_{empirical}^2 > \chi_{0.05}^2$, then the accuracy of the statistical significance of the characteristics of EG and CG after the post-test is 95%.

Thus, analysis of the experiment confirmed the alternative hypothesis: the difference between theoretical and empirical values of Pearson's criterion has occurred with not accidental, but with essential, reasons – the implementation of the developed technique (use of the e-learning for the teaching of quantum physics).

4. DISCUSSION

Shaw and Kennepohl [27] proved the expediency of teaching science online by studying the problem of how distance learners can participate in undergraduate research programs. The purpose of our study was to prove the advisability of using the e-learning of quantum physics in the Moodle environment to help students achieve better success in this difficult subject area.

There are many ways to categorize and understand learners' cognitive processes. One of the most commonly and globally used comes from the original work of Bloom [28], revised by Anderson and Krathwohl [29], in which the authors identified the following cognitive processes: remembering; understanding; applying; analyzing; evaluating; and creating. Remembering, understanding and applying refer to the assimilation of the information by learners. In analyzing and evaluating, using logical thinking, students should be able to independently analyze, summarize, argue and explain. Creating is characterized by the ability to synthesize ideas, offer new tasks and solve them.

E-learning of quantum physics in the Moodle environment ensures the development of learners' cognitive processes. E-learning tool includes thinking and material models. Learning models have formed the students' remembering and understanding, and have provided a forum for analyzing and evaluating. Modeling methods and thought experiments are the scientific methods of physics. The use of these methods in the Quantum Physics course performs the following roles:

- 1) they allow students to become acquainted with the methods of physics as a science;
- 2) effective methods of development of learners' cognitive processes (results of post-test).

5. CONCLUSION AND PROSPECTS FOR FURTHER RESEARCH

The possibilities of using the online Moodle environment have been analysed in this study. Online learning, combined with full-time, face-to-face study, was shown to significantly improve learning outcomes. In addition, costs for the purchase of educational materials were decreased. E-learning tool of quantum physics in the Moodle environment has been described, and its educational opportunities have been determined. Results showed that introducing an e-learning component for the teaching of quantum physics increased the level of students' cognitive activity.

Successful teaching of quantum physics is impossible without using learning models. Two types of learning models – material models and thought models – have been used. The method of creation of computer models using Easy Gif Animator has been discussed. The requirements for material models have been identified, and an example of material model of Large Hadron Collider has been demonstrated. We have considered modeling as a means of assisting the formation of students' cognitive activity. Using modeling methods and thought experiments helped to deepen learners' understanding of real experiments and physics theories. The results confirmed that learning models are the basis for students' understanding, logic, and creative thinking.

This technique could also be used in the teaching of other sections of physics such as mechanics, molecular physics and thermodynamics, electrodynamics, optics, and even other natural sciences, such as Chemistry, Geography and Biology.

Creation of e-learning tools of physics in other virtual learning environments and choice of the most effective environment for learning are the prospects for further research of this work.

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REFERENCES

- [1] S. Blackley, and R. Walker, "One-to-one laptop programs: Is transformation occurring in mathematics teaching?", *Issues in Educational Research*, vol. 25, no. 2, pp. 99-117, 2015. [Online]. Available: <http://www.iier.org.au/iier25/blackley.html>. Accessed on: January 12, 2017.
- [2] V. P. Oleksyuk, "Proektuvannia modeli khmarnoi infrastruktury VNZ na osnovi platformy apache cloudstack [Designing of university cloud infrastructure based on apache cloudstack]", *Information Technologies and Learning Tools*, vol. 54, no. 4, pp. 153-164, 2016. [Online]. Available: <http://journal.iitta.gov.ua/index.php/itlt/article/view/1453>. Accessed on: January 12, 2017. (in Ukrainian)
- [3] Kh. H. K. Moukali, and M. N. Saeed, "An overview of the interactive learning management system of jazan university, Saudi Arabia", *Information Technologies and Learning Tools*, vol. 58, no. 2, pp. 108-117, 2017. [Online]. Available: <http://journal.iitta.gov.ua/index.php/itlt/article/view/1496>. Accessed on: May 21, 2017.
- [4] M. Yildiz, and Y. Selim, "A qualitative study on transferring the experience of using technology from formal education to distance education", *The Turkish Online Journal of Distance Education*, vol. 16, iss 4, pp. 125-134, 2015. doi: 10.17718/tojde.93452.

