Some aspects of the use of cloud computing in the training of physics teachers

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Abstract. The specifics of the training of physics teachers lies in the extensive use of experimental research. E-learning, the role of which has increased due to quarantine restrictions, has the means of experimental research in its arsenal. The international educational community has developed and uses a variety of electronic educational resources, which are integrated into collections and libraries. The professional training of physics teachers is not an exception. Electronic educational resources make it possible not only to deliver educational material in a variety of ways, sometimes impossible without ICT, but also to simulate events and processes for their wider study in educational purposes. The use of cloud calculations in the form of virtual laboratory workshops is a way to solve existing problems in the training of future physics teachers. The use of cloud calculations in the educational activities of future physics teachers contributes not only to the improvement of educational material but also to the improvement of digital competence of all participants of the educational process. The research analyzed the available virtual laboratory practices, the scheme of using physics simulations was suggested, the examples of their use during physics teaching and the role of cloud calculations in the training of physics teachers were given. An analysis of the use of cloud computing and the best practices of this activity is carried out.

Keywords: physics teacher training · e-learning · virtual laboratories · e-educational resources · cloud computing

1 Introduction

Education is deeply influenced by the progressive introduction of information and communication technologies, which leads to the development and creation of e-learning or intelligent learning environments on a global scale for educational technologies [6]. E-learning uses modern multimedia, Internet technology, cloud computing, virtual and augmented reality to enhance the learning experience or the quality of instruction. E-learning gives students easy access to resources and services on the one hand, and facilitates remote exchange and collaboration on the other hand.

Being popular all over the world, virtual laboratories are a part of various fields of education. Virtual labs not only help students overcome the problem of lack of practical skills, but also help to overcome digital alienation and gain digital skills and abilities. It is clear that a virtual laboratory cannot completely replace experimental work and teacher work. But they provide practical support for the teaching activities of modern teachers and student learning activities. Thus, the study is intended to contribute to the use of math calculations by students who study at the specialty "Secondary education (physics)" with the expected efficiency.

The COVID-19 pandemic has accelerated the digitalization of university education and the development of e-learning [15, 18, 20]. The education system is undergoing a paradigm shift, which creates new opportunities in the learning environment, encourages the creation of new educational projects based on information and communication technologies. The acquisition of ICT competence by teachers and students is an urgent need for many universities due to the many benefits they can bring to teaching, learning and research. Over the last few years, ICT has entered all levels of education, changing the roles of teachers, lecturers and students. Information and communication technologies make it possible to create an effective creative learning environment in the learning process, which can lead to significant changes in the roles of both students and teachers, promote individualized learning and improve student motivation [14].

The specifics of preparing the future physics teacher lies in the high level mastery of physics devices, the establishment of educational physics experiments, the use of modern, especially digital, laboratories. The equipment needed for this purpose is not a common thing in modern Ukrainian schools. There are educational institutions which received modern equipment for physics classrooms for different purpose programs. Laboratory complexes by such manufacturers as Vernier, NTL, STEM-class, Elizlabs, etc. meet the "Standard list of educational equipment and facilities for educational laboratories and STEM-laboratories" (Order N574 of the Ministry of Education and Science of Ukraine from June 29, 2020). Thanks to modern equipment it is possible not only to conduct experiments while studying physics, but also to use modern computing technology for this process (BYOD technology). Designing the educational process based on the existing educational environment is one of the tasks of a physics teacher. Physics experiment during physics teaching is a necessary element, and therefore, the teacher tries to use all possible means for its organization. It is necessary to consider various options for improving the current situation, including the use of mobile devices for the benefit of teaching, the use of cloud computing for organizing virtual laboratory works, conducting calculating experiments, collaborative search and publication activities, etc.

2 Literature review

The system of in-service training of secondary school teachers is beginning to be reformed. Teachers are given the freedom to improve their professional level through non-governmental organizations, various forms of such training are recognized as acceptable. The requirements of the new standard of natural education define the skills associated with research. Dementievska [5] outlines the basics of inquiry based science education, which explains why research education should be important for educating science teachers. The challenges facing teachers in accordance with the main provisions of New Ukrainian School reform [23] and Ukraine's participation in the international PISA study [11] can be realized through the development of new forms of improving the professional level of teachers of natural education.

Training future physics teachers is a complex and multidimensional process that must combine pedagogical orientation and deep knowledge of physics. Researchers from different positions consider the process of professional training of physics teachers and try to apply not only modern pedagogical technologies but also modern technical and information tools. According to Martyniuk et al. [10], it is necessary to develop students' information and digital competence by actively implementing existing software and hardware in the physics educational process, in particular, laboratory workshops. The example of laboratory work carried out in educational institutions shows how modern software can be used to analyze the movement of bodies and determine the physical characteristics of this movement. Specific ways of performing laboratory work, analysis of its results and conclusions are given. It is in the combination of existing learning practices with modern gadgets, specialized and general programs that the main way of forming information and digital competence is seen. Further ways of modernization and improvement of the described methods of increasing the level of information and digital competence are proposed, which will lead to improved training of future physics teachers.

