Advances in Social Science, Education and Humanities Research, volume 437
International Scientific Conference "Digitalization of Education: History, Trends and Prospects" (DETP 2020)

Organization of Remote Learning with the Use of Moodle Electronic Information Educational Environment

Alykova O.M.[1,*] Smirnov V.V.[1,2] Stefanova G.P.[1]

[1]*Astrakhan State University, Astrakhan, Russia*
[2]*Caspian Sea and River Transport Institute, Volga State University of Water Transport, Astrakhan, Russia*
[*]*Corresponding author. Email: olga-alykova@mail.ru*

ABSTRACT
The purpose of this study is to test the possibilities of using the electronic information educational environment (EIOS) to personalize training and automate the control of the assimilation of acquired knowledge, including when performing virtual and telemetric laboratory works. To achieve this goal, an electronic learning resource was developed in the Moodle student learning management system, containing material on the main areas of physics, which is necessary for conducting both interactive classes with students and their independent work in any form of training. A wide variety of virtual and telemetric laboratory works in physics, allows satisfying the requirements of almost any educational program and implement personalization of training. Performing telemetric laboratory work, introduces students to the formulation of a real physical experiment. The presented methodology and organization of the educational process, the systematic work of students in an e-learning environment allows creation professional competencies related to the application of acquired physical knowledge in specific, close to real, situations.
Keywords: *learning management, electronic information educational environment, telemetric laboratory work, virtual laboratory work, activities, automation of knowledge control*

1. INTRODUCTION

Paraphrasing the famous statement of Ilf and Petrov about the car [1], it can be argued that for modern society remote education is not a luxury, but a means of transportation. This is confirmed by recent events in the world, the consequence of which was an order signed by the Minister of Science and Higher Education of the Russian Federation Valery Falkov [2], according to which, due to the unfavorable situation on coronavirus infection COVID-19, it is recommended to organize student training outside the university's location, including the use of e-learning and remote learning technologies. In general, the education system is guided by the Federal Law of December 29, 2012 N 273-ФЗ (as amended on December 29, 2017) "On Education in the Russian Federation" [3], which formulates the need to introduce e-learning (EE) into the educational process of universities and remote education technologies (DOT), as well as the requirements of the federal state standards of the third generation [4, 5]. This is a fundamentally new approach to all educational activities, which opens up the possibility of individualizing education through the personalization of education. The inclusion of students and teachers in the EIOS requires the formation of a new model of student learning. The main element of the considered environment is the student learning management system, the basic principle of which is the cyclical organization of the transfer of information, its presentation to students, the implementation of cognitive actions for its assimilation, as well as the availability of an operational feedback system.

According to the Federal State Educational Standards of Higher Education 3+ and the Federal State Educational Standards of Higher Education 3 ++, each student during the entire period of study should be provided with individual unlimited access to one or more electronic library systems (electronic libraries) and to the electronic information and educational environment (EOIS) of the organization, which allows gaining access to curricula, work programs of disciplines (modules), practices, publications of electronic library systems and electronic educational resources, and also provides interaction between participants of the educational process and gradual fixation progress of the educational process, interim assessment of the results and the results of the development of the study subjects.

Consistent with the provisions of the Federal State Educational Standards in the field of digitalization of education, the University "20.35" was organized on November 7, 2017 - a digital platform for personal development for everyone throughout life with constantly expanding lists of educational opportunities and four advisory services provided using the capabilities of artificial intelligence, using the technology of working with big data for recommendations on each development step. Using the capabilities of the University "20.35" in the electronic educational environment of universities allows the creation or adjustment of educational programs that are optimized for collecting and analyzing data, including the digital footprint (DF), in order to increase the effectiveness of educational activities. For this, conditions have been created on the platform for the formation of an educational result that leaves the DF, i.e. for educational activities. [6].

In most of the "Provisions on the electronic informational and educational environment" of universities, EOIS is defined as an integrated set of information and educational resources, information and telecommunication technologies and relevant technical and technological means that ensure that students learn the educational programs in full regardless of their location. An overview of the platforms on which EIOS can be developed is given, for example, in [7]. Table 1 Lists the most famous of them that have support for the Russian language.

