Experience in Education Environment Virtualization within the Automated Information System "Platonus" (Kazakhstan)

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ABSTRACT

This work reports on the use of virtual tools as means of learning process activation. A good result can be achieved by combining the classical learning with modern computer technology. By creating a virtual learning environment and using multimedia learning tools one can obtain a significant result while facilitating the development of students' intellectual faculties. One of the effective ways to form knowledge and skills is to carry out experimental studies. By carrying out laboratory practicals, one can set various goals facilitating the extension of frontiers of knowledge, significant enrichment, and diversification of learning. Students did some tasks in a traditional way, and the other tasks – when immersing themselves in a virtual environment. The work included monitoring the efficiency of virtual tools and degree of students' satisfaction.

1.   Introduction

One of the top priority trends in the development of the global learning space is the digital revolution in learning, which determines the use of computer technology as a tool for the expansion and transformation of the learning environment. Therefore, nowadays one can talk about a phenomenon implying the virtualization of the education environment. In the era of globalization, a need for continuous modernization and update of the educational system has been noted by most of the developed countries. Kazakhstan has also set some ambitious goals aiming at substantial modernization of its education. In 2010 the republic adopted a state education development program which focuses on

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the implementation of e-learning, and a comprehensive process meaning to provide the conditions for learning automation was initiated (State Education Development Program of Kazakhstan for 2011 – 2020). Various forms of e-learning are being successfully integrated in the learning environment of Kazakhstan (Akhmed-Zaki, et. al. 2014; Zhukeshov, et. al. 2015), and the program has set a goal to reach a 90% coverage of the e-learning system. To achieve this goal, it is necessary to modify the infrastructure dramatically, develop and adopt the requirements for the creation of electronic books and training packages (TP) used in e-learning, a regulation for individual and collective work of the system users', a technical regulation (assistance and operation of the e-learning system).

The Seifullin Kazakh Agro Technical University (KATU) went through a 5-year period starting from the implementation of automated information systems in the learning process, and initiated transition to an e-learning system. The article considers the results of the implementation of a virtual learning environment in general sciences, such as physics. Any education system pays great attention to the assessment of its "quality", which has also been specified in the state education development program. The education quality monitoring implies the development of criteria for knowledge assessment in each learning stage. One of the approaches implies academic ranking. Besides, the quality of learning is also influenced by students' motivation and satisfaction with the learning process.

2. Method

Various methods were used to carry out the research, namely: specific, general pedagogical and general scientific methods, as well as systemic and comparative analysis, synthesis, and generalization. The work included the designing of virtual content, analysis of the current and functioning automated information learning systems (AILS) and learning system management (LSM), since they perform different, though interrelated tasks. The AILSs to be used must be compatible with the Kazakh education standards implying trilingualism (Kazakh, Russian, and English). No system – neither an open one (implying integration and interrelation between several organizations, within the country and between countries), nor a closed one (functioning independently within one organization or corporation) – can perform successfully without modern and high-tech content, networks, as well as software and hardware.

During the development of a virtual environment for general subjects, the most effective learning forms, methods and examples based on information and communications technology were tested. The specific methods facilitated the development of new demonstration and laboratory experiments in natural sciences and the modernization of the existing ones, contributed to the creation and improvement of statistical and dynamic visual manuals, materials for students' individual work, as well as had an impact on the organization of elective and extracurricular activities. Thanks to the implementation of multimedia technology using virtual laboratory complexes in general sciences,

which is now being done in many higher education institutions (Jezierska, et. al. 2016; Potkonjak, et. al. 2016; Daineko, et. al. 2015), as well as their integration in the learning process at schools, the quality of education has improved significantly.

Using information and communications technology in the education system does not only influence education technologies, but also introduces new ones in the education process. This is due to the use of computer and telecommunications means, special equipment, software and hardware, network technologies, and automated information processing systems. New means of learning, knowledge transfer and storage, which include electronic training multimedia, are developing intensely; electronic libraries and archives, global and local education networks; learning platforms, information and reference search engines. The designing of experimental learning systems using information and communications technology is successfully used in the research of modern education systems (Toth 2016; Gorai, et. al. 2016).