The study by Kiv et al. [7] examines the possibilities of using specialized (virtual laboratories and simulators, software for modeling natural processes) in school research and general and general programming (CAS programming languages and libraries, electrical libraries). The authors believe that programming languages and libraries of programming language extensions in school research can be used to model phenomena that cannot be studied in a school laboratory (for example, to model radioactive decay or to demonstrate relativistic mechanics). Also, virtual laboratories in school practice are usually used in cases where students can not perform the experiment in real laboratories. For example, it is convenient for distance learning. The use of programming languages and libraries in physics research requires both students' competence in physics and programming competence. Therefore, the use of this software in physics lessons can hardly be recommended. However, programming languages and extension libraries can be a powerful tool for the formation and development of research competencies of physics students in extracurricular educational activities. The introduction of spreadsheets and CAS in school physics studies is the simplest and has its advantages.

According to the research of Merzlykin et al. [12], a modern means of supporting educational research in physics education is the cloud oriented electronic educational resources. The research has established that the technological basis for the conversion of traditional electronic educational resources for the support of educational physical studies into cloud oriented ones is virtualization of: storage devices (accessed under the Data as Service model), hardware (Hardware as Service), the computer as a whole (Infrastructure as Service), the software system (Platform as Service), the user's desktop (Desktop as Service), and the user interface of specific software (Software as Service). The choice of the leading means of cloud technologies for the formation of research competences of students in the professional teaching of physics is explained and it is established that their complex use at all stages of teaching physics research provides the possibility to form most of research competences. It is shown that in the process of forming the research competences (ability to plan the research, to use ICT tools for projecting research activities, to make conclusions on the obtained results and to assess the plausibility of the research results) the tools of cloud technologies play an additional role.

Developed by Merzlykin et al. [12], the model of using cloud technologies as a tool for shaping the research competencies of high school students in the process of vocational training in physics specifies the organization of educational activities for shaping research competencies (Olympiads, tournaments of young physicists, creative and research works, conferences, laboratory works and workshops, Physics experiment at home, elective and optional courses, professional groups on the basis of institutions of higher education and scientific professional schools of the Ukrainian Small Academy of Sciences) and methods of professional teaching of physics, the most necessary for formation of students' research competences are general (heuristic, research and project methods) and special methods (task, laboratory and simulation methods). The researchers also specified the main (software for modeling of physical processes, virtual laboratories, table processors, computer mathematics systems, statistical packages, software for downloading or recording video, audio, etc., and presentation editors) and additional (software for creating link diagrams, states, classes, objects, etc., software languages and libraries, word processors, laboratory journals, project management software, virtual simulators, content analysis tools, media editors, etc.), means of cloud technologies for creating research competencies.

In the general picture of informatization of education, more and more information tools are used to teach physics at a particular university. Information technology has not only effectively improved the quality and efficiency of teaching, but also places increased demands on teachers and students. Ma [8] described the impact of information technology teaching on the teaching of physics at the university explored from three aspects of cloud computing, smartphones and smart classrooms in the Internet age. At the same time, the researcher discusses the direction of development of reforms and innovations in physics teaching in order to change the existing model of physics teaching at the university and improve the quality of physics teaching through information technology teaching in the Internet age. The author concludes that the information approach to learning can not completely replace the traditional method of learning. In the era of information-oriented learning, more attention should be paid to the combination of information education technologies and traditional teaching methods in the Internet age. It is necessary to optimize the approach to classroom learning, and use information technology learning in the Internet age as a catalyst to improve the quality of teaching and open a new section of teaching physics at the university.

The study by Bogusevschi et al. [3] describes the results of the Water Cycle in Nature application, which demonstrates and teaches about the water cycle in nature. The application was developed as part of the NEWTON European Horizon 2020 project and was implemented during the physics lessons for 12–13 year old students in the city of Dublin, Ireland. The feedback about the programs and technologies used was collected using the Learner Satisfaction Questionnaire. Along with the previously reported statistically significant increase in the knowledge gained by the experimental group using the application compared to the control group, it was also shown that it provides students with a good learning experience, as about 74% of the students enjoyed learning with the Water Cycle in Nature application.

The virtual laboratory workshop in the Optics section is described by Billah and Widiyatmoko [1]. The workshop covers dispersion, diffraction, interference, and polarization. The users of this product take an direct part in monitoring, measuring and obtaining the empirical data. The virtual laboratory practice was tested and evaluated by a peer review process involving educational content experts, medical resource experts, and teacher practitioners. According to the observers, the workshop was rated "excellent" with a value of 4.63.

The research results of Vavilala [16] demonstrate the synthesis of high-performance computations, cloud computational servers (e.g., Google Colab), and high-performance platforms for deep learning (e.g., PyTorch). Using the Hopfield network as an example, the author demonstrates the capabilities of computer modeling for physical experiments and faster learning due to computer modeling of physical processes.

3 Research results

Training of future physics teachers involves the formation of mastery of both general and specific skills of professional activity. Specific skills of training future physics teachers include: in-depth knowledge of physics; skills in working in physical laboratories; work with physical devices; selection and adjustment of equipment for physical workshops and experiments; organization of students' work during the physical workshop; ability to explain physical phenomena; ability to conduct experiments and experiments with physical phenomena and processes; solving physical problems.