Table 1 EOIS Platforms Supporting the Russian Language

Platform	Knowledge test system	Application Languages	DBMS
MOODLE [8]	tests, assignments, seminars, activity on the forums	PHP	MySQL
Sakai [9]	tests, tasks, activity on the forums	Java	MySQL, Oracle, hsqldb
ATutor [10]	tests	PHP	MySQL
Claroline [11]	tests, exercises	PHP	MySQL
Dokeos [12]	tests	PHP	MySQL
OLAT [13]	tests, tasks	Java	MySQL PostgreSQL
OpenACS [14]	tests		MySQL, PostgreSQL
ILIAS [15]	tests	PHP	MySQL

In Russia, one of the most popular is the Moodle platform - Modular Object-Oriented Dynamic Learning Environment. The design and development of Moodle is guided by a special teaching philosophy, which is characterized as "social constructionist pedagogy" [8].

The main element of the considered environment is the student learning management system, the basic principle of which is the cyclical organization of the transfer of information, its presentation to students, the implementation of cognitive actions for its assimilation, as well as the availability of an operational feedback system. The system provides the student with the opportunity to carry out interactive activities for the assimilation of knowledge, and for teachers - a platform for the operational visualization of grades, important events and ideas, to inform students about changes in the educational process, and also has the ability to carry out an independent automated assessment of their achievements.

2. BACKGROUND

The purpose of this study is to test the capabilities of Moodle-based EIOS to personalize training and automate the monitoring of virtual and telemetric laboratory work. To achieve this goal, an electronic learning resource was developed that contains material on the main sections of physics, which is necessary for conducting both interactive classes with students and their independent work in any form of training. E-learning resource contains: lectures on all sections (video lectures, presentations, and notes); multimedia materials [16], necessary for mastering the main provisions of the subject, including video recordings of experiments performed under the guidance of ASU teachers, which are freely available or in other sources; virtual and telemetric laboratory work, animated models of physical phenomena, processes, experimental installations, performed and developed by ASU teachers, and are freely available; reference material; tasks for practical classes, control, and test tasks, case tasks [17, 18]. Taking into account personal teaching experience, each of the listed elements is being modernized in the electronic educational resource of the physics course.

Consider how the assimilation of educational material in the topic: "Ideal gas. Gas Laws" using the Moodle e-learning environment. The study of the material begins with a lecture that outlines the basic concepts of this topic, the main parameters of a thermodynamic system, the concept of an ideal gas, isoprocesses, gas laws and their graphical interpretation, the equation of state of an ideal gas on the Moodle platform, this training material has been laid out in a compressed form. It is necessary to organize the assimilation of this material, i.e. application of basic concepts, laws in specific situations, when performing certain types of activities.

Physical theories and laws corresponding to them are strictly valid only for idealized objects that do not exist in nature. Therefore, before applying these laws, it is necessary to find out whether real concrete objects indicated in the condition of the problem can be considered idealized.

In molecular gas theory, the idealized object is the ideal gas. To answer the question: "Can the gas under study be considered ideal under these conditions?", We need to recall the content of the concept of "ideal gas", and also remember that we can consider molecules as material points (elastic balls) that do not interact with each other under normal conditions. Under normal conditions, 1 cm3 contains 1019 molecules, the average distance between them is about 10 nm, while the intermolecular interaction is insignificant at distances of 0.5-1.0 nm. therefore, if the pressure of the real gas is less than p ≤105 PA, it can be considered ideal. However, it should be remembered that as the temperature decreases, the gas can condense and go into a liquid state. For a liquid, the laws of an ideal gas are not satisfied. According to the definition and existing models, real gas is considered ideal at pressures comparable to atmospheric and at temperatures far from the liquefaction temperature. A more rigorous study of real gases, an analysis of the Van der Waals equation will occur later, it will be established that for each gas there is a set of critical parameters pk, Vk and Tk, when all of which are reached, the gas undergoes a phase transition and is transformed, for example, into a liquid. To analyze the situations contained in the exercises below, you need to know the critical parameters of the gases.

To master the concept of "ideal gas", a system of exercises (tasks) has been developed, the purpose of which is to perform activities by students "bringing real gas to the concept of ideal". Therefore, it is necessary to highlight the signs, focusing on which real gas can be considered ideal.

