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TRAINING OF FUTURE TEACHERS OF COMPUTER SCIENCE: MODELING THE PROCESS BASED ON THE USE OF ELECTRONIC EDUCATIONAL RESOURCES

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INTRODUCTION

Today, the leading strategy for developing Ukrainian society is to join the European one. A prerequisite for this process is the introduction of new paradigms in higher education, which has undeniable achievements in the training of specialists, including in computer science. Electronic educational resources (EER) play a significant role in this process, rapidly penetrating all spheres of society, including education, where electronic educational resources are actively used to learn. However, most of the disciplines aimed at professional training of future computer science teachers are taught with limited information technology, which fails to ensure proper systematic and continuity in education. In most cases, these disciplines need to be a system of targeted selection. Electronic educational resources will allow the student, a future computer science teacher, to perceive these technologies as an integral system of modern teaching tools in their professional training.

Analysis of current research. Many Ukrainian and foreign scientists have considered the introduction of EER into the educational process of computer science teacher training. It is the subject of discussion at conferences and in periodicals. In particular, the peculiarities of using IT in the training of specialists are presented in the works of V. Petruk[1], O. Naboka[2], V. Shamonia[3], M. Yachmenyk[4]. The theoretical and methodological approaches to the use of IT in teacher training were

[1] Petruk V., Rudenko Yu., Yurchenko A., Kharchenko I., Kharchenko S., Semenikhina O. Analysis of the Results of the Pedagogical Experiment on the Integrated Analysis of the Average and Dispersions. *International Journal of Modern Education and Computer Science (IJMECS)*. 2022. Vol. 14, No. 6. P. 25-34. DOI: https://doi.org/10.5815/ijmecs.2022.06.03

[2] Ostroha M., Drushlyak M., Shyshenko I., Naboka O., Proshkin V., Semenikhina O. On the use of social networks in teachers' career guidance activities. *E-learning in the Time of COVID-19*. 2021. Vol. 13. P. 266-277. DOI: https://doi.org/10.34916/el.2021.13.22

[3] Shamonia V., Semenikhina O., Proshkin V., Lebid O., Kharchenko S., Lytvyn O. Using the PROTEUS virtual environment to train future IT professionals. *CEUR Workshop Proceedings*. 2020. Vol. 2547. P. 24-36. URL: http://ceur-ws.org/Vol-2547/paper02.pdf

[4] Yachmenyk M., Kharchenko I., Semenog O., Kyrylenko N., Ostroha M., Bohoslavskyi S., Semenikhina O. The Formation of Infomedia Literacy of Students in a Media Tournament. *46th MIPRO ICT and Electronics Convention (MIPRO-2023)*, Opatija, Croatia, 2023. P. 660-665, DOI: https://doi.org/10.23919/MIPRO57284.2023.10159736

considered by M. Drushlyak[5], P. Mulesa[6], O. Semenog, etc.[7], O. Semenikhina, etc.[8], S. Semerikov[9], I. Shyshenko, etc.[10] and other[11]. Some aspects of the multifaceted problem of using EERs in the training of specialists are reflected in the works of D. Budiansky[12], Yu. Rudenko[13] and other. One of the main reasons for the increased attention to electronic educational resources is the convenience and simplicity of their use, the tools available for searching, analyzing, and summarizing information content, and its further use.

During professional activity, a computer science teacher has to solve tasks related to searching for available EER, analyzing their feasibility in the educational process, and creating EER to support their professional activities. Such skills should be developed during professional training, which is currently one of the leading tasks of higher teacher education. At

[5] Drushlyak M.G., Semenikhina O.V., Kondratiuk S.M., Krivosheya T.M., Vertel A.V., Pavlushchenko N.M. The Automated Control of Students Achievements by Using Paper Clicker Plickers. *Proceedings of 43 International convention on information and communication technology, electronics and microelectronics (MIPRO-2020)*, Opatija, Croatia, 2020. P. 688-692. DOI: https://doi.org/10.23919/MIPRO48935.2020.9245281

[6] Мулеса П., Семеніхіна О. Педагогічні умови підготовки майбутніх учителів математики та інформатики до використання засобів віртуальної наочності у професійній діяльності. *Фізико-математична освіта*. 2023. Том 38. No 2. С. 37-42. DOI: https://doi.org/10.31110/2413-1571-2023-038-2-006

