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USE OF DIGITAL TECHNOLOGIES IN THE COURSE OF PHYSICS AT TECHNICAL UNIVERSITY

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Abstract

A study is being carried out in the search for methods of using digital technologies in a physics course at a technical university. The possibilities of using online lectures, practical exercises and virtual laboratory work are being investigated. The search for a balanced solution using virtual and real laboratory work has been done. Attention is paid to ensuring the information security of educational Internet resources of universities. It is concluded that universities need to pay attention to ensuring information security, fault tolerance, and scalability of online educational resources. To identify the student's identity on the university's online resources, it is proposed to use an enhanced qualified signature recorded on a St. Petersburg electronic card. Thus, the St. Petersburg electronic card can be used to receive scholarships, as an electronic record book and library card for the library, as well as an authentication tool on an educational Internet resource. In connection with the development of the Internet, students gained access to a huge array of knowledge, and the teacher no longer plays the role of a single source of information. The teacher should be able to direct and organize work in small groups of students. It is necessary to form the student's skills in caring for his physical, mental and spiritual health from the moment one enters the university. Therefore, it is important to introduce classes on the development of health-saving technologies in full-time and distance learning.

Keywords: Online education, physics, distance education, virtual laboratory work, effective educational technologies, health-saving technologies.

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1. Introduction

In technical universities, a physics course is usually included in the curriculum in the preparation of specialist engineers and master's degree students. It is impossible to imagine the formation of the future highly qualified technical specialist, researcher or developer without learning physics. The rapid change of technology in society and the constant modernization of production structures and processes dictate the need to increase the effectiveness of universities not only in obtaining the necessary amount of knowledge in physics, but also in attracting new technologies of the educational process in order to increase students' motivation, increase their independent work and instilling project work skills in small groups. When using distance learning methods, it is necessary to provide a student identification procedure with a high degree of reliability in real time. The authors are considering the possibility of improving the educational process by using modern digital and health-saving technologies in a physics course.

2. Problem Statement

The use of digital technologies in teaching physics requires the study of new urgent tasks to develop technologies for their effective application with an increase in the quality of the educational process. The following issues need to be considered:

- Search for effective methods of using online learning;
- Ensuring high availability and information security of online university resources;
- Search for a balanced solution using virtual and real laboratory work;
- Maintaining students' health with prolonged use of online courses.

2.1. Finding effective online learning techniques

In recent decades, we have seen an active growth in the online education market. Some universities are actively creating their solutions for the implementation of online education, and some universities simultaneously use the solutions of major world leaders in the field of network education (Vaganova et al., 2018). For example, eight Russian universities are partners of the Coursera international educational platform: St. Petersburg State University, Moscow Institute of Physics and Technology, National Research Nuclear University MEPhI, Tomsk State University, National Research University Higher School of Economics, Moscow State Institute of International Relations Russian Ministry of Foreign Affairs, Peter the Great St. Petersburg Polytechnic University, Novosibirsk State university. In addition to universities, Coursera partners are two Russian organizations: ANO Sberbank Corporate University and Yandex.

To implement their own online education platforms, Russian universities mainly use the Moodle distance learning environment (Vaganova et al., 2019). This system is a free and licensed by GNU GPL web application. The high quality of the Moodle system and the possibility of free use allowed it to be widely used in Russian universities (Gerasimova et al., 2018).

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2.2. Ensuring high availability and information security of online university resources

It should be noted that solutions independently implemented by universities do not allow solving the problems associated with ensuring high availability, fault tolerance, scalability and information security. Solving these problems requires high costs for the rental of computing resources in geographically distributed data centers and high qualifications of full-time IT specialists at the university. As recent events associated with the abrupt transition to distance education, carried out in connection with the implementation of measures to prevent the spread of the coronavirus COVID-19, have shown not all university information systems can withstand increased loads. It should be noted that a small number of universities are ready to repel hacker attacks on their educational network services. For example, hackers can hack the system and modify test results, steal information about students and university teachers, and can steal the content of distance learning courses. Are many universities ready to repel DDoS attacks? We have tested a number of sites of Russian universities using Moodle. The following vulnerabilities were discovered by the authors: obsolete PHP and Nginx software, the publicly available Git directory, incorrectly configured security headers, and the lack of cloud-based protection against DDoS attacks.