The content of the activity "Summing up the concept of an idealized object" in molecular physics can be represented in the form of the following Table 2.

Table 2 Summing up the "Ideal gas" concept

Definition of an idealized object	**Indicative signs of bringing a real object under the concept of idealized**	**The system of actions when summarizing the concept of an idealized object**
Perfect gas A gas whose molecules can be considered non-interacting material points	$p \leq 10^5$ Pa, where p is the gas pressure under given conditions; 10^5 Pa - pressure at which gas molecules can be considered non-interacting material points. $t > T_k$, t is the temperature at which the gas molecules can be considered non-interacting material points; T_k is the critical temperature.	1. Name a sign characterizing an ideal gas. 2. Determine gas pressure values under given conditions. 3. Determine the gas temperature in these conditions. 4. Compare the obtained values with the values of pressure and temperature of an ideal gas and draw a conclusion. 4. To make a conclusion.

Gas name	**Boiling Point ° C**	**Melting point ° C**	**Critical temperature ° C**
Nitrogen	196 °	-211 °	-147 °
Argon	-186 °	-190 °	-121 °
Hydrogen	-259 °	-253 °	-239 °
Helium	-269 °	-272 °	-268 °
Carbon dioxide	-78	-65 °	31.1 °
Oxygen	-183 °	-218 °	-119 °
Ethylene	-103 °	-169 °	10 °
Ethane	-84 °	-171 °	35 °
Propane	-187.69 ° C	-42.07 °	97 °

To organize the assimilation of this material, i.e. the application of basic concepts, laws in specific situations, when performing certain types of activities, the Moodle system provides the ability to perform special tasks. These are exercises and tasks. At school, the ideal gas model is studied, but the indicated action is not formed. Let us cite as an example of the exercises for bringing real gas under the concept of "ideal gas". Tasks are performed in extra time, on an individual trajectory.

Exercise 1. Follow the specified system of actions and establish whether this gas can be considered ideal in the following situations.

1. Air pressure under normal conditions in the tires of the front wheels of trucks MAZ-6516W8-420 and MAZ-6516W8-430 is 4.2 bar, and in the tires of the rear 5.5 bar.

2. The submarine has two reservoirs in communication. When immersed, one of the tanks is completely filled with water, and the second contains air. When a boat emerges, water is completely displaced by it from the tank.

3. A silver water spider builds an air house in the water, transferring air bubbles on its legs and abdomen and placing them under the dome of a web attached to the aquatic plants with their ends at a depth of 50 cm.

4. To carry out work on the bottom of the river to build foundations for the foundations of bridges, locks, etc., use caissons (Fig. 1). What is the air pressure in the caisson if its base is at a depth of 25 m from the surface of the water in the river? External pressure is considered normal.

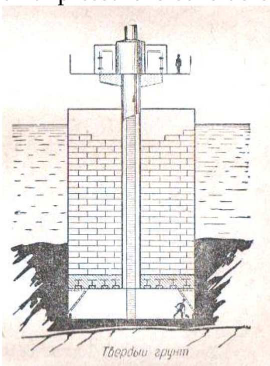


Figure 1 Caisson device

The Moodle system allows providing students with help in the form of knowledge-guides and ways to complete tasks. In relation to the concept "of ideal gas" before the assignment, a definition and indicative signs are given, as well as a way to bring this definition under the concept. The technical capabilities of the Moodle electronic educational environment provide an opportunity to randomly select three exercises (Fig. 2) from the developed exercise system, which avoids cheating, because each student is offered his own set of exercises, chosen by the program at random. The preparation of such tasks (choosing the range of each variable parameter, taking into account the dimensions of all parameters, determining the type of response, for example, write the answer in kPa or nm) and the large amount of time required for such work pays off by the ability to check and rate it almost instantly.