[7] Semenog O., Semenikhina O., Oleshko P., Prima R., Varava O., Pykaliuk R. Formation of Media Educational Skills of a Future Teacher in the Professional Training. *Revista Românească pentru Educaţie Multidimensională*. 2020. Vol. 12. Is. 3. P. 219-245. DOI: https://doi.org/10.18662/rrem/12.3/319

[8] Semenikhina O., Yurchenko A., Sbruieva A., Kuzminskyi A., Kuchai O., Bida O. The Open Digital Educational Resources In IT-Technologies: Quantity Analysis. *Information technologies and learning tools*. 2020. Vol. 75. No 1. P. 331-348. DOI: https://doi.org/10.33407/itlt.v75i1.3114

[9] Kiv A.E., Semerikov S.O., Shyshkina M.P., Striuk A.M., Striuk M.I., Yechkalo Y.V., Mintii I.S., Nechypurenko P.P., Kalinichenko O.O., Kolgatina L.S., Vlasenko K.V., Amelina S.M., Semenikhina O.V. 9th Workshop on Cloud Technologies in Education: Report. *CTE Workshop Proceedings* [Online], 2022. Vol. 9, p.i-lxxvii. DOI: https://doi.org/10.55056/cte.75

[10] Shyshenko I., Martynenko O., Chkana Ya., Spas T., Udovychenko O., Semenikhina O. A mathematics teacher's training to create a maker space in mathematics lessons by means of GeoGebra. *45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO 2022)*. Opatija, Croatia, 2022. P. 909-914. DOI: https://doi.org/10.23919/MIPRO55190.2022.9803433

[11] Yurchenko A., Drushlyak M., Sapozhnykov S., Teplytska S., Koroliova L., Semenikhina O. Using online IT-industry courses in the computer sciences specialists' training. *International Journal of Computer Science and Network Security.* 2021. Vol. 21, No. 11. P. 97-104. DOI: https://doi.org/10.22937/IJCSNS.2021.21.11.13

[12] Budianskyi D.V., Drushlyak M.G., Semenikhina O.V., Kharchenko I.I., Horbachuk V.O., Chashechnikova O.S. Electronic Resources Typology In The Formation Of Specialist's Rhetoric Culture. *Information technologies and learning tools*. 2021. Vol. 81. Is. 1. P. 82-96. DOI: https://doi.org/10.33407/itlt.v81i1.4292

[13] Rudenko Yu., Naboka O., Korolova L., Kozhukhova Kh., Kazakevych O., Semenikhina O. Online Learning with the Eyes of Teachers and Students in Educational Institutions of Ukraine. *TEM Journal*. 2021. Vol. 10, Iss. 2. P. 922-931 DOI: https://doi.org/10.18421/TEM102-55

the same time, the problems of involving EER in the educational process remain and require more in-depth study. The analysis of scientific and pedagogical literature and monitoring of the current state of professional training of future computer science teachers allowed us to identify the following contradictions:

– the level of development and dissemination of modern electronic educational resources and the lack of effectiveness of their implementation in the process of teaching computer science disciplines;

– the requirements of the information society for the outcome of computer science teacher training by the level of information technology development and the lack of effective models of such training based on electronic educational resources;

– a significant number of computer science courses in the professional training of future computer science teachers and insufficient educational and methodological support.

Therefore, the involvement of EER in the professional training of future computer science teachers is an essential prerequisite for successfully implementing their professional activities, so this study **aims** to model the process of training future computer science teachers using EER.

Research methods

theoretical: analysis of monographs, articles, materials of scientific and practical conferences, psychological, pedagogical, methodological, and unique literature on the problems of introducing electronic educational resources in the educational process; generalization and systematization of domestic and foreign experience of using electronic educational resources in the process of training teachers of computer science, personal pedagogical experience of using electronic educational resources in the educational process; modeling to develop a model of training future teachers of computer science

empirical: pedagogical questionnaires, surveys, interviews with teachers and students, observation of the process and results of studying computer science disciplines to determine the actual state of teacher training.

Results. The systematic analysis of the available electronic resources conducted at the beginning of the study allowed a separate group to identify electronic educational resources, which are understood as educational, scientific, information, reference materials, and tools developed in electronic form and presented on any media or placed in computer networks, reproduced by electronic digital technical means and necessary for the effective organization of the educational process, in terms of its content with quality educational and methodological materials.