The specifics of the training of future physics teachers is the widespread use of experimental research. Experimental work is one of the most important sources of knowledge. In combination with modern equipment, technical devices and appropriate means of the educational process, experimental work contributes to a deeper acquisition of knowledge, skills and abilities. Regular use of experimental work in teaching and studying physics helps to acquire skills and understand mechanisms and phenomena, explains their origins in the context of theories, develops and improves experimental skills and abilities that will be very useful in future professional activities, and finally nurtures maximum accuracy of experiments. Experiment certainly helps to understand the peculiarities of physical processes, as it is the most important way to understand the connection between theory and practice by transforming knowledge into beliefs.

Practical classes are among the features of educational programs in natural sciences at universities. However, these activities require a lot of modern equipment and special technical devices and appliances. Unfortunately, Ukrainian universities face a number of problems with the purchase of technology and modernization of equipment due to lack of money. The next factor is quarantine restrictions due to biological threats or even armed conflicts and the need to move to save lives. Even if the laboratory is fully equipped with the necessary tools and materials, real experience requires much more time to prepare, complete the task, as well as to analyze the results of work. Virtual labs and virtual experiments can be a good alternative to real experimental work. They allow teachers and students to be flexible, to train practical skills before real life situations. In addition, many students can study theory online, but there are some significant limitations when trying to gain skills online or using traditional methods. Indeed, virtual labs can be effective in helping students acquire analytical and research thinking skills, develop strong persuasion skills, and make decisions in uncertainties [2].

The real discovery in the teaching of school physics is the fact that modern mobile devices include a set of sensors capable of measuring time, acceleration, angular velocity, magnetic field induction, illumination, noise level, atmospheric pressure, humidity. What is important is that the student, using the device available to him, becomes a real researcher of the world around him, and this is one of the main goals of teaching physics. The technology of using mobile devices in the learning process of students is called BYOD (Bring Your Own Device) and today is one of the areas of pedagogical research [4, 10, 21, 22].

The use of sensors of mobile devices for these purposes is possible with the help of such applications as Smart Tools, Sensor Kinetics, Physics Toolbox Suite, Sensor Multitool and others. Mobile applications allow not only to measure physical quantities, but also build graphs of changes in measured parameters in real time. With the help of a mobile device, you can measure values both in class and at home or on the street.

Based on the above considerations, we can identify the following meaningful line of professional training of future teachers of physics:

– organization of practical research of the environment taking into account the conditions of use of information technologies;
– use of specialized software to turn mobile devices of learners into a device for measuring various physical parameters in real time;
– processing of the received data by available applications of the comprehensive data analysis.

The implementation of a mixed form of education with components of non-formal education in the speciality (educational program) 014 "Secondary Education (Physics)" can be very useful [21]. E-learning allows future teachers of physics to update their knowledge, get acquainted with new devices and methods of experiments, update their knowledge of the use of ICT in educational activities [22]. The use of virtual laboratories has many advantages: it allows you to conduct experiments at any time, feel safe when conducting dangerous experiments, see all the details of the experimental process and take an active part in conducting experiments. On the basis of virtual laboratories, students have the opportunity to conduct repeated experiments until they are completely satisfied with the results of the experiment.

Open education, among others, provides an opportunity to involve simulations and virtual laboratories in educational activities. For the educational program 014 "Secondary Education (Physics)" PhET simulations (https://phet.colorado.edu/uk/) developed by the University of Colorado are well known. Harvard University has combined a variety of world-class e-learning resources on the LabXchange platform (https://www.labxchange.org/). As of November 2021, LabXchange contains 3,674 links to e-learning resources and their physics-related kits. Videos, simulation texts cover all sections of modern physics, contain information on the history of physics and the latest physical theories. In addition to simulations from the University of Colorado (figure 1), there are simulations from The Concord Consortium (https://concord.org/). The simulations located on the GitHub resource (https://github.com/) are constantly evolving, but unfortunately these electronic educational resources are not cataloged.

No less interesting, but unfortunately not free to use, is the resource PraxiLabs (https://praxilabs.com/). The resource contains electronic educational resources in the form of virtual 3D simulations of laboratory experiments (figure 2). The format of educational resources allows them to be integrated into popular learning management systems (Moodle, Blackboard LEARN and others) using Learning Tools Interoperability (LTI) technology. You can get acquainted with the possibilities of the PraxiLabs resource through demonstration simulations.