The automated information system "Platonus" allows automation of the main information processes related to education process planning, organization and monitoring in a higher education institution. Using an education process monitoring system allows organizing a periodic collection of current and final performance and attendance indicators, optimizing the formation of statistical data in accordance with the demands involved, provides teachers and students with a convenient regulated access to the information in question (Nemtsev, et. al. 2012). The monitoring results are used to form the final assessment of a student's performance in a subject. Thanks to comprehensive information about the level of students' academic achievements, the teacher can make prompt decisions to improve the quality of students' preparations and manage the learning process effectively by following its positive dynamics. Using an education process monitoring system allows organizing a periodic collection of current and final performance and attendance indicators, optimizing the formation of statistical data in accordance with the demands involved, provides teachers and students with a convenient regulated access to the information in question.

3.   Results and Discussion

The main elements in e-learning are automated information education systems and automated information education management systems. Education and management are conducted by means of an education portal which is a learning platform allowing students to get education services using educational computer support means, both software and hardware, the Internet and Intranet technologies. Thus, a virtual education environment always operates on a browser platform. It represents a certain aggregate of virtual tools integrated in a space comfortable for users, with a user-friendly interface reproducing regular learning with uniform access to all learning components. Obviously, such a virtual environment must be organized in such a way that it is not only

secure and available, but also constantly developing in order to satisfy its users' needs. (Uribe, et. al. 2016; Maksimov, et. al. 2015; Baxendale and Mellor 2015).

The first information system at the Seifullin Kazakh Agro Technical University was the automated education management system "Tamos University Suite" (AEMS "TUS"). Then, in 2013 it was replaced by the AIS "Platonus". The main components of the information and education space of the university, which are actively used in the university education activity, include some Internet resources, such as the Education Portal (http://portal.kazatu.kz/), Electronic Library (http://portal.kazatu.kz/e-books/), the Automated Information System for Distant Learning "Platonus" (http://platonus.kazatu.kz/) (Abeldina, et. al. 2015)

The automated information system functioning at KATU has the following functional capabilities:

− Distant learning represents a hybrid of the case and network education technology;
− Individual academic calendars;
− The messaging and task assignment system facilitates the internal correspondence and provides control over task fulfillment;
− Overview and access to TPs (cases, lecture materials for a specific subject);
− Testing system;
− Forum;
− Chatroom;
− Electronic Library;
− Access blocking for students and employees.

The AIS "Platonus" differs from the AEMS "TUS" in having "Virtual Classrooms" (Figure 1) providing the possibility to conduct online classes using a graphics board.
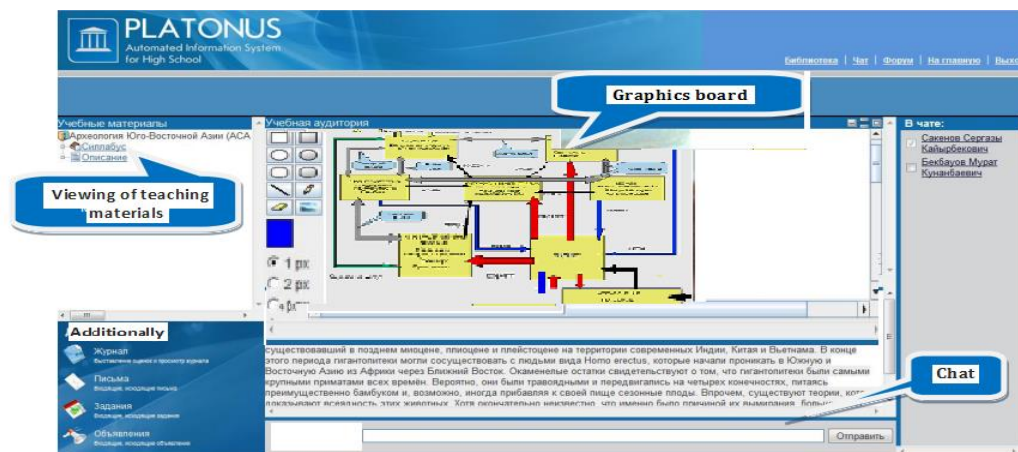

