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## INFORMATIONAL AND COMMUNICATIONAL TECHNOLOGIES OF SUPPORT IN A PRODUCTIVE TEACHING OF PHYSICS IN THE SECONDARY SCHOOL

*Анотація.* Наведено результати аналізу досвіду застосування засобів ІКТ підтримки у продуктивному навчанні фізики. Показано, що для підвищення якості навчання необхідним є впровадження вебтехнологій, а саме: освітніх веб-сайтів і блогів, які передбачають інформаційно-презентаційну, консультативну, інформаційно-методичну, просвітницьку, навчальну підтримку діяльності вчителя й учня, відкривають нові можливості взаємодії з суспільством. Обмін даними будь-якого змісту (текстові документи, аудіо-відео файли, архіви, програми) можливий завдяки електронній пошті (e-mail). Одним із дієвих засобів підвищення ефективності продуктивного навчання фізики є електронні підручники, які забезпечують неперервність і повноту дидактичного циклу процесу навчання, представляють теоретичний матеріал, забезпечують тренувальну освітню діяльність і контроль рівня знань, а також інформаційно-пошукову діяльність, математичне та імітаційне моделювання з комп'ютерною візуалізацією і сервісні функції за умови здійснення інтерактивного зворотного зв'язку.

Обґрунтовано, що найбільш універсальним технічним засобом продуктивного навчання є електронна інтерактивна дошка, яка надає вчителю й учням унікальне поєднання комп'ютерних і традиційних методів організації освітньої діяльності: з її допомогою можна працювати практично з будь-яким програмним забезпеченням і одночасно реалізовувати різні прийоми індивідуальної і колективної, публічної («відповідь біля дошки») роботи учнів. Розглянуто актуальність застосування на уроках фізики мультимедійних технологій. Однією з беззаперечних переваг засобів мультимедії показано можливість розроблення на їх основі інтерактивних комп'ютерних презентацій із фізики. З упровадженням ІКТ змінюються сама структура освітнього процесу, форма подачі знання, і, що найважливіше, – комунікація між тим, хто навчає, і тим, кого навчають. Проведення уроків при комплексному застосуванні продуктивних та інформаційно-комунікаційних технологій забезпечує набуття учнями не тільки глибоких і міцних знань, а й вміння розвивати інтелектуальні, творчі здібності, самостійно набувати нових знань і працювати з різними джерелами інформації.

**Ключові слова:** фізика; продуктивне навчання; веб-ресурси; e-mail; електронний підручник; інтерактивна дошка; мультимедія.

**Introduction.** One of the main innovations in General secondary education is the introduction of productive learning, the main issue of which is not only mastering a certain amount of knowledge, but also the direction of the acquired knowledge to the solution of urgent practical and theoretical problems for the development of student's personality, raising intellectual level. However, the introduction of new technologies into the educational process will be effective and expedient only in that case, when they manage to preserve the benefits of traditional forms of learning and give new opportunities during their development and usage.

All learning resources are real in the traditional process of learning Physics, and the possibility of access to them for students depends on real time, real places and real context. The regime, order, and intensity of training in this case do not almost depend on the student, but a substantial disadvantage of educational process organization is the conservatism of the technologies, developed didactic and methodical materials, absence of the mobile feedback. The dominant technology is the printed (paper) educational materials in the form of textbooks, collections of tasks, methodological manuals, scientific and methodical periodical

literature etc. The teacher has to do a lot of preparatory work for the lesson, as well as a large amount of work for checking educational tasks that are done by students themselves (a well-known problem of checking copybooks). Finally, it takes a lot of time to work with such documents as a class register, report etc.

A significant way of solving the problems is the application to informational and communicational technologies, with the help of which students and teachers have access to the endless amount of information and means of its processing operations. It is important to get to know how to orient in the information flow and to develop skills of effective searching necessary information, to evaluate the quality and reliability of the obtained data. Modern student can compare the process of productive learning with a labyrinth, where there is an entrance and a lot of different ways to exit. You can wander in one of them for a long period of time and as a result lose the interest, but others are shorter, more interesting and effective [14].