Also quite interesting is the Labster virtual lab (https://www.labster.com/). Once a week, the company holds a 30-minute webinar, which can be attended by no more than 100 people (https://wp.labster.com/introduction-to-labster/). It is at this webinar that the company introduces the conditions of use and opportunities for their development. It should be noted that virtual experiments

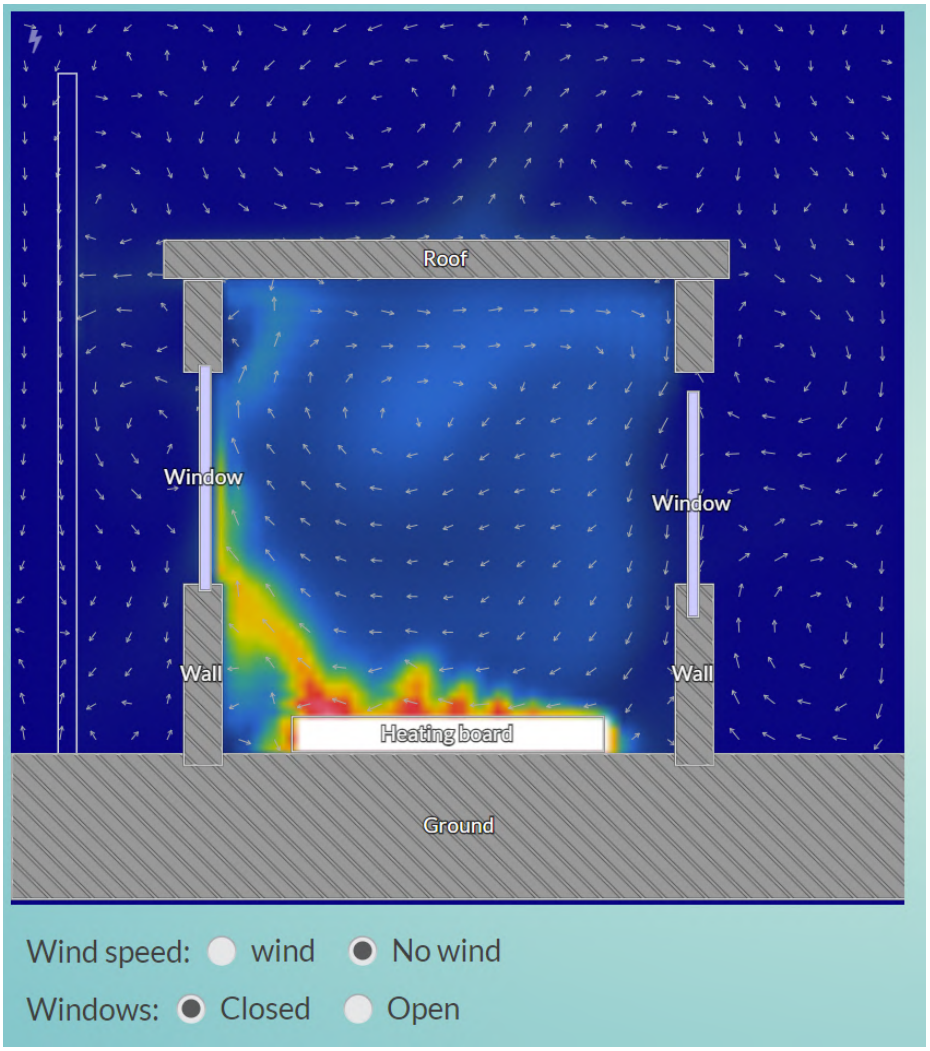

Fig. 1. An application of the physics simulation from The Concord Consortium collection.

are built into learning management systems. The Labster platform has a free trial account (https://www.labster.com/pricing) and is constantly updated.

Useful for use in e-learning is a set of open e-learning resources from California State University, Long Beach (https://www.csulb.edu/) called MERLOT (https://www.merlot.org/merlot/). More than 6.8 thousand electronic educational resources are contained in the MERLOT collection related to physics. In addition, the system allows you to search other libraries and sites of popular educational resources on the Internet.