It is worth emphasizing separately that in many systems the user authentication system has not been developed. At the entry level, universities should implement authorization through the Unified Identification and Authentication System (UIAS). In the future, the authors recommend the introduction of an advanced qualified electronic signature (AQES). AQES can be recorded on a smart card such as, for example, a single card of a Petersburger (SCP). SCP is an electronic smart card that combines the capabilities of a bank, discount and bonus cards, as well as an electronic travel card and an electronic signature carrier. You can issue a SCP at the branches of the largest banks in St. Petersburg. Currently, the Committee on Economic Policy and Strategic Planning of St. Petersburg, together with the leading universities of St. Petersburg, is implementing a pilot campus project.

Students and faculty of St. Petersburg will be able to use the SCP as:

- admission to university buildings and classrooms;
- electronic library card;
- electronic record book;
- a carrier of AQES used for authentication and authorization on the educational resources of the university;
- student scholarships receiving.

In some cases, it is more rational for universities to use the services of third-party educational platforms, such as Coursera and the National Open Education Platform (NOEP) project (Kudinov et al., 2018). It should be noted that the NOEP project is built on the Open edX platform, licensed under the AGPL and Apache licenses.

The AGPL (GNU Affero General Public License) is supported by the Free Software Foundation. This allows one to use and share unmodified code, modify the code, and use and share the modified code.

The Apache license is supported by the Apache Foundation. It allows the same use, sharing, and alteration as AGPL, but changes that are made to the code may be licensed not only by AGPL.

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The NOEP project contains 521 courses in various areas of training. It was created by the "National Platform for Open Education" Association, established by leading universities, namely: Lomonosov Moscow State University, St. Petersburg Polytechnic University, St. Petersburg State University, National University of Economics "MISiS", NRU HSE, MIPT, UrFU and ITMO University. It should be noted that to create such a global project, it was worth developing your own domestic software package, free of possible software bookmarks. Through software bookmarks, attackers can modify the content of courses, for example, inject false information into them or disrupt the operation of the educational system. It should be noted that experts on the introduction of online education do not pay due attention to ensuring the information security of educational systems. It should be noted that if the site is protected by a foreign SSL certificate, then at any time the certificate can be revoked and the security of working with the site will be compromised. The Russian authorities so far have been unsuccessfully taking measures to solve the problem of "certificate dependence" on Western countries.

2.3. Finding a balanced solution using virtual and real laboratory works

Special attention should be paid to the current trend of the transfer of training laboratory facilities into a virtual environment (Soppa & Matus, 2018). Of course, virtual laboratory work (VLW) has a number of advantages compared to real laboratory work (RLW) such as: lower cost and the ability to perform VLW remotely. However, for students of technical universities it is important to gain skills in working with real facilities and VLW will be a good complement to RLW. The student can familiarize himself with the laboratory work in advance by working with VLW and then perform the real laboratory work more successfully. Not all laboratory work can be put into practice. For example, studies such as studying the magnetic field created by red blood cells when moving in capillaries (Kopyltsov, 2019), studying various structures of antireflection coatings (Novikova, 2019), studying the operation of airborne radar stations (Bestugin et al., 2019), studying the problems of improving the quality of wireless communication channels (Kopyltsov et al., 2018), studying the characteristics of radiation of aircraft antennas at high temperatures (Bestugin et al., 2014) are more convenient, faster and cheaper to sell using a virtual environment. Thus, first, within the framework of VLW, we model various physical phenomena with a large number of parameters changing, and then, within the framework of RLW, we implement and investigate a particular solution.

However, VLW have several disadvantages. VLW does not always fully emulate the work of RLW. Students do not get the necessary experience with real equipment. The rejection of RLW in favor of VLW will lead to a discrepancy with the federal state educational standard of higher education, a sharp decrease in the quality of training of future engineers.