**Analysis of the last investigations and publications.** The problem of introduction of electronic means into the educational process is the subject of research for many scientists that investigate various aspects of the mentioned problem: the issue of modelling and computer study, program education in researches of Yu. K. Babanskyi, V. P. Bepalko, R. S. Hurevych, B. S. Hershynskyi, I. Ya. Lerner, N. F. Talyzina [1; 5]; development and functioning of informational and analytical systems of management of educational process in the researches of V. I. Bykov, M. I. Zhaldak, Ye. I. Pudalova [3; 6]; they investigate the process of organization and management of educational activity in the computer-oriented environment; activation of the learning activity and the development of pupils' creative skills with the means of informational and communicational technology (ICT) during the process of teaching Physics are investigated in scientific works of V. P. Myliar, N. L. Sosnytska, S. M. Pastushenko, T. M. Yatsenko, O. I. Denysenko, Y. V. Yechkalo, V. E. Krasnopolskyi, N. P. Lytkina, I. O. Teplytskyi [11; 17]; the use of computers in students' individual work of Physics was investigated by Y. O. Zhuk, Y. P. Reva, O. M. Sokoliuk [9; 16]; the use of informational technologies in school educational experiment became the subject of investigation for S. P. Velychko, V. O. Izvozchikov, L. M. Nakonechna, Y. M. Oryshchyna, N. L. Sosnytska, V. I. Sumskyi and others [10]; the formation of pupils' informational competence at the lessons of Physics study L. H. Karpova, O. V. Liskovych, O. P. Pinchuk, V. D. Sharko and others [1; 14]. Investigations connected with the development and use of e-books were held by B. Hurshynskyi, O. Yershov, Y. Mashbits, V. Monachov and others [2; 7; 13; 15]. There is an interesting research of pedagogues (O. H. Asmolov, O. L. Semenov, O. Y. Uvarov, Y. D. Patarakin) towards the possibilities of social services WEB 2.0 usage in educational process.

**Unsolved aspects of the problem.** Despite the tremendous amount of research on the problem of information introduction technologies in educational process of Physics, not all methodological questions are developed in detail that is why it complicates the implementation of ICT into teaching practice. Moreover, it is possible to ascertain the substantial backlog of the education system in the field of ICT in education. Deep introduction of computer technologies into the educational process prevents the problem of the organic combination of traditional teaching methods and informational and telecommunication technologies.

**The purpose of the article** is highlighting theoretical basis and methodic of ICT use during the productive teaching of Physics.

**Results of investigation.** The concept of *information technology* appeared in the 1980-ies. International organizations ISO and IEC, creating the joint technical Committee for standardization of information technology JTC1 (Joint Technical Committee, 1987), in the statutes of the Committee JTC1 gave such a definition of «information technology»: «In this concept are combined methods, means and systems related to the collection, production, treatment, transmission, distribution, storage, operation, performance, use, protection of various types of information» [12]. Subsequently, next to the word «information» appeared

the word «communication». Clarification of the term was necessary for emphasizing the importance of a dissemination of global and local computer networks, which provide new opportunities to searching, transmission, exchange of information. Together with powerful storage devices they contribute to creating a society in a global distributed information resource, available to anyone. Now ICT includes hardware (computers, servers) and software (operating systems, network protocols, search engines, etc.).

Physics is one of the subjects, which gives a lot of material for developing a variety of methods and techniques of working with information. Teaching Physics is connected with the use of a large amount of diverse information and it makes the use of computer technology especially effective as it allows you to process information very quickly and present it in the form of tables, charts, diagrams, models, and to determine the relationship between different objects and phenomena, structures and functions.

The technology of productive physics training organically complements the active use of the **global network Internet**. The Internet is a structure that develops the most dynamically and has almost unlimited informational, communicational and educational prospects. Internet resources can be used in teaching Physics, including World Wide Web (WWW) and Electronic mail (E-mail).