- [5] N. Kotluk, and S. Kocakaya, "Researching and evaluating digital storytelling as a distance education tool in physics instruction: an application with pre-service physics teachers", *The Turkish Online Journal of Distance Education*, vol. 17, iss 1, pp. 87-99, 2016. doi: 10.17718/tojde.59900.
- [6] G. B. S. Teoh, A. L. W. Lin, and K. Belaja, "Which aspects of the English language do distance learners find difficult?", *The Turkish Online Journal of Distance Education*, vol. 17, iss 3, pp. 111-119, 2016. doi: 10.17718/tojde.19593.
- [7] M. Rajesh, "Revolution in communication technologies: impact on distance education", *The Turkish Online Journal of Distance Education*, vol. 16, iss 1, pp. 62-88, 2015. doi: 10.17718/tojde.26353.
- [8] S. Şahin, and Ç. Uluyol, "Preservice Teachers' Perception and Use of Personal Learning Environments (PLEs)", *International Review of Research in Open and Distributed Learning*, vol. 17, iss 2, pp. 141-161, 2016. doi: <http://dx.doi.org/10.19173/irrodl.v17i2.2284>.
- [9] M. R. Sarmadi, M. Farajollahi, B. Saeidipour, and M. Ahmadifar, "The impact of lecturers' thinking styles on students' creativity in distance higher education", *The Turkish Online Journal of Distance Education*, vol. 17, iss 4, pp. 105-117, 2016. doi: 10.17718/tojde.87234.
- [10] H. E. Fischer, and M. Horstendahl, "Motivation and Learning Physics", *Research in Science Education*, vol. 27, iss 3, pp. 411-424, 1997.
- [11] S. J. Chow, and B. C. S. Yong, "Secondary school students' motivation and achievement in Combined Science", *US-China Education Review B*, vol. 3, iss. 4, pp. 213-228, 2013.
- [12] T. A. Ghbari, "The Effect of ARCS Motivational Model on Achievement Motivation and Academic Achievement of the Tenth Grade Students", *The New Educational Review*, vol. 43, iss 1, pp. 68-77, 2016. doi: 10.15804/tner.2016.43.1.05.
- [13] V. Shtoff, *Modelirovanie i filosofija [Modeling and philosophy]*. Moscow, 1966. (in Russian)
- [14] L. Kalapusha, "Osnovni vymohy do demonstratsiinykh modelei z fizyky [Basic requirements for the demonstrational models of physics]", *Metodyka vykladannia fizyky [Methods of physics teaching]*, no. 5, pp. 102-106, 1970. (in Ukrainian)
- [15] L. Kalapusha, *Modeliuvannia u vyvchenni fizyky [Modeling in the physics teaching]*. Kyiv, 1982. (in Ukrainian)
- [16] G. Kobel, "Modeliuvannia jak zasib aktyvizatsii piznaval'noi diial'nosti uchniv na urokakh fizyky [Modeling as a means of revitalization of learners' cognitive activity at the physics lessons]", dissertation of Ph.D. (Pedagogical Sciences), State Pedagogical Dragomanov University, Kyiv, 1995. (in Ukrainian)
- [17] L. Yeates, *Thought Experimentation: A Cognitive Approach, Graduate Diploma in Arts* (By Research) dissertation, University of New South Wales, 2004. [Online]. Available: <https://www.dropbox.com/s/nczwi1vkb7x88qd/TECA.pdf?dl=0>. Accessed on: January 10, 2017.
- [18] I. Hadar, and E. Hadar, "An Iterative Methodology for Teaching Object Oriented Concepts", *Informatics in Education*, vol. 6, iss 1, pp. 67-80, 2007.
- [19] M. Muñoz, M. Lourdes, J. Rodríguez, and J. Gutiérrez de Mesa, "Electrical Storm Simulation to Improve the Learning Physics Process", *Informatics in Education*, vol. 12, iss 2, pp. 191-206, 2013.
- [20] C. Rogers, "Scientific modeling". *Encyclopedia Britannica*, May 21, 2012. Available: <https://www.britannica.com/science/scientific-modeling>. Accessed on: January 10, 2017.
- [21] I. Korsun, "Contribution of Ukrainian scientists to the development of quantum physics", *Ukrainian Journal of Physics*, vol. 62, no. 1, pp. 67-79, 2017. doi: <https://doi.org/10.15407/ujpe62.01.0067>.
- [22] The Official Web Site of the Nobel Prize. Available: http://www.nobelprize.org/nobel_prizes/physics/. Accessed on: January 15, 2017.
- [23] What is the Worldwide LHC Computing Grid? Available: <https://web.archive.org/web/20120125141939/http://lcg.web.cern.ch/LCG/public/overview.htm>. Accessed on: January 15, 2017.
- [24] I. Korsun, and V. Syrotjuk, "Udoskonalennia metodyky provedennia fizychnogo lektsiinogo demonstratsiinogo eksperymentu u vyshchii pedahohichnii shkoli [Improvement of methods of demonstrational experiment on lectures of physics in pedagogical university]", *Zbirnyk naukovukh prats' Kamianets-Podil's'kogo natsional'nogo universytetu imeni Ivana Ohienka [Collection of scientific papers Kamianets-Podilsky State University]*, no. 10, pp. 150-151, 2004. Available: <http://journals.uran.ua/index.php/2307-4507/article/view/31459/28094>. Accessed on: January 18, 2017. (in Ukrainian)
- [25] I. Korsun, "Vdoskonalennia eksperymental'noi pidhotovky maibutnikh uchyteliv fizyky [Improving of experimental training of pre-service physics teachers]", *Naukovyi chasopys Natsional'nogo pedahohichnogo universytetu imeni M. Drahomanova [Scientific journal of National Pedagogical Drahomanov University]*, vol. 32, pp. 105-109, 2012. Available: <http://enpuir.npu.edu.ua/bitstream/123456789/4040/1/Korsun.pdf>. Accessed on: January 19, 2017. (in Ukrainian)