2.4. Preserving the health of students with prolonged use of online courses, as well as with offline training

Academician of RAMS M.M. Davydov, president of RAMS, noted back in 2006: "We no longer have healthy school graduates". Thus, applicants enter the university when they are completely physically and psychologically exhausted. Accordingly, one cannot get a good learning outcome from such students. And this problem arose not one hundred and not two hundred years ago, but began with the introduction of a training system, when schoolchildren and students should sit at their desks and passively participate in

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the learning process. Learning outcomes are tightly assessed, and the learner is formed a fear of making a mistake. In this way, any creative element is killed in children. And at the same time, we know that any creative process is a path of trial and error. Many scientists are trying to solve this problem, including V.F. Bazaar, which has developed a health-saving technology for teaching students. It should be noted that the conditions of study at the UNIVERSITY are very different from schools and therefore it makes no sense to transfer school health-saving technologies to the university educational environment (Tsibulnikova & Khoptinskaya, 2020).

From the moment a student enters the university, it is necessary to form the skills in taking care of the physical, mental and spiritual health. Therefore, it is important to introduce classes on the development of health-saving technologies in full-time and distance learning (Irkhin et al., 2019). In the case of distance learning between physical modules, one can insert physical breaks. If in the classroom or in the corridor of the university Russian students are unlikely to do exercises, at home students who care about their health are likely to perform physical exercises. It is important for universities to pay attention to such aspects as ventilation and air purification, maintaining cleanliness of the premises, providing the opportunity to purchase clean drinking water and food, and observing breaks between classes. It is also important to conduct classes on effective educational methods that would save time.

3. Research Questions

Our study was devoted to the following questions.

- How one can use online courses to improve the quality of students in the physics course?
- What tools can be used for e-learning?
- How secure are university educational online resources?
- What technologies should be used to identify and authenticate users in online educational systems of universities?
- What is the role of health-saving technologies at the university?

4. Purpose of the Study

It is assumed that the answers will help to achieve an improvement in the quality of student learning and contribute to maintaining their health.

5. Research Methods

The studies were carried out on the basis of the Department of Physics of the University of Aerospace Instrumentation. Observations were carried out during lectures, practical and laboratory work in physics in the first and second courses. Almost all students of our university undergo fundamental training in physics, so the authors of this article had the opportunity to collect enough statistical data in two years to get the results of the study.

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5.1. Assessment of residual school knowledge in physics in first-year students

The assessment of residual knowledge in physics was carried out on the basis of written and computer tests at the beginning of the year for first-year students.

5.2. Assessment of perception of online and real lectures

To assess the perception of lectures, two student groups of approximately the same academic performance were selected and material was provided for one group in an online form and the second in the form of a standard lecture. The level of residual knowledge on lectures was measured by computer and written tests, as well as by the results of an oral interview.

5.3. Evaluation of the results of using virtual laboratory works

In the course of the study, we assessed the depth of students' understanding of the physical phenomenon of students in the course of performing virtual and real laboratory work. In this part of the study, students did VLW and RLW in different combinations: only VLW, performing VLW and then RLW and performing only RLW. Evaluation of the result was carried out on the basis of interviews with students and computer tests.

5.4. Assessment of learning outcomes in solving physics tasks

During the study, we studied the results of training students to solve tasls in various sections of general physics in online and offline classes. Evaluation of the result was carried out on the basis of tests to solve tasks.

6. Findings

As a result of our work, we found that in order to improve the quality of the educational process, attention should be paid to the following current trends:

1. The development of online education.
2. The availability of free access to large amounts of knowledge through the Internet
3. The focus of school education on a single state exam.
4. Education becomes continuous.
5. The introduction of health-saving technologies in the educational process.

6.1. Online Education Development

In Russia, the development of online education is developing quite rapidly, but so far not all universities are ready to integrate them into their educational programs (Kireev et al., 2019). Obviously, you can replace face-to-face lecture classes with online lectures. Lectures take a large number of hours in vocational training programs at technical universities. This time can be used for in-depth study of the material and practical exercises. In online mode, the listener can listen to a lecture at a convenient time and anywhere, can re-listen to insufficiently mastered fragments of a lecture or the entire lecture in its entirety. In the transition from traditional lectures to online lecturers, teachers can pay more attention not to scoring

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the material, but to analyzing the material, which caused difficulties for students. The teacher based on the received high-quality feedback from students will be able to modify the lecture material.