*World network of World-Wide Web (WWW)* has caused a real revolution in informational technologies and a boom in the development of the Internet. The number of servers that make up the main content of the network doubles every 50–60 days and today it has already exceeded a million. Educational resource in the Internet is an opportunity to present their achievements, post relevant information for stakeholders (parents, students, schoolchildren, teachers, students, teachers, colleagues, etc.), to inform the society about the educational services, to publish their achievements, materials, research results, to implement the exchange of experience, consultations and the like. WWW servers can be used: by the teacher to search for additional and updated information for the lessons; by students to search for information for preparing various kinds of creative works (papers, abstracts, business games, educational conferences).

Currently, there is a number of promising web technologies. A particular place is held by educational web sites as components of the Internet space. A website (web – «the network» and site – «place») is a set of web pages available on the Internet through Http/https, united by a common root, and usually a theme, a logical structure, design and authorship. Using web sites of the network Internet provides access to a wide range of achievements of the world science and technology. It is evident in the great number of electronic resources for educational, informational, illustrative, entertaining and literary content that can affect the overall development, education and competence of school users. In the context of our research we focused our attention on the educational web sites that promote realization of productive teaching Physics, especially:

– <http://physics.com.ua/> – electronic web-journal (scientific investigations and technological developments on Physics: news, facts, people, humor, satire, lyrics.)

– <http://sp.bdpu.org/> – «School Physics» (contains answers to basic theoretical questions relating to the presentation of the school Physics course or its separate sections, the physical reference books, collections of tasks and tests, instructions for a typical laboratory works and physical workshop. More than 950 video clips of experiments on Physics, 250 animations of physical phenomena, 130 models, 1000 images).

– <http://ujp.bitp.kiev.ua/> – Ukrainian physical journal (is a general edition of the department of Physics and Astronomy of NAS of Ukraine that publishes original articles and observations in the sphere of experimental and theoretical Physics).

– <http://gutpfusik.blogspot.com/> – «Good Physics».

– <http://aufu.host-ua.org.ua> – the Ukrainian civil organization «Association of Teachers of Physics: Way of Education – XXI».

– <http://cmodel.in.ua> – computer modelling of physical phenomena.

– <https://sites.google.com/site/vvtuvir> – the web-site of Ukrainian open tournament of young inventors and innovators.

– <http://sites.google.com/site/edisonixxi> – the all-Ukrainian contest of young inventors and researches «Edison's of the XXI century».

– <http://sp.bdpu.org> – site-catalogue of educational materials on school Physics.

– <http://class-fizika.narod.ru> – popular about Physics. Interesting materials on Physics for schoolchildren, teachers and all curious.

– <http://elkin52.narod.ru> – interesting tasks on Physics, issues on camping and nature, touristic observations, Sherlock Holmes and his questions, Vovochka's tasks, tests etc.

– <https://phet.colorado.edu/uk/> – site of interactive simulations PhET that offers free and generally accessible modelling on nature sciences, translated into Ukrainian and adapted to the requirements of educational programs and state standards on Physics that can be used during Physics studying, during explaining new material, for individual and group tasks, for home works, during laboratory works and practicums. PhETs are created on the basis of scientific and pedagogical investigations and encourage students to educational research and experimentation using intuition of an environment similar to the game.

– <http://www.int-edu.ru/soft/fiz.html> – Russian version of one of the most famous programs in Physics Interactive Physics (Real Physics), developed by the American firm MSC. Working Knowledge. The program is a computer-aided design platform in which a student or a teacher can create their own models of physical phenomena and do experiments. All experiments are accompanied by computer animations, dynamic charts, diagrams of vectors. There are methodical materials, as well as a number of models and designs that you can download.

– <http://www.cacedu.unibel.by/partner/bspu/optic/index> – program and methodical complex «Active physics» (by the Ministry of Education of Belarus Republic) is intended for the formation of the basic concepts, skills and problem-solving skills in Physics and its active use in different situations. The database contains 6000 variants of tasks-situations with the help of which the user can build scenarios of training with individual approach and personal practices of the teacher. Each section offers several pre-set training scenario, corresponding to individual classes. The content and level of selected material is aligned with current curricula and textbooks of grades 7–10. The program can be used as a demonstration experiment, explanation of a new material, experimental research tasks, problem tasks with game elements, computer laboratory works.