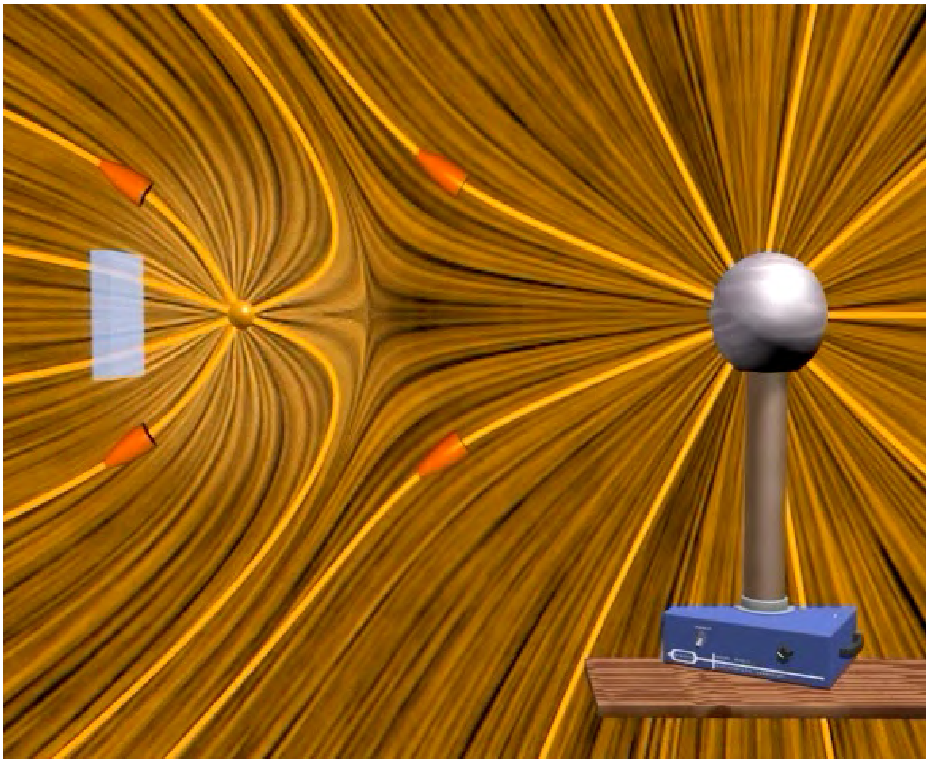

Fig. 2. The application of the simulation of the electric field from the MERLOT collection.

The Go-Lab online laboratory (https://www.golabz.eu/) is supported by the University of Twente (http://www.utwente.nl/en), École Polytechnique Fédérale de Lausanne (EPFL) (https://www.epfl.ch/) and Information multimedia communication AG (https://www.im-c.com/). The purpose of the Go-Lab is to promote the development of innovative learning technologies with a focus on virtual laboratories, which positions itself as a "Sharing and Authoring Ecosystem". From the sections of physics, the laboratory currently contains 715 virtual laboratory works, 70 of which are available in Ukrainian.

The Physics at School kit (https://www.vascak.cz/) contains simulators in the following sections: mechanics, gravitational field, mechanical oscillations and waves, molecular physics and thermodynamics, electrostatics, electric current, semiconductors, electric current in liquids, electric current gases and vacuum, magnetic field, alternating current, optics, special relativity, atomic physics and nuclear physics. The simulators are developed by Vladimír Vaščák and are available for both desktops and mobile devices. The policy of free translation into various languages has made it possible to translate into more than 30 languages, including Ukrainian.

The Apps on Physics simulator collection (https://www.walter-fendt.de/html5/phen/) is developed and maintained by Walter Fendt and is constantly updated. As of February 2022, the collection contains 55 simulations implemented in HTML5 and implemented in 19 languages, the Ukrainian language is not available. The simulations cover all sections of the school physics course and can be run on different devices.

The online laboratory OLABS (http://www.olabs.edu.in/) contains simulations in physics, chemistry, biology, mathematics and English. Created with the support of the Ministry of Electronics & Information Technology of India. In physics, laboratory work is related to secondary education and is designed for grades 9–12 and consists of the following components: theoretical block, laboratory work procedure, animation with explanation (on virtual equipment), video recording of work on real equipment, list of additional learning resources, self-test, a simulator for working with a form of execution (which can be saved as a file or printed) and a feedback unit. Similar simulations are available at VALUE @ Amrita (https://vlab.amrita.edu/?sub=1).

The resource myPhysicsLab.com (https://www.myphysicslab.com/) offers to study simulations in mechanics, oscillations and waves. Simulations from Erik Neumann represent not only a visual model of the interaction between the parts, but also build graphs of various kinds for further analysis of the results of the experiment.

The Open Source Physics project (https://www.compadre.org/osp/index.cfm) contains a collection of simulations, computer modeling, training materials, and resources for computational physics, etc. The Tracker tool extends traditional video analysis by allowing users to create particle models based on Newton's laws. Since the models are synchronized with the video recordings of real objects and painted directly on them, students can verify the models experimentally by direct visual inspection. Simulations for students, guided study of physical systems and concepts. is a powerful approach to the learning experience. Easy Java Simulations provides students and teachers with computational tools for studying physics without the need to learn Java programming details. OSP educational packages combine computer modeling with teaching materials and student workstations. The packages can be modified according to the needs of the instructors and students. Open Source Physics provides great resources for computational physics and physics modeling. Included: Eclipse Environment for OSP; OSP Output Code Libraries; OSP Best Practices; Documentation. An example of a simulation of optics is shown on the figure 3.

Computational physics can also be implemented by means of universal systems. Such systems include the cloud computing service CoCalc (https://cocalc.com/). As a cloud implementation of the Sage project, it supports the editing of Sage arcs, LaTeX documents, and Jupyter notebooks. CoCalc works in the Ubuntu Linux environment, which can be interfaced via a thermal, additionally granting access to most Linux features. The main concept of both Sage and its cloud implementation of CoCalc is using the existing open source mathematical software and combining their use in one place, adding the capabilities of LaTeX