6.2. Availability of free access to large amounts of knowledge in the Internet

It is obvious that the teacher is no longer the only source and carrier of information. Students can find any information in the Internet. Thus, the role of the university teacher is changing. Instead of playing the role of a source of information and control, the teacher turns into a trainer who helps students find the optimal path for mastering knowledge and skills. A mutual role is currently played by mutual learning by students in small groups. And the teacher should be able to direct and organize work in small groups of students. Thus, the university acquires the features of a self-learning system. The emotional and moral climate within student groups is very important. The teacher should be able to maintain a positive and joyful atmosphere of the learning process in the classroom with students. It is important that the teacher is aware that the result of the training depends on the quality of collaboration between the teacher and students. The teacher's position is inadmissible - "I read the material to you, and it is your problem how to learn it." The teacher should try to understand what moments of the material are poorly absorbed by students and, together with students, look for approaches to overcome the problems of mastering complex material. That is, the position "me and they are students" should be changed to the position "we". Thus, in modern conditions there is a need to strengthen the feedback of students with the teacher. In the context of online education, such feedback can be carried out through conferences, through free third-party services such as Skype, Zoom, Proficonf, Google Hangouts, Appear.in, ooVoo. In terms of information security, it is preferable to deploy your conference systems, for example, based on the BigBlueButton web conferencing system (ICS) (Faye et al., 2018). At the same time, BigBlueButton ICS can be successfully integrated with the Moodle SDO.

6.3. The focus of school education on a unified state exam

The authors' observations of the first-year students led to the conclusion that the level of knowledge acquired by students at the school is insufficient to master the teaching material at the university. This is due to the fact that future applicants spend 10 and 11 high school classes in preparation for the unified state exam (USE) (Francesconi et al., 2019). In this case, the majority of applicants, in preparation for the USE, are set to reach the best level at the time of the exam, but there is no installation for long-term storage of information. Thus, after passing the USE and obtaining the required level of points, the applicant safely forgets all the knowledge learned to pass the exam. Thus, at the university, the teacher is going to restore knowledge at the school course and at the same time ensure the assimilation of material at the university level. Studies conducted by the authors in this work showed that neither school nor university education is aimed at teaching students to learn effectively.

The authors recommend that an optional "Learn to study" course be included in the university's program, in which students learn how to master new knowledge and methods for long-term storage of information. However, some universities are already introducing such courses into their programs, for example, Russian State University named after S.A. Yesenin.

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In the course of the study the authors found out that for effective mastering and memorization it is important to repeat the material all the time. Such things as presence of semantic connections between the elements of educational information and the use of intersubject communications are also very important.

6.4. Leaning turns into life-long model

It should be noted that the speed of development and technology change is increasing every year. Life expectancy is steadily increasing. And this means that a person even after graduating from a university must continuously upgrade his qualifications to a very respectable age. Some professions disappear due to the automation of production and the advent of new technologies. In this case, the specialist will need to change the profession. Thus, the university can not only prepare a specialist, but also accompany his professional development and also a change of profession. Universities can actively use online technology to do this with their former graduates.

6.5. The introduction of health-saving technologies in the educational process

The learning process is closely related to the physical and psychological condition of a person. Therefore, for effective educational work with students and graduates, the university will need to train them in methods of supporting physical and mental health (Gafiatulina et al., 2019). If a university graduates a well-trained specialist, but his health does not allow him to work fully, it is obvious that such a specialist will not be able to sell his services on the labor market at an adequate cost. Perhaps one will not be able to work at all at the university.

7. Conclusion

To improve the quality of physics education, technical universities need to actively introduce online education. However, a complete transition of technical universities to online physics education is not possible. It is wise to combine offline and online forms of training. With online training, the question arises of ensuring information security and identification. For St. Petersburg universities, it is proposed to use UIAS recorded on the SCP smart card for identification. In the process of teaching students, it is necessary to strengthen work in small groups and mutual learning of students of each other. It is necessary to teach students self-study skills and effective educational technologies. It is very important to pay more attention to the use of health-saving technologies and the motivation of students to study.

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