– <http://www.fizika.ua/index.Htm> – «Physics.ua» (site for pupils and teachers of Physics where textbooks on Physics for 7, 8, 9 grades, collections of tasks and tests, descriptions of laboratory works, theme and lesson plans, methodical developments are situated).

– <http://www.uic.ssu.samara.ru/> – evrika is the source material for the inventive theme. Here you can find the description of a typical intentional approaches as well as information about everything related to the process of creativity and invention. In addition to text and images, the site materials are illustrated with three-dimensional animated graphics. These movies are recorded in MPEG format. Here are the author's program «How to increase creativity and to learn to make inventions» is intended for pupils of 7–11 grades of secondary schools, gymnasiums and lyceums and guidelines thereto, as well as information about everything connected with the process of the invention; tests for knowledge control.

One of the most interesting projects of the International educational and resource networks that are being implemented in Ukraine and Europe – is the network project «I\*EARN» (<http://www.kar.net/~iearn/>). With I\*EARN students of more than 80 countries create a joint international and national telecommunication projects in different directions. The network actively collaborates with teachers and students from different countries. In the framework of resource and methodical center «I\*EARN» actively works the national program the «Coordinator of I\*EARN in Ukraine». In electronic project «Let's Revolutionize

Education» (Let's make a revolution in education) pupils can discuss the goals and objectives of education, to search for something common and suggest ways to overcome the obstacles they encountered (<http://www.iearn.org.ua/index.html>).

Another kind of web resources is educational blogs. If you go deep enough, the blog is a resource/website/page on the Internet, where everyone can represent himself, his thoughts, interests, hobbies, knowledge of his own preferences. This blog may perform not only informational goal, but also controlling, organizing, introductory and developmental goals. Blog possibilities are the following: recommendations for students towards various topics of studying; viewing educational lectures videos, by embedding them into the blog; publications of questionnaires, online tests, integrated calendars, a variety of slide shows; reports on events in the classroom; the exchange of useful links to Internet resources; exchange of knowledge on ICT; exchange of gadgets with different functions (e.g., interactive periodic table); useful tips for parents interested in their children's education; work with gifted children.

*Using a blog*, a teacher can conduct monitoring and evaluation of knowledge. It is very convenient to use forms created with Google means. In the blog you can post a link to the task as well as build the questionnaire.

Embedding objects into the blog saves time for searching and downloading tasks. Directly before the lesson, even if the speed of the Internet connections is low, a teacher can load the desired page from the content of the lesson and work with objects. Another interesting example of built-in tasks is educational games created with the online Learning Apps.org (as an example). These games have several varieties: jigsaw puzzles, crosswords, find a couple etc. Personally, we use these games to update knowledge and enhance students' interest in the subject.

The blog of a teacher can become a kind of repository of materials for organization of students' individual work. This can also be additional material on the subject on the basis of which students can complete individual tasks. It is also a number of links to resources on the topic – a kind of entry point into the informational space network. Besides, it includes multimedia content – as a material for observations and individual conclusions that allows you to create a problem situation in the learning process. These presentations are created by students and mutually reviewed by them. In addition, the blog post can be a kind of «announcements» for future lessons, seminars, discussion classes, workshops and knowledge control. Questions to the lesson, samples of tasks for future examinations with a review of their solution, instructions, everything is placed in one subject blog and contribute to a better organization of the educational process. Quite often we give children these «instructions» just verbally, and they do not always have the opportunity to comprehend them fully. If it is necessary, they are able to return to these instructions and look through them one more time and this means that preparatory stage of this kind of academic work is not always full and provides further successful work.

As a result, educational web-resources (sites, blogs) provide informational and presentational, consultative, informational and methodical, educational and training support of teacher's and pupil's activity, open new opportunities for interaction with civilization.

*Electronic mail* (e-mail, or email, short for electronic mail) – is a popular service in the Internet that makes exchange of data of any contents (text documents, audio and video files, archives, programs) possible. Almost all services of the Internet, which are used as services of direct access (online), have interface of electronic mail. It can be used by teachers for the exchange of educational and methodical information with their colleagues, methodologists, leading scientists from various regions of the country and the world; by pupils for exchange of educational creative projects with their peers from other Universities; by teachers and students for mutual exchange of information.