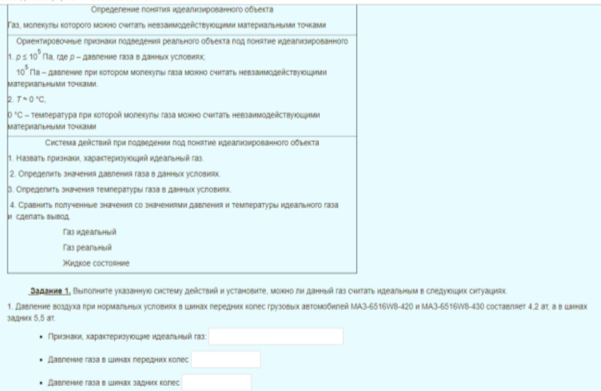


Figure 2 Window for the exercise "... can this gas be considered as ideal in the following situations"

It is possible to identify the level of mastering the concept of "ideal gas" using the type of question "multiple choice", which offers an alternative approach - to choose several correct ones from the proposed answer options (Fig. 3).
All types of questions are stored in a database that can be edited. Most productive if the teacher forms the tasks. The number of attempts to pass the test by the student is regulated by the teacher, and each attempt is evaluated automatically. The result of passing the test can be displayed on the student's monitor - an assessment indicating the correct answer, or simply an assessment.

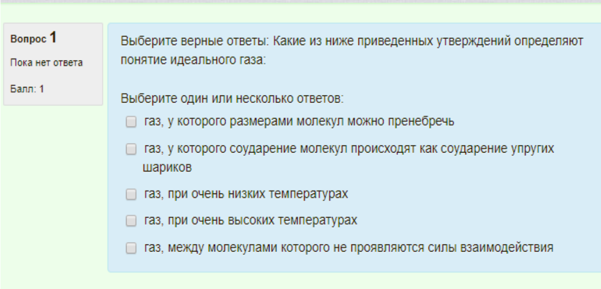


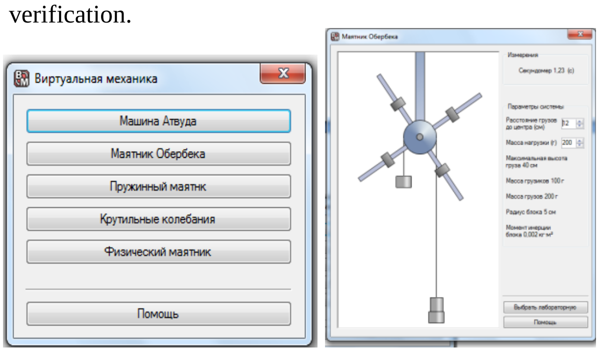
Figure 3 Example of a multiple-choice test: choosing the right answer from the proposed options

The educational environment Moodle provides the opportunity to use laboratory work, both virtual and experimental, performed by telemetry in the learning process.
Let's consider some examples illustrating the possibility of using virtual laboratory work. Figures 4a and 4b show the appearance of the Virtual Mechanics interface available on the Internet and a view of one of the laboratory works of the Oberbek Pendulum, a fragment of Table 2 with individual tasks is given. So, in particular, in this work, students are invited to solve the cognitive problem of experimentally finding the moment of inertia of a cruciform pendulum. This value can be found from the results of a virtual experiment by the ratio

$$J = R^2\left(\frac{t^2}{2h}\Delta mg - \left(2M + \Delta m\right)\right) - J_0 .$$

The values h, M, Δm, J0, R and r are given in the work, t is measured. The student is offered the value of the moment of inertia, found experimentally, to correlate with its theoretical value J = 4 mr2.

Specific numerical values Δm and r are determined according to Table 3 (about 50 task options are offered), which allows for each student
to implement an individual educational trajectory. One hundred percent reproducibility of a virtual experiment allows automating of the laboratory work results verification.



a) b)

Figure 4 a) the appearance of the interface of "Virtual Mechanics" b) the window of the laboratory work "Oberbek Pendulum"

Table 3 Options and their initial values

	Laboratory number 1				Laboratory number 2				Laboratory number 3		Laboratory number 4			Laboratory number 5			
	Height, cm	Overload, r			r, cm	Overload, r			weight, g	N/m	*l*, cm	*d*, mm	*m*, kg	Distance	Deflection angle		
No.	H	Δm₁	Δm₂	Δm₃	r	Δm₁	Δm₂	Δm₃	m	k				cm	α₁	α₂	α₃
1	100				7	10	100	200	10		100		100	45			
2	90				8	20	110	210	120		105		200	40			
3	80	10	20	30	9	30	120	220	140	10	110	1	300	35	3	5	10
4	70				10	40	130	230	160		115		400	30			
5	60				11	15	140	240	180		120		500	25			
26	90				8	30	120	220	600		125	3	600	10			
27	80				9	40	130	230	620		130		700	5			
28	70	70	80	90	10	15	140	240	640	15	135		800	45			
29	60				11	60	150	250	660		140		900	40			
30	15				12	70	160	270	680		150		1000		4	8	12
31	100				13	75	165	275	700		100		1100				