Figure 1 – A virtual classroom in the AIS "Platonus"

A virtual learning environment can function on one computer or a local network of an education institution, or in the global network. Inhabitants of an education space include end users, teachers, and students. The learning process

is coordinated and maintained by its administrator who, based on the current state of the software, must have appropriate programming knowledge and skills. The learning environment can be oriented towards an individual subject, but it can also include a wide range of them.

Teachers using a virtual laboratory in teaching note the following features:

− Virtual laboratories fulfill learning programs distantly, extramurally, at home, etc. To communicate with teachers, students can use a blog where each teacher can create specific topics for discussion (Figure 2).
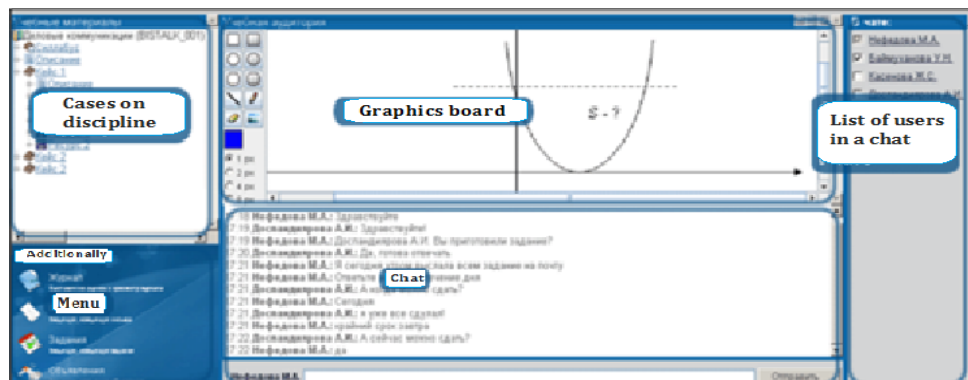

Figure 2 – Information exchange in a chatroom using a graphics board

− Using Internet resources and a virtual classroom in the automated information system (AIS) "Platonus" significantly reduces the time which a teacher needs to prepare for classes, as well as to control task fulfillment.

− The content, which includes not only text files, but also video and audio materials, increases the appeal and simplicity of education (Figure 3).
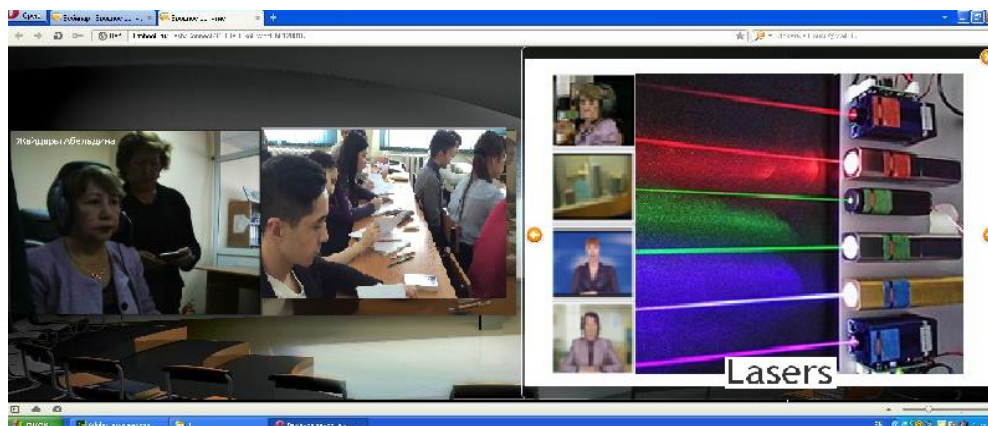

Figure 3 – Video repositories in the automated information education management system

− Students must acquire practical skills in laboratory classes. The virtual laboratory compensates for the lack of equipment in the physical laboratory of an educational institution.