One of the effective ways to increase the efficiency of productive training in physics is electronic textbooks. An electronic textbook (ET) is a computer pedagogical program

designed primarily for the presentation of new information supplementing the printed publication and serves for individual and individualized learning and allows testing in a limited form the student's knowledge and abilities.

ET is an educational program system of complex appointment, which ensures the continuity and completeness of the didactic cycle of the learning process, presents theoretical material, provides training and control of the level of knowledge, as well as information retrieval activities, mathematical and simulation with computer visualization and service functions provided on an interactive feedback basis.

At present, electronic textbooks exist in two forms: on compact disks and on the Internet. These ETs have both common features and differences. In both cases, the electronic textbook allows you to get knowledge of the subject anywhere and anytime using a personal computer. But ETs available on the Internet have several advantages: they can be used similar by many students; the teacher is provided with an opportunity to get acquainted with the results of the students' activities and make appropriate decisions on optimizing the learning process.

Many authors of the ET understand the electronic version of the print edition (doc, docx, pdf, djvu). Defining the term «electronic textbook» the scientists refer to the non-identity of electronic versions of printed textbooks and ET as a modern educational qualitative product, taking into account the level of information technologies development.

The analysis of software and pedagogical tools in physics, which are created and used in the educational process, shows that such products have almost 40 productions of 9 Ukrainian companies:

- *Kvazar – Micro Techno*: «Physics 7», «Physics 8», «Physics 9», «Physics 10», «Virtual physical laboratory 7–9», «Virtual physical laboratory 10–11», «Library of electronic visualizations 7–9», «Library of electronic visualizations 10–11», «Electronic task force 7–9»;

- *Kontur Plus*: «Physics» for independent work, «Virtual Physical Laboratory» for independent work of students, «Physics 7», «Physics 8», «Physics 9», «Virtual Physical Laboratory – 7»;

- *ZAT «Transport Systems»*: «Physics 11», «Physics 7», «Virtual Physical Laboratory. Physics. 7»;

- *Umniki*: «Physics 7», «Physics 8», «Physics 9», «Virtual physical laboratory – 7», «Physics 11», «Physics by 200 points», «Tests», «Physics. Prepare serio ZNO»;

- *New School*: «Physics 7», «Physics 8», «Physics 9», «Physics 10», «Physics 11», «Virtual Physical Laboratory 7»;

- *Osnova*: «The electronic designer of the lessons. Physics 7–11»;

- *Study Buddy*: «Your personal tutor. Video lessons. 7–11»;

- *Atlantic – Records*: «Physics for entrants»;

- *Soroka Biloboka*: «Physics for 200 points».

In our opinion, the software and pedagogical means of production of «Kvazar – Micro Techno», which has been distributed in schools since 2006 and has the relevant recommendations of the Ministry of Education and Science of Ukraine, is one of the most complete and demanded product due to its high efficiency and mobility. We cannot talk of course about the high quality of this product (especially the video created in the 80's of the 20th century), but the presence of such components as the teacher's constructor, the teacher's console, allows the teacher to supplement the product, create his own lessons using multimedia effects and animation.

Another tool for intensifying learning is the interactive whiteboard. *The interactive whiteboard* is a touch screen (like an enhanced version of the monitor), which can be controlled not only with the mouse, but also with the touch of a finger, to make headings with special color markers. The interactive whiteboard is used in conjunction with a computer, a multimedia projector and a multimedia product [9].

Elite Panaboard software is a product that allows you to create vivid, dynamic, visual, informative and powerful footnotes and presentations using drawings, videos, object and text galleries, as well as various resources, including the Internet. The note is shown in a presentation format with the extension «peb». In the lesson, not all pages of the prepared notebook can be used or not all hidden objects can be opened, thus reducing the time of demonstration. Unscheduled pages may be used for extracurricular activities or to invite students to work on their own. The software for interactive whiteboards allows you to clearly structure your classes. Ability to save lessons, supplement them with records improves the way of submitting the material. Due to the variety of materials that can be used on the interactive whiteboard, students are more likely to capture new ideas. They actively discuss new topics and quickly memorize the material.