Generalization of different classifications of electronic educational resources by functional feature, structure, nature of information, form of

presentation, purpose, availability of printed equivalent, nature of basic information, distribution technology, and nature of interaction between the user and the electronic publication gave grounds to use the following e-resources in the training of a teacher of computer science: electronic educational publications, electronic means of educational purpose, computer training systems, pedagogical software, electronic educational and methodological resources. The systematic analysis of such resources confirmed the practicality of their use as teaching aids in training a computer science teacher. It led to the study of the category "computer science teacher's readiness for professional activity" (a complex personal formation, the essence of which is a set of interrelated components: subject (mastering special computer science knowledge), methodological (mastering the techniques and methods of teaching computer science) and psychological (the presence of personal qualities necessary for a specialist)). This category ensures the current implementation of pedagogical activity and is the basis for further creative self-realization and professional self-improvement of a computer science teacher.

Our methodological analysis of computer science teacher training contributed to identifying several approaches and principles that ensure the formation of computer science teacher readiness for professional activity. Among them are systemic, informational, professional, and personal, activity, competence, synergistic approaches, general didactic and specific teaching principles, and particular principles of building and using electronic educational resources. In particular, we consider the principle of scientificity, guiding, and cognitive information as the basis for forming the subject component of the computer science teacher's readiness. We perceive the principle of phasing as a guideline for the accumulation of knowledge and skills of future computer science teachers in the context of continuous improvement of their readiness. The principle of the possibility of returning to what has been previously studied determines the implementation of individual teaching technologies, which are based on electronic educational resources. The feedback principle allows one to accumulate professional knowledge and skills, considering mistakes and their correction, which is the basis for reflection on professional activity and self-analysis skills. The principle of appropriate computer support ensures the balanced use of electronic educational resources, which are the primary means of professional training. The principles of building and using electronic educational resources include cognitive visualization, quantization, completeness, manageability, and editing, ensuring the development of quality educational resources and their balanced use.

Adherence to these approaches and principles will contribute to, among other things:

- activation of independent learning activities of students;
- activation and development of visual thinking through visual presentation of educational information, development of consciousness and creative activity of students under the guidance of the teacher;
- psychological comfort in the information interaction of learners with electronic educational resources.

The described approaches and principles are the basis of the model of computer science teacher training using EER, which includes a conceptual component, a content component (educational program, EER, academic disciplines, and practices), a procedural component, which consists of the stages of involving EER (selection/ improvement/ development of EER, implementation of EER, analysis of results), methods (problem-solving, heuristic, project method, training, etc.), forms (lectures, seminars, workshops, etc.), and a practical component.

Below, we describe the features of the model's implementation with the author's developments and recommendations.

1. Active implementation of modular learning technologies

Implementation of the model involved using modular technology in developing authoring courses and constructing EER. The latter was carried out based on the following algorithm of actions:

1) define the comprehensive didactic goal and the main module;
2) specify the integral goals and their corresponding submodules;
3) build a logical graph – the structure of a modular program;
4) determine the structure of intermediate goals in each integral didactic goal;
5) build a logical graph (the structure of a specific module) based on the intermediate goals' structure.

After the stage of building the module structure, the stage of forming the content of the modules begins, the implementation of which includes:

1) presentation of learning objectives;
2) formation of learning content;
3) management of learning activities and methodological support of the learning process;
4) providing feedback.

1. Presentation of learning objectives.

If the learning process sets goals for the learners, it stimulates their motivation to learn. Therefore, the goals defined when forming the content of modules should be based on intermediate didactic goals that will interest the learners. If the didactic goal is aimed at teaching, imparting knowledge, and developing skills and abilities, then the goals formulated at the beginning of the module should focus on identifying the effectiveness of

learning. That is where the principle of a conscious perspective comes into play.

Essential criteria for forming modules are specificity, clarity, and unambiguity in interpreting learning objectives. The wording of the learning objective should be so specific and clear that it can be understood by all learners and serve as a criterion for learning effectiveness.

The objectivity of setting learning objectives depends on the basic preparedness of the learners. In this sense, the work of scientists (particular, [14]) which is considered the learning process activity and distinguishes two types of it – reproductive and productive, is essential. In his opinion, the learned information is only reproduced in various combinations and combinations in reproductive activity. At the same time, no new information is added to the original information on the subject. In other words, reproductive activity is a direct reproduction of the learned algorithm of action on the same learning element on which the learning was carried out. Examples of reproductive activities include describing the educational features and properties of previously studied subjects, calculating using a proposed formula, designing based on instructions or a prototype, presenting the information learned, and solving typical problems that require direct use of knowledge in typical conditions.