Virtual laboratories (VLs) and interactive exercisers are perfect techniques for teaching students, and such approaches turned out to be useful for understanding the technical principles in many fields of science and engineering. The work (Redel-Macias, et. al. 2016) involved the development of a virtual environment which simulated real operations performed in a laboratory to obtain energy from biomass. The researchers note an effective increase in the quality of the learning process thanks to the self-explanatory and attractive interfaces of virtual complexes. The software shows its virtual audience a sequence of actions, the main characteristics of natural properties of biofuel imitating the reality step by step. The monitoring carried out to assess the use of virtual laboratories by graduates showed a high satisfaction level and usefulness of VL tools, and the positive performance rate reached 6 out of 7 points on average. Besides, the efficiency of the VL in the learning process was also proved by the final exam in which the students got 8 out of 10 points.

The research (Belli and Marleni 2015) revealed some changes in the perception due to the virtualization of education spaces and adaptation of the testees to digital learning objects placed in a virtual environment. The reference point was the culture study based on the deductive analysis of educational phenomena illustrating the transformation of perception of digital objects in e-learning. Thus, the Internet allows substantial expansion of the virtual reality borders involving global problems in everyday life, which allows learning the problems which stimulate changes in the spatial-temporal practice. Consequently, virtual education represents a tool which brings students various opportunities allowing them to raise their learning efficiency (Segedy, et. al. 2013).

The concept of cloud computing has significantly changed the traditional approach towards the supply, management, and integration of applications. The matter of the concept of cloud computing lies within the provision of end users with a remote dynamic access, computing resources and applications (including operation systems and infrastructure) via the Internet. The main advantage of clouds is that the end user does not need to have a powerful system, which means a substantial cost reduction. This is likely to have a significant impact on the education environment in the future (Tuncay 2010). Cloud computing is a perfect alternative for education institutions which, having an insufficient budget but still in the need to provide efficient functioning of their information systems, can thus save on computer maintenance and network devices combining them with a high level of service availability. In the nearest future, the cloud computing technology will have a great impact on the education and learning environment, on the creation of conditions for their own users (i.e. students, teachers, and administrators) in order to perform tasks efficiently while reducing the costs thanks to the use of the existing cloud applications offered by cloud service suppliers (Alabbadi 2011). The modern development of information technology and Internet/Intranet, in particular, makes it necessary to protect the information transferred on a distributed corporate network using open-access networks. Information and network security issues arise when specific virtual tools are used to provide adequate training in laboratory

environments in which practical aspects of the subject can be studied (Marsa-Maestre, et. al. 2013).

When developing online learning platforms providing access and opportunity for distant control over hardware and software resources, it is necessary to provide the end user with some convenient services for. In this regard, the work (Fernandez, et. al. 2013) has considered some technical solutions providing students with the opportunity to participate in a laboratory session remotely. The efficiency of such classes is determined by the level of communication, virtualization and development of data bases. Within the scope of the project (Luis, et. al. 2013), some real scenes created by means of computer programs provided the opportunity to overview the virtual environment allowing control and acquisition of practical skills. One of the peculiarities of such designs is that they are supposed to facilitate access for some user categories (disabled, based on their language skills, etc.) to the university facilities by means of web applications and also provide the most accurate simulation of the physical reality as if they were there for real, allowing interaction with them. Besides, the users could study various objects of the virtual space determining the state, potential, safety and other properties of studied elements, connect or get access to the learning materials, getting an interactive online consultation.