The interactive whiteboard is used at different stages of the lesson. By creating a multimedia tutorial, the teacher can construct slides. It is expedient to show them as separate pages during actualization, repetition, study of new material, fixing the learned. There are possibilities to create materials for individual and frontal surveys, current and final control. Tasks, the level of their complexity, time and place of inclusion in the lesson are determined by the teacher himself. The materials of the interactive abstract are additional to the basic teaching materials (textbooks, workbooks, etc.) that are used in the process of computer science education.

Today's *multimedia technologies* are the most widespread use of information and computer technologies in physics classes, which can dramatically increase the effectiveness of active teaching methods for all forms of educational process organization. Broadly speaking, «multimedia» means a range of information technologies that use a variety of software and hardware for the most effective impact on the user (who has become listener, reader and viewer at the same time). Due to the application of simultaneous media, audio and visual information in multimedia products and services, these tools have a great emotional charge and actively involve the user's attention [4].

It has been experimentally established that during the oral presentation of the material perceived by the listener and able to process up to one thousand conventional units of information, and in the case of «connection» of the vision organs – up to 100 thousand such units [4]. Therefore, it is obvious that the use of multimedia media is highly effective, based on visual and auditory perception of the material.

One of the undeniable advantages of multimedia is the ability to develop on their basis interactive computer presentations in physics. Presentation is a set of successively changing pages of one another – slides, on each of which you can place any text, drawings, diagrams, video, audio fragments, animation, using various design elements. They do not require special training of teachers and students and actively involve the latter in cooperation.

Comparing computer presentations with traditional learning tools, the following benefits should be noted: the sequence of presentation of the material may vary, depending on the audience or purpose of the report, there is an opportunity to return to the issues already considered; the presentation may contain a brief note of the report and notes for the speaker; the use of multimedia effects in the presentation will make it possible to focus listeners on the mainstream and contribute to better memorization of information; you can quickly create the required number of copies of an electronic presentation; The convenient transportability of the presentation – a small amount and the ability to send materials by e-mail.

The benefits of the method of using presentations in the learning process as the main carrier of educational information and the main means of its presentation are probably not limited to the above list. Undoubtedly, with its further use (especially in closer connection with Internet technologies), the possibilities of using such method in the educational process will be further expanded, but even a cursory analysis of the first experience shows its promise.

Noting the positive use of presentations in the learning process, there are some limitations: with the frequent use of computerized training systems, stereotyping of thinking

increases; volitional quality decreases; creativity decreases with independent student materials preparation; much time is spent on creating a quality presentation; there is a possibility to include too much or too little information in the slide.

Thus, the use of ICT in the educational process, in particular physics, is not limited to solving the mentioned pedagogical tasks, but also has significant didactic possibilities for activating cognitive activity.

Productive educational and cognitive activity by means of ICT can be organized in the following directions: sequential or selective elaboration of theoretical material; fixing of study material, which is studied by traditional methods; mastering the content of phenomena and processes by means of simulation computer simulation; fastening the studied material using a specially designed test system; testing of skills and tasks of solving tasks; implementation of virtual laboratory work; preparation for the use of real laboratory work; obtaining background information (working with a reference system, an information retrieval system, a database).

At the physics lesson, all these areas are very important, because they increase the level of cognitive activity of students, and especially senior pupils. Conducting lessons in the integrated application of productive and information and communication technologies ensures that students acquire not only deep knowledge but also the ability to develop intellectual, creative abilities, independently acquire new knowledge and work with different sources of information.

**Conclusions and perspectives for further studies.** The presence of a computer in physics classes is not a guarantee of successful student's mastery with relevant knowledge. The task of computerization of physical education requires deeper approaches to its solution: changes in teaching models, modernization of methodological systems in the context of new information technology teaching.

Prospects for the use of ICT in physics classes are as follows: the formation of key competencies of students in the process of learning and in extracurricular activities; increasing motivation for student learning; mastering of computer literacy by students, raising the level of computer literacy of a teacher; organization of independent and research activity of students; creation of own bank of educational and methodical materials ready for use in educational process; development of modern style of thinking, cognitive abilities of students; aesthetic appeal of lessons.

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