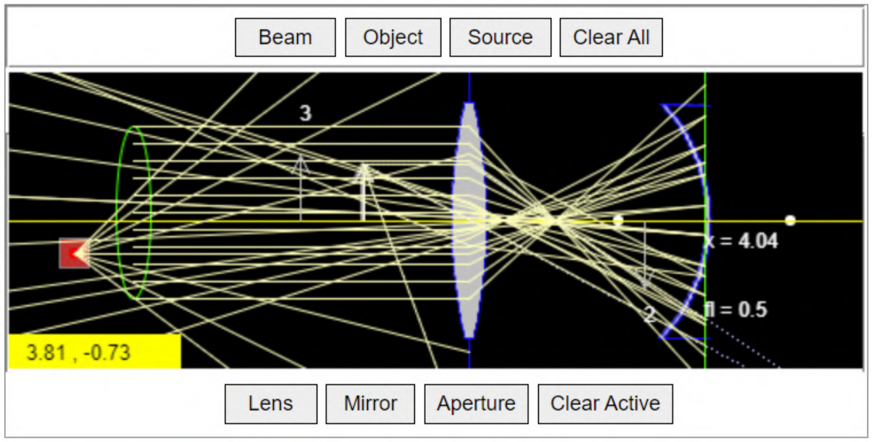

Fig. 3. An example of the simulation from the Open Source Physics project.

mathematical text processing and the possibility of Python programming [9]. An example of the laboratory work in physics is shown in figure 4.

Salnyk [13] determined the methodological grounds for the combination of real and virtual experimental investigations in physics. They include:

– providing direct and mediated by means of ICT communication between the subjects of study, involving the student in the processes of planning, management and monitoring of the study, providing universal access to educational and scientific resources;
– using the different types of educational research in physics vocational training based on the same type of ICT devices that are used during the whole length of the training period for different forms of organization;
– creating an open educational environment as a cooperative environment for teachers and students through the use of cloud teaching technologies and support for students' educational and research activities;
– the involvement of devices and technologies that correspond to the level of development of physics as a science, requirements to its study with the aim of high level competence in research work to the means of support for physics students;
– using the forms of organization of educational activities for the formation of research competencies and methods of vocational training, best practices of educational and research activities with the aim of creating the most favorable conditions for the formation of research competencies of students.