New designs in information and communications technology and continuous changes in education and research technology have led to new ways of interaction between teachers and students, between researchers and their projects. This is called interference (concurrence) between the two types of communication, preparation and learning: the traditional ones used in the real world, in a usual academic field, and the modern ones placed in a virtual environment (Berechet and Istrimschi 2011). The researchers have attempted to determine and describe how new technologies in education, such as e-learning, digital television, virtual classrooms, video conferences, can expand the narrow range of interests, knowledge and communications, as well as break the barriers and make distances shorter in order to initiate and develop relations between different cultures, institutions, and people. To be a modern, highly-professional and attractive education institution, to create and distribute know-how, concepts and knowledge, a university must constantly learn to use the latest innovations in information and communications technology, combining both traditional and modern methods. For the moment, virtualization and digitalization of education content and scientific research are essential.

More and more education institutions of all levels (primary, secondary, college, university) are starting to digitalize the content of their lectures and courses, meaning to thus "virtualize" their content or even "virtualize" their education scenarios (Galindo Cuesta 2011). To do so, they are using computer platforms (LMS) as a means of improving the quality of teaching and learning. Although the use of LMS is the means to fulfill the need for the virtualization or development of education methods and update of education, such platforms are still far from what a modern student needs for learning and communicating. It is necessary to find some methodological approaches to information and communications technology in education based on the (communication)

member's own behaviors on the network, acknowledging the difference between the use of virtual instruments in and outside the learning process.

And the work (Molina-Aiz, et. al. 2011) presents some education events developed as part of different innovation projects undertaken at the Engineering College of University of Almeria (Spain) over the last five years. Following the completion of projects, a transition from the traditional lecture-oriented approach to a learning environment oriented towards a person-oriented method using partial virtualization of members and other information and communications technology was made. A computer with Internet access and a slide projector are available for all sessions in a classroom, and they allow combining videos, slide presentations, and information taken from web pages. Virtualization increases the education resource significantly, improving the mobility and activating the learning process while maintaining quite low costs (BouSaba, et. al. 2010). Computerization helps improve teaching in various courses, in particular, information technology (IT) contributing to an easier access to software, as well as providing various computing environments with a rich set of functions, thus improving the course supply and expanding the scope of the university resources.

One of the most favorable environments for virtualization is physics, since computer models of physical phenomena and experiments are being built in modern learning technology smoothly. Moreover, not every physical experiment can be carried out in full, especially for educational purposes. Such restrictions are determined by various factors (Kim 2012).

− Restrictions arising due to large sizes, e.g. the planetary motion in the solar system, geological and global phenomena, etc. In this case it is impossible to carry out natural experiments.

− Restrictions arising due to macroscopic sizes, e.g. atoms are about one tenth nanometer (10^{-8} cm = 10^{-10} m = 0.1 nm). Therefore, to handle a small amount of atoms or even individual atoms, one needs instruments distinguishing objects of a nanometer or even less. Such instruments based on quantal effects allowed to solve brand new technical tasks and they are collectively called nanotechnology. The first instrument which allowed approaching to the nanometer range of spatial dimensions was the scanning tunnel microscope (Menskij 2005).

− Energetic factors − highly-energetic characteristics can make an experiment almost impossible to carry out. For instance, the need to accelerate elementary particles to speeds close to the speed of light requires a gigantic accelerator similar to the Large Hadron Collider (LHC), which only unions of largest countries could afford. Over 10 thousand scientists and engineers from over one hundred countries have been taking part in the construction and research of the LHC. The Large Hadron Collider will allow carrying out experiments which were impossible before and which will probably confirm or disprove some part of formulated physical models in nuclear interactions (Plavko, et. al. 1981).

− Environmental restrictions − any massive experiments involving the environment must be regarded as dangerous and undesirable. In particular, most countries have refused to carry out experiments involving uncontrolled thermonuclear fusion for that reason too (Ratis 2009).

− Financial restrictions – high costs may impede experiments.