- [26] L. Marianenko, "Psykhologichni umovy formuvannia piznaval'noi aktyvnosti slabovstyhaiuchykh starshoklasnykiv [The psychological conditions of formation of senior pupils' cognitive activity, who poorly study]", dissertation of Ph.D. (Pedagogical Sciences), Institute of Psychology Ukraine, Kyiv, 1992. (in Ukrainian)
- [27] L. Shaw, and D. Kennepohl, "Student and faculty outcomes of undergraduate science research projects by geographically dispersed students", *International Review of Research in Open and Distributed Learning*, vol. 14, iss 5, pp. 69-81, 2013. doi: <http://dx.doi.org/10.19173/irrodl.v14i5.1551>.
- [28] B. S. Bloom (Ed.), M. D. Engelhart, E. J. Furst, W. H. Hill, and D. R. Krathwohl, *Taxonomy of educational objectives: The classification of educational goals. Handbook 1: Cognitive domain*. New York: David McKay, 1956.
- [29] L. W. Anderson et al., *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives (Complete edition)*. New York: Longman, 2001.

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ФОРМУВАННЯ ПІЗНАВАЛЬНОЇ АКТИВНОСТІ СТУДЕНТІВ ЗА ДОПОМОГОЮ ЕЛЕКТРОННОГО НАВЧАННЯ ПІД ЧАС ВИВЧЕННЯ КУРСУ КВАНТОВОЇ ФІЗИКИ

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Анотація. Метою даної статті є доведення необхідності використання електронного курсу у середовищі Moodle у навчанні квантової фізики для досягнення студентами успіху у вивченні цього складного розділу фізики. Можливості використання середовища Moodle у дистанційному навчанні були проаналізовані. Алгоритм створення електронного курсу квантової фізики у середовищі Moodle був описаний і навчальні можливості даного електронного курсу були визначені. Необхідність використання матеріальних і мислених моделей для навчання квантової фізики була доведена. Метод моделювання і мисленні експерименти пояснюють фізичні явища, допомагають краще зрозуміти реальні експерименти та суть фізичних теорій. Метод створення комп'ютерних моделей за допомогою Easy Gif Animator був обговорений. Були визначені вимоги до матеріальних моделей і продемонстрований приклад матеріальної моделі Великого адронного колайдера. Результати показали, що електронне навчання квантової фізики підвищує рівень пізнавальної активності студентів. Ця методика може бути використана для вивчення інших розділів фізики та інших природничих наук.

Ключові слова: пізнавальна активність студентів; електронне навчання; середовище Moodle; навчальні моделі; квантова фізика.

ФОРМИРОВАНИЕ ПОЗНАВАТЕЛЬНОЙ АКТИВНОСТИ СТУДЕНТОВ С ПОМОЩЬЮ ЭЛЕКТРОННОГО ОБУЧЕНИЯ ПРИ ИЗУЧЕНИИ КУРСА КВАНТОВОЙ ФИЗИКИ

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Аннотация. Целью данной статьи является доказательство необходимости использования электронного курса в среде Moodle при обучении квантовой физики для достижения студентами успеха в изучении этого сложного раздела физики. Возможности использования среды Moodle в дистанционном обучении были проанализированы. Алгоритм создания

электронного курса квантовой физики в среде Moodle был описан и учебные возможности данного электронного курса были определены. Необходимость использования материальных и мысленных моделей для обучения квантовой физики была доказана. Метод моделирования и мысленные эксперименты объясняют физические явления, помогают лучше понять реальные эксперименты и суть физических теорий. Метод создания компьютерных моделей с помощью Easy Gif Animator был обсужден. Были определены требования к материальным моделям и продемонстрирован пример материальной модели Большого адронного коллайдера. Результаты показали, что электронное обучение квантовой физики повышает уровень познавательной активности студентов. Эта методика может быть использована для изучения других разделов физики и других естественных наук.

Ключевые слова: познавательная активность студентов; электронное обучение; среда Moodle; учебные модели; квантовая физика.



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