According to the specified methodological requirements for conducting physics experiments using cloud technologies, teachers should have in their arsenal the appropriate software, including the cloud service, and a coordinated method for teaching physics through the use of cloud calculations. Firstly, it is the means

```
In [58]: # write your code here
         from math import *
         import numpy as np
         import matplotlib.pyplot as plt
         import phys201quantum as phys201q


         %matplotlib inline

         psi0 = phys201q.make_psi0([-8, 8], 250, 'gaussian', .25, 0, 0)
         V = phys201q.make_piecewise_potential([[-8, 0], [8, 0]])
         psi_evol = phys201q.schro_evolve(psi0, V, tmax=1.5)

         phys201q.plot_psi_at(psi_evol)
Out[58]: Doing 363 steps of size 0.004129 with sigma=dt/(4dx^2)=0.250000
         Outputting 100 time slices separated by 3 dt=0.012387

         (<Figure size 432x288 with 2 Axes>,
          <matplotlib.axes._subplots.AxesSubplot at 0x7f46b104dc50>)
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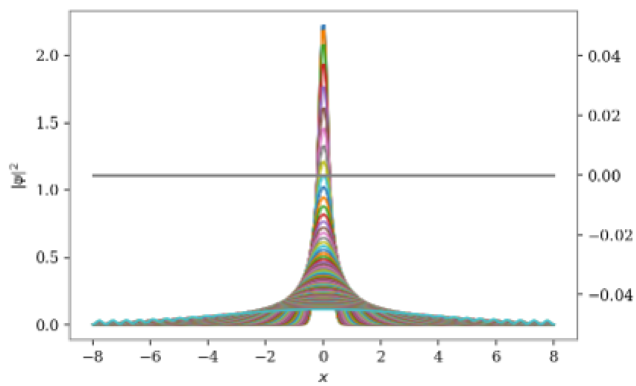

Fig. 4. Performing physics calculations in the CoCalc system.

of communication between the participants of the educational process that are often realized by cloud services. The organization of training through notice boards, public groups and channels, joint documents with available access allow you to solve the problem of getting all the participants in the educational process to the initial activity. Discussion of the learning process, educational tasks, problems, and issues that may arise is necessary both during the distance and classroom-based forms of educational activities. The presence of ICT communication allows for a quick transition from one form of organization to another, motivates students to self-organization and teaches the frequency of educational activities. The planning of educational activities makes it possible to use a wider range of learning technologies.

Secondly, it is the use of electronic educational resources in the classroom form of learning. Introduction of new material using multimedia teaching materials, in-process and summary evaluation by means of automated testing or collection of answers with the subsequent announcement of the results by means of infographics. Project activities of students, which will be carried out and implemented by means of digital technologies provides the opportunity to include all participants in the educational process in the creative teamwork. Using smart technologies as a support system for the initial process is not only "train" students to use them, but also to form information competence, increase the productivity of educational activities, reduce the workload of searching for the necessary initial information.

Thirdly, it is a possibility of organizing self-study activities of physics students. The current content servers contain teaching materials, simulators, computational models, and so on from various areas of physics. Teaching the same subjects has different approaches, which makes it possible to innovate the teaching material. Moreover, some physics subjects are not covered in the school program or are placed on the self-study activity. Electronic educational resources in physics, including those based on the cloud servers, make it possible to conduct interdisciplinary research. The STEM education is presented in the electronic educational resources. For this teaching technology it is necessary to have a certain preparation [19]. It is a common practice to organize self-educational activities not only by providing the necessary electronic educational resources but also by completing collaborative project tasks, peer review of completed tasks, organizing extracurricular activities, etc.

Consider in more detail the example of the use of virtual laboratory workshops in the training of future physics teachers. Professional training of future physics teachers identifies physical experiment as the main source of knowledge about the world and its laws, and if in the classroom on molecular physics future teachers have the opportunity to conduct experimental research with the necessary laboratory equipment, during self-education physical experiments can not be conducted. In this case, it is necessary to use physical simulators and empirical data processing programs. And since independent work is not always performed in the laboratories of higher education institutions, it must be provided in the conditions of extracurricular activities. This requirement involves a review of methods and tools for studying the discipline "Molecular Physics" with the introduction of a new means of learning – information and communication technologies to support the study of the discipline.

The software to support the study of the discipline "Molecular Physics" includes simulators of physical processes, tools for processing and visualization of measurement data, tools for creating electronic educational resources and more. Studying thermodynamic isoprocesses in gases, you can use the established laboratory installation (figure 5). In this case, to calculate the results it is necessary to use software for processing tabular information.

Physical simulators have animation and detailing of processes that the researcher during the physical experiment can not observe the available meth-

Fig. 5. Device for studying gas laws (https://www.didact.com.ua/product/nabir-dlya-vivchennya-gazovih-zakoniv/).