− Social (political, religious, moral, ethical, etc.) factors can also impede real experiments. For instance, thanks to the national anti-nuclear movement nuclear tests were banned in Kazakhstan (Chasnikov 1998).

Training experiments are even more restricted, and that is why computerized experiments and phenomena have a definitively positive effect. One should mention that virtual works do not replace but complement real experiments. Laboratory classes are a kind of students' practical individual work, which facilitate the deepening and consolidation of theoretic knowledge and practical skills for the sake of professional training (Tolstik 2006). An experiment is a research method which is reproduced under specified conditions an unlimited number of times and which provides an identical result. A physical experiment boosts observation and analytical skills involving physical phenomena; one should note that this skill is universal and involves other human activities as well (Abeldina, et. al. 2015).

Besides the science-methodological and learning regulatory documentation developed for the virtualization of the learning environment (course programs, electronic training packages, multimedia presentations of lectures, and practical classes), a multimedia physics laboratory was integrated in the KATU virtual laboratory, and it includes over 40 laboratory works for all branches of physics. Classes can be conducted in three languages: Russian, Kazakh, and English for polylingual groups.

The laboratory represents a computer classroom with methodological software simulating real physical phenomena. To study the influence of the virtual environment on students, research on how computerization of cognitive activities influences the formation of students' development level was carried out during several years in student groups at the Seifullin KATU. The experiments were carried out as part of training and research works, during laboratory practicals. Students were divided into the "control group" who performed tasks in a traditional laboratory and the "experimental group", or "mixed group", who performed some tasks in a traditional way and some tasks in a virtual environment.

In a first-year polylingual group (where students study some subjects in the official state language, some – in Russian, and some – in English) of the Faculty of Energetics students were provided with virtual and traditional laboratory tasks. The mixed group included 21 students, most of whom had finished Kazakh schools. Physics classes were conducted in Russian that is why the performance on junior courses was 70%.

The following topics were provided in accordance with the syllabus (a student's learning program).

Topics for virtual laboratory tasks:

1. Alternating current circuit elements. Capacitive and inductive reactance, their dependence on alternating current frequency and parameters of elements.
2. Study of magnetization intensity of paramagnetic materials.
3. Study of Fraunhofer diffraction on a slot.

4. Recording of volt-ampere characteristics of semi-conducting diodes.

Topics for traditional laboratory tasks:

1. Determination of the horizontal constituent of terrestrial magnetic field intensity.
2. Study of oscillations in a circuit with a neon lamp.
3. Determination of the length of a light wave by means of the diffraction grating.
4. Determination of the concentration of sugar water solution with a polarimeter.

The duration of laboratory tasks performed traditionally and in a virtual laboratory during the term can be determined based on the chart created for an average student. As a rule, the duration of students' work on computers normally did not exceed 30 minutes.
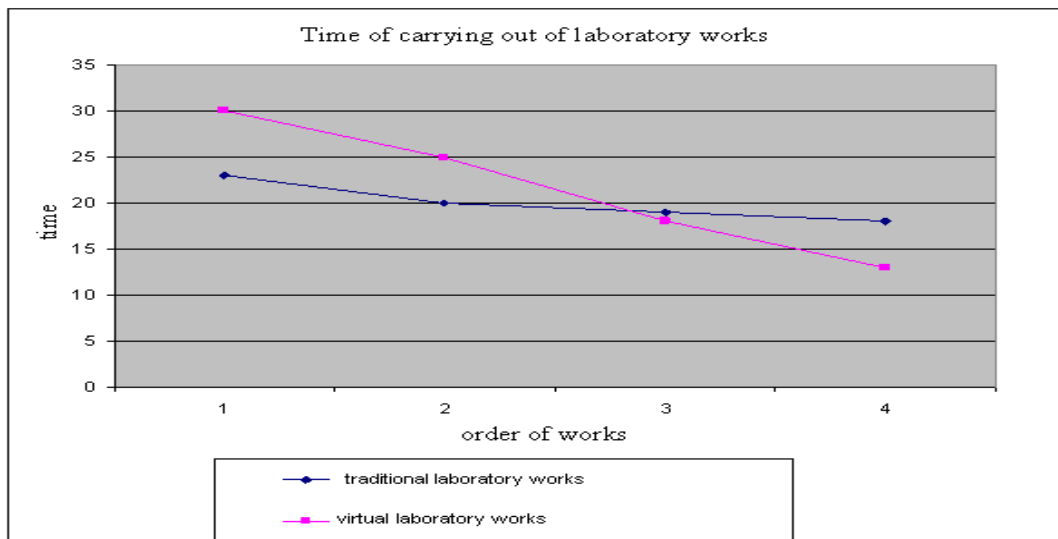