Productive activity is performed not by strictly repeating previously learned operations but "by analogy, using learned methods of activity in new conditions or on new educational elements."

2. Formation of learning content.

When forming the content of modules, the principle of modularity, the principle of completeness of the educational material in the module, and the principle of optimal transfer of information and methodological material are fundamental. The criterion for forming module educational content is the continuity of intra– and inter-subject connections. On this basis, the content of cognitive modules is formed according to the graph of the logical structure of the subject or course, which was taken as the basis for building the module structure.

It is more difficult to form the content of operational-type modules, which require knowledge of different subjects or even sciences. In this case, it is necessary to find a "central subject" (course, discipline, science), the knowledge and skills of which are more necessary to implement specific tasks. A graph of the logical structure of this subject (course, discipline, science, etc.) is built, which indicates not only intra-subject but also inter-subject connections. Then, in the individual learning elements that make up

[14] Курлянд З.Н. Особливості педагогічного процесу у вищому навчальному закладі. Педагогіка вищої школи : навч. посіб. URL: https://westudents.com.ua/glavy/50271-14-osoblivost-pedagogchnogo-protsesu-uvischomu-navchalnomu-zaklad.html

the module's structure, those topics of the main subject that are necessary for studying a particular learning element are selected, taking into account the provision of its autonomy and the completeness of its educational material. In this regard, the content of the educational component, in addition to the above topics, includes those topics of other subjects (courses, disciplines, sciences), which are indicated by interdisciplinary connections.

The next stage is the differentiation of learning content. One of the main conditions for the optimal transfer of educational information, according to [15], is the identification of the material that must be sufficiently disclosed to the learner and the material that the learner must consider and find out for himself. The primary learning material is disclosed in the central part of the module, and additional learning material is presented separately in the form of portions of information or literature (in a concise form).

The effectiveness of using the module in the educational process will depend on the completeness of the academic content that meets the specific didactic goal and learning objectives and how this information is presented. When presenting information, it is advisable to pay attention to the mechanism of the knowledge acquisition process.

It is necessary to understand the difference between a task and a problem: a task is an objective phenomenon; for the subject of learning, it exists from the very beginning in a material form (usually in written signs), while a problem is a subjective phenomenon and exists in the mind of the subject of learning[16]. The structure of the task always includes such elements as "given" and "find the unknown," and in the structure of the problem, the main components are "known" and "unknown"; its solution means finding a connection between the known and the unknown. In the modular learning process, educational (theoretical and practical) and practical problems can be solved. Practical problems require practical efforts and a new organization of existing knowledge, skills, and problem-solving abilities. Solving educational problems requires new knowledge, skills, and abilities known to science but unknown to the learner. The scientists formulated six basic requirements for a learning problem, based on which the most effective problem situations can be created:

– the learning problem should be related to the proposed learning material and logically follow from it;

– the wording of the question, task, or learning situation related to the learning problem should not contain contradictory information;

[15] Крисько В. Сутність і зміст педагогічного процесу та педагогічної діяльності. Педагогіка і психологія : підручник. 2015. URL: https://stud.com.ua/36254/psihologiya/sutnist_zmist_pedagogichnogo_protsesu_pedagogichnoyi_diyalnosti

[16] Словник синонімів української мови : в 2 т. / А.А. Бурячок, Г.М. Гнатюк, С.І. Головащук та ін. Київ : Наукова думка, 2006. 1040 с.

– the content of the learning problem should indicate the direction and ways of solving it;

– the solution to the problem should be feasible for the learner but not too easy;

– the linguistic formulation of the problem should consist of pre-sentences containing concepts known to the learner, but these sentences should also contain elements that are related to the unknown in the problem itself;

– problematic questions, learning tasks, and examples in formulating issues should emotionally impact the learner and encourage active work.

It is also necessary to pay attention to the presentation of educational material (it is revealed by the rules for implementing the principle of optimal transfer of information and methodological material). The presence of a dialog mode and the use of symbols when reading specific information are conditions for effectively presenting educational material in modules.

We consider repeating the learning material to the learner to form the module content. In modular learning, it is advisable to choose a symbolic model as the basis for developing tools designed to summarize and systematize knowledge and skills in the final learning elements since modules can also be used for the exclusively independent work of the learner. Therefore, decoding the content models of the generalized educational material, in this case, should be carried out independently.