ods. Physical simulation of PhET "Properties of gases" also has such properties (figure 6). The motion of molecules, their velocity distribution, the number of molecules that have been "pumped", etc. provide additional opportunities for research. Despite the existing advantages of computer simulation of physical processes, their use in educational activities should correspond to the following scheme:

– forecasting the physical phenomena that will be demonstrated;
– acquaintance with computer models of physical processes, conditions of change of sizes and their parameters;
– conducting an experiment on a computer model, collecting the obtained data;
– analysis of the obtained results.

The proposed scheme of using physical simulations is suitable for both independent work and group work, without excluding the distance learning option. In addition, the data obtained during the computer simulation can be processed collectively. Each of the participants makes measurements with the specified step

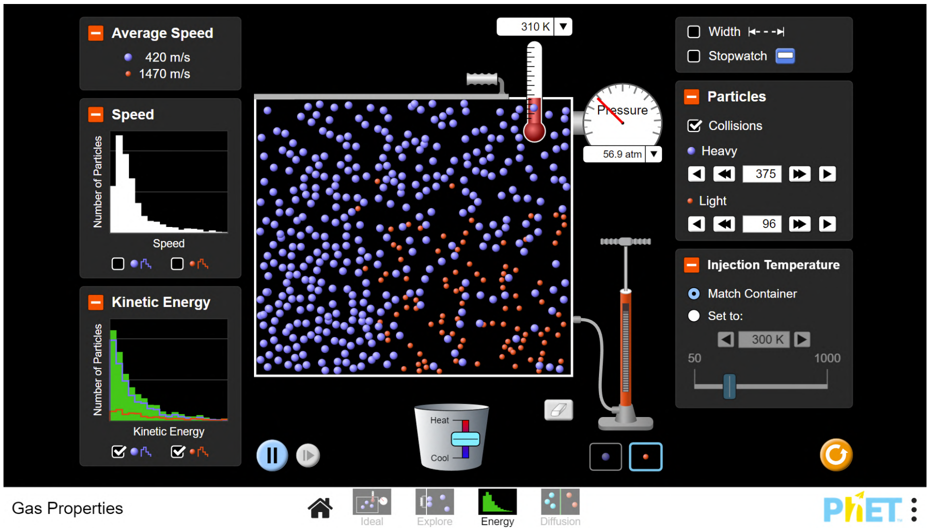

Fig. 6. PhET simulation "Gas properties".

and different initial values. This results in a large amount of data, the processing of which with the help of tabular data software makes it possible to obtain more accurate general conclusions.

An example of a task using computer simulation is as follows: using computer simulation of physical processes PhET "Gas Properties" (https://phet.colorado.edu/sims/html/gas-propertieslatest/gas-properties_en.html) at a constant volume to determine the relationship between gas temperature and pressure for different gases and their concentrations (big and small), different number of gas molecules. Record the results of research in the table, the results of measurements are presented in the form of a graph of pressure versus temperature for different numbers of molecules of different types.

The obtained results of the simulation are entered into a table and possible regularities are calculated. An example of such a table is the table in figure 7 made in the Google Sheets cloud application. During the simulation, the data of gas temperature and generated pressure in the chamber at a constant volume are entered. After completing the task, the relationship between temperature and pressure is analyzed, it will be sufficient to construct a diagram of the dependence of these two quantities.

On the methodological associations of physics teachers in the cities of the northern part of Donetsk region and the associations of physics teachers of physics of vocational higher education in the northern part of Donetsk region there was an interview conducted on the use of cloud computing in physics teaching. On a scale of 1 to 5 respondents answered the questions about the use of cloud computing in their own educational activities. The obtained results are presented in the diagram in figure 8 (for comparison figure 3.37 in the [12]. The

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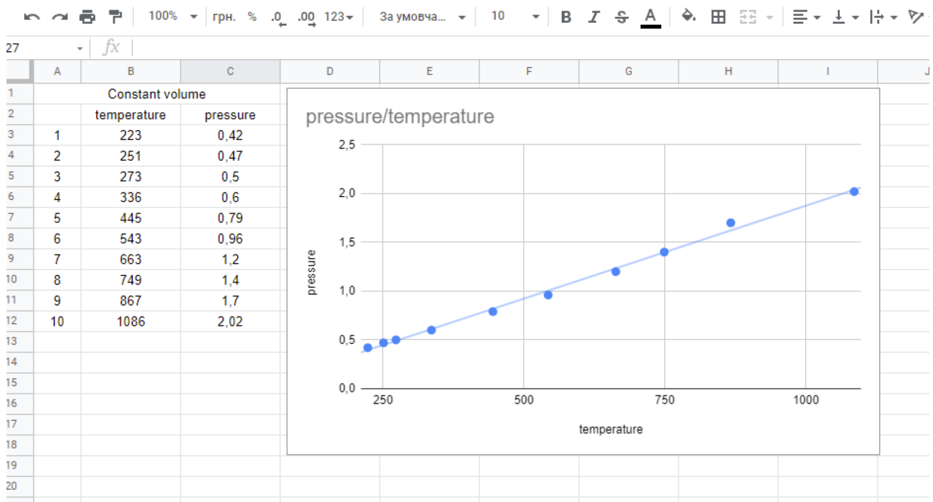

	Constant volume	
	temperature	pressure
1	223	0,42
2	251	0,47
3	273	0,5
4	336	0,6
5	445	0,79
6	543	0,96
7	663	1,2
8	749	1,4
9	867	1,7
10	1086	2,02

Fig. 7. Analysis of the obtained data after the simulation of the physical process.

interview with respondents revealed the following statements. The low level of use of statistical packages, computer mathematics systems is explained by the lack of significant amount of empirical data necessary for calculations and the lack of necessary knowledge in middle school students. Most calculations are done by hand or by electronic spreadsheets. The use of open electronic educational resources is disrupted by the lack of their localization in most cases. Simulators of physical processes, software for modeling of physical processes and virtual laboratories are often used when it comes to the calculations.

4 Conclusions

Modeling is an essential element of scientific knowledge, a mean of investigating objects, events and phenomena. The use of modeling in physics is caused by both impossibility to carry out investigations on real objects and the danger that some physical processes can pose. The specifics of training of future physics teachers is in the use of experimental physics laboratory practices. The current organization of the educational process requires extensive use of e-learning, in which digital technologies play an important role. The use of cloud calculations to study physics significantly increases the efficiency of the teaching process, makes it more meaningful, thorough, contributes to the development of digital skills and abilities of students and teachers, improves the quality of teaching and encourages distance learning and/or blended learning which became very popular during the COVID-19 pandemic. Indeed, virtual tools cannot completely replace physical experimental work and the teacher's explanations, but virtual tools can support the work of a modern mentor, the student's teaching activity, and increase professionalism, open new horizons and, most importantly, allow

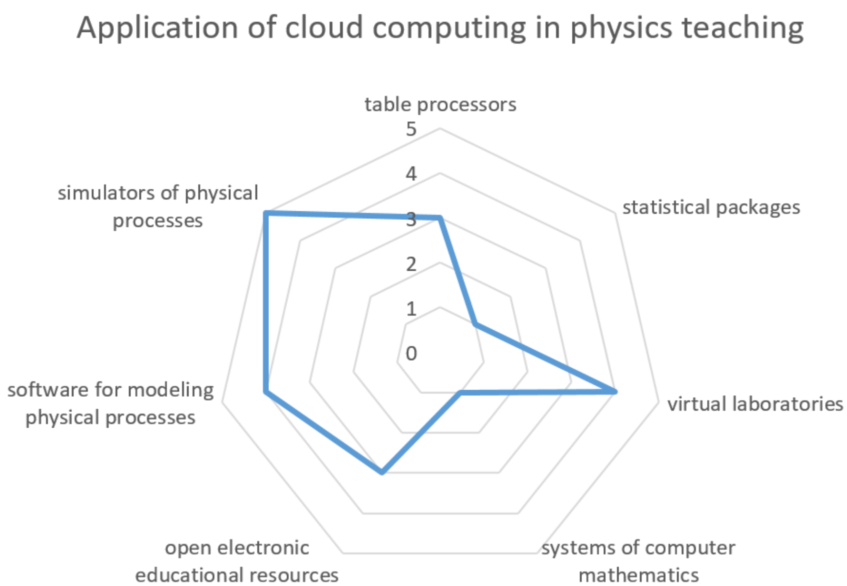

Fig. 8. The use of cloud computing in physics classes.

to improve the motivational component of learning through active dialogue of the student with the computer, by encouraging him on the way to success and mastering elementary knowledge of the natural sciences, including physics.

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