Figure 4 – Time spent on laboratory tasks

In Figure 4, the X axis represents the numbers of virtual and traditional laboratory works, and the Y axis – the time spent on the work in minutes. As the figure shows, although at the beginning the students spent more time on fulfilling virtual tasks, by the end they had fully mastered the multimedia programs and started spending less time. At the beginning of the experiment, some students said that they wanted to do all the tasks in a traditional way, but after having mastered the computer programs, they saw no difference between the traditional and virtual way of carrying out experiments. Most students' performance improved significantly rising from 5 to 7.5-9 points as per the ten-point assessment system for laboratory tasks. In traditional laboratory lessons, the students either had to be united in small groups due to a small number of tasks or perform the tasks in turns, which did not always coincide with the lecture topics specified in the curriculum. Carrying out laboratory lessons in the

virtual classroom helped avoid the problem, since each student did his/her own tasks on his/her computer individually, frontally, in accordance with the theoretic learning plan. Since virtual tasks were performed simultaneously, the students could consult each other and discuss the experiment, but everyone had their own tasks which were different from the others, which prevented copying other students' answers.

In order to find out the students' attitude towards the way (virtual and traditional ones) the experiment were carried out, appropriate monitoring implying written and oral survey was performed among the students. The survey was carried out via the automated information system "Platonus". The survey showed the following results.

Table 1 – Results of the survey conducted among junior students by means of a questionnaire: What do you think of the virtual method of performing laboratory works?

	Questions:	Virtual laboratory	Traditional laboratory
1	Do you spend less time on performing laboratory tasks?	80%	20%
2	Do you learn a lot of new and interesting things in a laboratory lesson?	50%	50%
3	Which method do you consider the most effective?	65%	35%
4	Do you like working on the computer?	85%	15%

The questionnaire results represent a positive attitude towards working in the virtual laboratory. The result analysis showed that the common students' attitude regarding their satisfaction with the learning conditions is quite positive and remains on a definite level. An open survey among the students was conducted to find the advantages and disadvantages of the virtualization of laboratory works. The "advantages and disadvantages of the virtualization of laboratory works" noted by the surveyed are presented in Table 2.

Table 2 – Open survey on advantages and disadvantages of virtualized laboratory work

No.	Advantages of the virtualized laboratory	Noted in%	Disadvantages of the virtualized laboratory	Noted in%
1	Time saving	70	A work is done in a pre-determined computer program, it is impossible to change the conditions in contrast with	15

			real works.	
2	It is interesting to assemble a circuit (learning the details)	65	It impossible to actually feel and touch the equipment, not just see it in a picture.	30
3	Individualization of laboratory tasks	70	No affection to working on the computer	15
4	No responsibility for the equipment	80	Reduced time necessary for communicating with the teacher	60
5	Students' lives in safety	80	No practical skills in operating with real instruments	50
6	Possible to carry out works, which are impossible to carry out under our actual conditions	100	Increased time spent in front of the computer	50
7	Individual approach to each student	85		

Due to the wide involvement of students in the virtual education space, a survey on students' computer literacy, their abilities and skills was conducted. Based on Table 3, one should mention that senior students are more sensible at using computer capabilities. They increase and boost students' interest thanks to multimedia technology, activate thinking and learning efficiency thanks to interaction. The technology allows modeling and virtualizing processes which are difficult to present in the reality (from modeling dangerous physical and chemical phenomena to economic models).