3. Management of learning activities and methodological support of the learning process.

Forming modules continues after the presentation of learning objectives and learning content. The management of learning actions of the subject of study and methodological support of the learning process occupies an essential place in the modules. Since modular learning involves self-study and management, it is vital to present a list of critical knowledge and skills the learner must have to master this learning element at the beginning of each module. For self-regulation, along with the list of essential knowledge and skills, it is necessary to present a list of literary sources, the study of which will allow one to achieve the required initial level of mastery.

It is necessary to provide methodological support for the learning process to promote the realization of independence in learning.

Methodological support includes:

1) illustrative material that allows for a deeper understanding of the information being studied (in the form of drawings and diagrams);

2) data that specifies the theoretical material;

3) information that expands or deepens the learning process (additional literary sources in forming textbooks, reference books, patents, inventions, and scientific publications).

All materials on methodological support are presented in parallel with the primary educational content, or their sources are indicated.

4. Providing feedback.

In modular learning, including in modular programs, in some modules, cyclic control is implemented, that is, feedback on the regulation of the educational process by the control system. Cyclic control can be carried out according to the "black box" principle when feedback and process regulation are realized at the end of the process and according to the "white box" principle when feedback and regulation are carried out at different stages of the learning process.

Management should be based on a modular program's "white box" principle. The general management theory provides a system of requirements for implementing the "white box" principle. Three tasks need to be solved to provide feedback in modular training:

1) to determine the content of feedback (to identify a set of controlled characteristics);

2) to diagnose the quality of learning;

3) determine the frequency of feedback.

The set of controlled characteristics is selected based on didactic goals. The learner's achievements in those learning tasks that are essentially subordinate to the accomplishment of learning objectives can be monitored. This requirement serves as a criterion for the formation of modules.

Learning tasks that act as controlled characteristics can be varied by performing specific laboratory work, summarizing the results, performing practical work, and preparing an essay, term paper, or project.

Diagnostics consists of identifying the required quality of knowledge and skills, measuring its value, and assigning a specific grade.

An essential criterion for the formation of modules is the openness of diagnostics.

This criterion requires that the learner be presented with control characteristics at the beginning of each specific portion of the learning content, indicating their quantitative assessment and control methods. The characteristics are given (sometimes optional) at the beginning of each module, and the learning element after the learning objectives are indicated[17].

It is advisable to use the testing method to control the quality of knowledge and skills acquisition while studying the educational material contained in the modules.

[17] Буряк В. К. Організація модульного навчання. *Вища школа*. 2009. № 7. С. 18-31.

The modules use achievement tests aimed at identifying the ability of the subject of study to the methods of activity acquired by him after the relevant training.

We developed the ET "Information Systems" according to the described approaches. The construction of educational material is subject to scientific principles, availability of guiding and cognitive information, phasing, return to previously studied, feedback, and appropriate computer support. It can be studied in a linear educational trajectory and a more complex study scheme due to the modular approach to presenting the material through general didactic and integral goals. Classes formulate the purpose of studying a particular module (or topic within it) and provide theoretical material in various formats (video, audio, visual, text). Knowledge testing is offered to ensure that the principles of interactivity and feedback are implemented.

2. Active use of open educational resources for the organization of independent work

The term "open educational resources" (OER) was first introduced into scientific circulation at the Forum on Open Learning Systems for Developing Countries, organized by UNESCO in July 2002: "Open educational resources are educational and scientific resources that are in the public domain or released under a license that allows their free use and modification by third parties"[18].

According to this definition, the characteristic features of open educational resources are:

– methodological, educational, or scientific orientation of the materials;

– support for various formats and media for submitting materials;

– publication of educational and scientific materials in the public domain under an open license;

– providing free access, use, processing, and redistribution of materials by other users;

– minimum restrictions (or lack thereof) when working with open educational resources;

– Open licensing, which is built into the current intellectual property rights system and which is defined by the relevant international conventions[19, 20, 21].

[18] Bates T. National strategies for e-learning in post-secondary education and training. Paris, 2001. 132 p. URL: http://unesdoc.unesco.org/images/0012/ 001262/126230e.pdf

[19] Hylén J. Open Educational Resources: Opportunities and Challenges. *Educational Research and Innovation.* Paris, France : OECD Publishing, 2006. URL: http://www.oecd.org/edu/ceri/37351085.pdf

[20] McGreal Rory. Why open educational resources are needed for mobile learning. *Increasing Access through Mobile Learning*, 2014. P. 49-59 – URL: http://en.copian.ca/library/research/commonwealth_of_learning/perspectives/perspectives.pdf

Therefore, open educational resources can be considered publicly available educational and scientific materials that follow "open licenses" and allow users to use them freely – copy, modify, and create new resources based on them.