An example of using virtual laboratory work developed by ASU teachers as part of the study of the topic "Semiconductors" is given below [19]. Students get acquainted with minimizing the circuitry implementation of logical statements using the Karnaugh maps (Fig. 5). The student is offered a truth table (upper right corner of Fig. 5), on the basis of which the full implementation diagram first emerges, after which it is minimized using the Karnaugh maps. A comparison of the work of the full and reduced schemes is carried out.

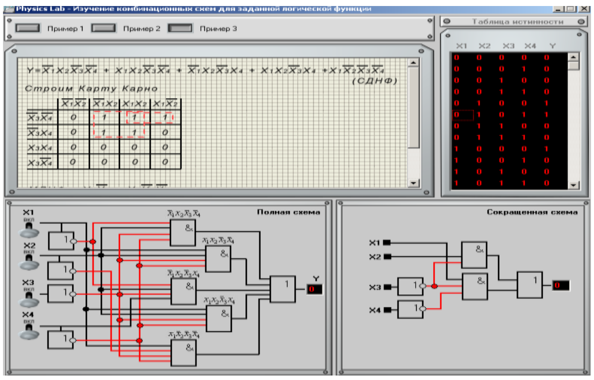


Figure 5 Virtual laboratory work "Minimizing the circuitry implementation of logical statements using the Karnaugh maps"

Another type of laboratory work that can be implemented in the educational environment of Moodle is carried out by telemetric method [20, 21]. Students can perform such laboratory work at home if it is necessary to use remote learning on a compulsory basis in connection with force majeure circumstances (quarantine, severe frosts, illnesses, etc.).

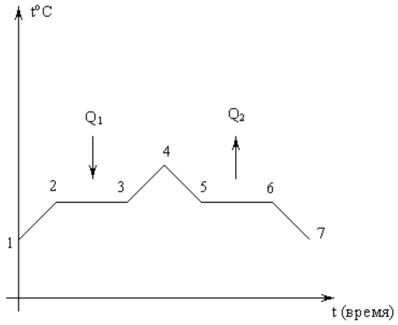
The developed laboratory work is performed as follows. Students watch a video recording of a real physical experiment, study methodological recommendations that formulate the goal and objective of the study, describe in detail the idea of the experiment and the method of processing the obtained experimental data, a list of necessary actions by students. Further, during the first work, students get acquainted with computer tools, using which they can measure time intervals and coordinates of objects on the frames of the video. These values allow calculating the speed, acceleration of bodies, the trajectory of their movement, determine angles, angular velocities, etc. It is possible to transfer the measured data into an easy-to-use spreadsheet, simplifying the cumbersome operations of their processing, with the help of these tables the data can be analyzed and presented in graphical form. There are ample opportunities to compile a work report using the obtained tables and graphs, for example, using the standard WordPad editor.

Let us consider an example of the laboratory work "Measurement of entropy during heating and melting of tin" performed by the telemetric method in studying the course of physics (section "Mechanics. Molecular Physics and Thermodynamics") first-year students in the field of Engineering, profile "Equipment and technology for welding production".

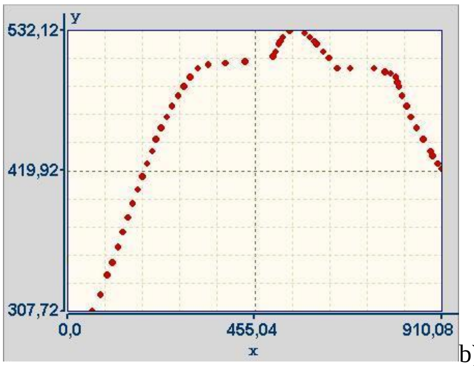
a) b) c)

Figure 6 Windows of the laboratory work "Measurement of entropy during heating and melting of tin": a) installation; b) millivoltmeter; c) spreadsheet