Table 3 – Results of survey on students' computer literacy

How well can you perform the following tasks on the computer on your own?			
Skill	I know how to do it	I could learn how to do it	I don't think I could do it
Write a letter in a text editor	92.9%	7.1%	0.0%
Enclose a file to an e-mail	71.4%	28.6%	0.0%
Save digital pictures on the computer	71.4%	0.0%	28.6%
Arrange storage of electronic documents in folders and subfolders	71.4%	14.3%	14.3%

Track students' performance dynamics	57.1%	21.4%	21.4%
Use Spreasheets (like Microsoft Excel) to store information/record or analyze data	64.3%	35.7%	0.0%
Take part in discussions on forums or user groups on the Internet	50.0%	35.7%	14.3%
Create presentations (e.g. Microsoft Power Point) using simple animation effects	57.1%	35.7%	7.1%
Use the Internet for online shopping	42.9%	28.6%	28.6%
Prepare tasks requiring computer skills	64.3%	28.6%	7.1%
Find useful resources online	78.6%	7.1%	14.3%
Assess the students' academic achievements/results	57.1%	14.3%	28.6%
Cooperate with colleagues using common resources, such as Google Drive, Drop Box	50.0%	35.7%	14.3%
Install software	57.1%	21.4%	21.4%

A virtual environment allows individualizing learning not only based on the rate at which learning takes place, but also based on the logics and type of students' perception, organizing distance learning, including classes for students unable to attend classes due to an illness or another reasonable excuse. The virtualization of education space allows students to look for necessary materials online on their own when preparing reports and papers, helps them find answers to complicated questions. The speed and accuracy of collection and processing of information about the learning progress increase dramatically thanks to computer testing and task control, and it is possible to introduce urgent correction of the collected analytical material.

4.   Conclusion

One should acknowledge that the last decades have witnessed a decrease in the students' interest to natural sciences in general and physics in particular, which is one of the problems in school and higher education. The negative changes which have emerged in natural sciences education over the last years are related to the increasing complexity of curriculum and reduction of time necessary for mastering it, as well as insufficient provision of special equipment in the learning process. Physics as a subject includes issues related to the world outlook, morals and environment, but is usually unpopular with students. The specific nature and complexity of the subject do not contribute to a greater interest to the subject or deeper knowledge of the subject necessary for further education or professional activity. And it is the active use of information and

communications technology that is supposed to reverse the trend and improve the quality of natural sciences education.

Thanks to the fact that the learning environment easily adapts to various automated information systems and maintains electronic education standards, it can be widely used at Kazakh higher education institutions and schools. It is especially topical for small schools, remote higher education institutions and small institutions typical of countries such as Kazakhstan having a large territory, low density, and great distances. The virtualization and automation of education allow saving on equipment since it can be replaced with computer simulators which do not wear or spoil and allow carrying out practical laboratory classes frontally without affecting the quality of learning. The researchers arranged a virtual laboratory for physics at the Department of Physics and Chemistry at the Kazakh Agro Technical University and another virtual laboratory for physics, including 20 laboratory tasks, in gymnasium 51 in Astana.

Computerization is going on really fast, and our graduates are going to deal with computer technology almost in every human activity. But even the most advanced automated information system could not replace a teacher completely. Only a teacher can get the audience interested, encourage curiosity, gain their trust; a teacher can direct students' attention towards the peculiarities of the subject, assess their efforts, and motivate them. A virtual environment facilitates the teacher's work, releasing him/her from the least creative part of the work under certain conditions while intensifying the learning process, being an exerciser and simulator of a real process.

5.   Acknowledgements

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