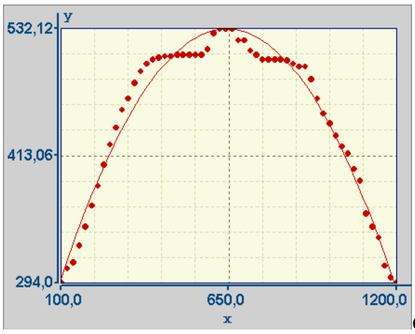
The essence of the work is the heating and melting of tin, which is in the crucible, which is placed in an electric furnace. Fig. 6a shows an experimental setup. The temperature of the tin in the crucible is measured using a thermocouple, one end of which is immersed in tin, and the other in a cryogenic storage dewar with oil. The oil temperature during the experiment is constant and equal to room temperature. The thermoelectromotive force arising inside the thermocouple in the presence of a temperature difference in the junctions is measured by a millivoltmeter (Fig. 6, b). Students start the video and every minute they record the temperature of tin in the built-in spreadsheet (Fig. 6, b). According to the data obtained, by pressing a button, a graph is automatically plotted against the temperature of the sample versus time with constant heating and cooling. If the work is performed correctly, the graph of the results corresponds to the theoretical data (Fig. 7, a). According to the graph (Fig. 7 b, c), temperatures corresponding to the sections parallel to the time axis are determined, and the melting temperature of tin is found from their average value. It should be noted that the temperature of tin during melting remains constant, although heat continues to be supplied to the system. Next, the main data and the resulting schedule are formed in the basic report template.



a)



b)



c)

Figure 7 Tin melting and crystallization graph:

a) theoretical curve:
1-2 - heating of a solid, in state 2, the destruction of the crystal lattice begins and ends in state 3. The supplied energy Q1 goes to the destruction of the crystal lattice.
3-4 - heating the liquid.
Then the reverse process begins.
4-5 - liquid cooling.
5-6 - crystallization process, which is accompanied by the release of energy Q1 = Q2. In state 6, the formation of the crystal lattice is over.
6-7 - cooling of a solid body.
c), d) experimental curves.

According to the formula

$$\Delta S = cm\ln\frac{T_n}{T_k} + \frac{\lambda m}{T_n},$$

where c and □– specific heat capacity and specific heat of melting of tin, determine the change in entropy during heating and melting of tin. The specific heat of fusion and the specific heat of tin are found in reference books. The received data is entered into the generated report. The conclusion is formulated. Answers to security questions are added. The finished report is attached to the corresponding task on Moodle. The teacher evaluates the stages of work and puts an assessment according to the formed criteria.

3. DISCUSSION OF RESULTS

The use of the Moodle system for the implementation of remote learning, including in the presence of "force majeure" circumstances, has shown its effectiveness. The lecture, test component of the EIOS has been worked out for a long time. The laboratory component of the teaching of physics is also successfully integrated into the system. Moreover, in the works performed by the telemetric method, students deal with the formulation of a real physical experiment conducted by a physicist, and captured on video. At the same time, students form competencies associated with the organization of physical research, obtaining and processing experimental data and generalizing the results. The computer program is used here as a computing tool. The combination of video material of real laboratory work with the capabilities of a computer program for conducting virtual measurements creates the effect of participation in a real physical experiment. The tabular data of these experiments conducted by students are quite diverse, which requires, so to speak, "manual" verification of the results of laboratory work.

A wide variety of virtual laboratory work in physics allows satisfying the requirements of almost any educational program. The idealized models used in this case simplify the essence of the experiment, which is a definite drawback of virtual work. However, one hundred percent reproducibility of the results of work makes it easy to automate their verification.

Tables of tasks 2,3 given for example confirm the real possibility of personalizing training - each student has an individual educational task for each section studied.

4. CONCLUSION

The presented methodology and organization of the educational process are introduced into the practice of teaching students of Astrakhan State University when they study a course in general and experimental physics on the LMS MOODLE platform. The systematic work of students in an e-learning environment allows you to create professional competencies related to the application of acquired physical knowledge in specific, close to real, situations.

REFERENCES

[1] I. Il'f, Ye. Petrov, Zolotoy telenok. M.: Prosveshcheniye, 1987, 288 p.

[2] Prikaz «O merakh realizatsii Ukaza Prezidenta RF ob ob"yavlenii v Rossiyskoy Federatsii nerabochikh dney». https://minobrnauki.gov.ru/ru/documents/card/?id_4=1120&cat=/ru/documents/docs

[3] Federal'nyy zakon ot 29.12.2012 N 273-FZ (red. ot 29.12.2017) «Ob obrazovanii v Rossiyskoy Federatsii»

[4] FGOS 3+. http://fgosvo.ru/fgosvo/92/91/4

[5] FGOS 3++. http://fgosvo.ru/fgosvo/151/150/24

[6] Universitet «20.35». Instruktsiya po primeneniyu. https://ntinews.ru/in_progress/likbez/universitet-20-35-instruktsiya-po-primeneniyu.html, svobodnyy

[7] V.A. Bogomolov, Obzor besplatnykh sistem upravleniya obucheniyem, Educational Technology & Society, 10(3) (2007)

[8] MOODLE. www.moodle.org

[9] SAKAI. http://www.sakaiproject.org

[10]Atutor. www.atutor.ca

[11]Claroline. www.claroline.net

[12]Dokeos. www.dokeos.com

[13]OLAT. http://www.olat.org

[14]OpenACS. http://openacs.org

[15]ILIAS. www.ilias.de/ios/index-e.html#ilias

[16]O.M. Alykova, Opyt ispol'zovaniya mul'timediynogo uchebnogo posobiya «Fizicheskiye eksperimenty» v lektsionnykh demonstratsiyakh po kursu fiziki v vuze, Sbornik trudov XIII Mezhdunarodnoy uchebno-metodicheskoy konferentsii «Sovremennyy fizicheskiy praktikum», Moskva 23-25 sentyabrya 2014, M., Izdatel'skiy dom Moskovskogo fizicheskogo obshchestva, 2014, pp. 61-62

[17]O.M. Alykova, V.V. Smirnov, Virtual'naya lektsionno-demonstratsionnaya auditoriya po fizike. opyt sozdaniya, Materialy XIII Mezhdunarodnoy konferentsii «Fizika v sisteme sovremennogo obrazovaniya (FSSO-15)» T. 1, Sankt-Peterburg, 1-4 iyunya, 2015, pp. 215-218

[18]O.M. Alykova, V.V. Smirnov, G.P. Stefanova, Elektronnaya obrazovatel'naya sreda Moodle kak sredstvo izucheniya kursa fiziki. Fizika v sisteme sovremennogo obrazovaniya (FSSO-2019), Sbornik nauchnykh trudov XV Mezhdunarodnoy konferentsii T. 1, Sankt-Peterburg, 3-6 iyunya 2019, SPb.: Izd-vo RGPU im. A.I. Gertsena, 2019, pp. 131-135

[19]V.V. Smirnov, R.V. Yemel'yanov, I.Yu. Shtrigel', Virtual'naya laboratornaya rabota «Izucheniye kombinatsionnykh skhem dlya zadannoy logicheskoy funktsii», № gos. registratsii 2010611857 ot 11.03.2010, zayavl. 19.01.2010

[20]O.M. Alykova, I.M. Arov, M.D. Zuyeva, Primeneniye laboratornykh rabot, vypolnyayemykh s ispol'zovaniyem telemetricheskogo metoda, pri izuchenii kursa fiziki v vuze, Sbornik materialov Vserossiyskoy molodezhnoy konferentsii «Innovatsii i tekhnologii Prikaspiya», Vserossiyskoy nauchno-prakticheskoy konferentsii «Issledovaniya molodykh uchenykh – vklad v innovatsionnoye razvitiye Rossii» T.1 (Astrakhan', 10-13 oktyabrya 2012), Astrakhan', Astrakhanskiy gosudarstvennyy universitet, Izdatel'skiy dom «Astrakhanskiy universitet», 2012, pp. 52-54

[21] A.I. Fishman, A.I. Skvortsov, B.K. Laptenkov, Vozmozhnosti telemetricheskogo praktikuma v organizatsii uchebno-issledovatel'skoy raboty studentov mladshikh kursov i shkol'nikov, Fizicheskoye obrazovaniye v vuzakh, 23(1) (2017) 84 -90