Open educational resources emerged in 2001 when the Massachusetts Institute of Technology created OpenCourseWare – the Open Course Environment (MIT OCW)[22, 23], allowing Internet users to use developed educational materials freely. The following arguments are made in favor of creating open educational resources.

1. Educational institutions that receive public funding must provide free access and use of their materials since they are partially created with citizens' taxes and thus have already been paid for by society.

2. Restricted access to materials can lead to duplication of efforts, which entails additional costs for society.

3. The placement of open educational resources creates a positive image of the university, which helps to attract students and funding from non-governmental funds.

Open educational resources should be considered not only as a fashionable phenomenon in education but, first and foremost, as a mandatory direction for developing educational institutions in particular and education in general. Expanding open educational resources is increasingly blurring the boundaries between formal and non-formal learning and offers radically new approaches to knowledge dissemination. That happens when the effective use of knowledge becomes a critical factor in economic success for individuals and institutions. Open education projects provide free access to quality educational resources available online and thus undoubtedly contribute to expanding the participation of open educational resources in higher education and further promoting education[24, 25].

The world's leading universities have open educational environments where they host educational resources. Universities from all over the world provide access to open educational resources. Here are just a few of them:

– USA: Yale University (Fig. 1), Princeton University, Massachusetts Institute of Technology (Fig. 2);

– European countries: The Open University (Fig. 3), Paris Institute of Technology, University of Nottingham (Fig. 4);

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[21] Orr D., Rimini M., Damme D. Open Educational Resources: A Catalyst for Innovation. Paris, France : OECD Publishing, 2015. 146 p. DOI: https://doi.org/10.1787/9789264247543-en

[22] edX: Build new skills. Advance your career. URL: www.edx.org

[23] MIT OpenCourseWare | Free Online Course Materials. URL: https://ocw.mit.edu/

[24] Bennet L., Londoni M. E-books in academic libraries. *The Electronic Library.* 2005. Vol. 23, No 1. P. 9-16. DOI: https://doi.org/10.1108/02640470510582709.

[25] Mariz C., Stephenson J., Carter M. Interactive whiteboards in education: A literature scoping survey. *Australian Educational Computing*. 2017. Vol. 32, No 1. URL: https://journal.acce.edu.au/index.php/AEC/article/view/135/pdf

– Japan: Nagoya University (Fig. 5);
– Australia: University of Southern Queensland (Fig. 6).

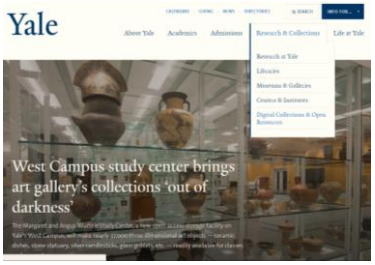

Fig. 1. Yale University website

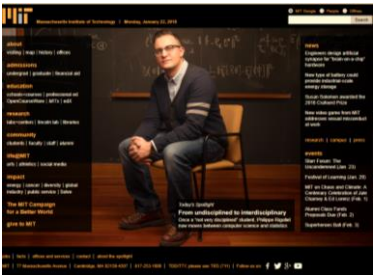

Fig. 2. Massachusetts Institute of Technology website

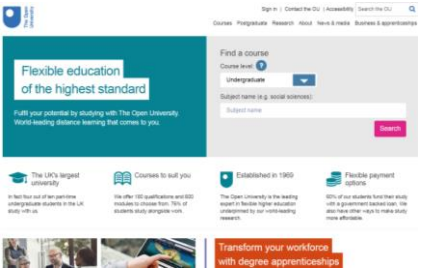

Fig. 3. The Open University website

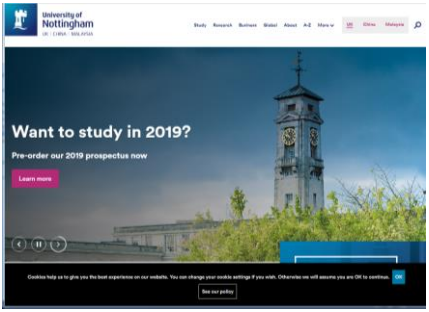

Fig. 4. University of Nottingham website

Fig. 5. Nagoya University website

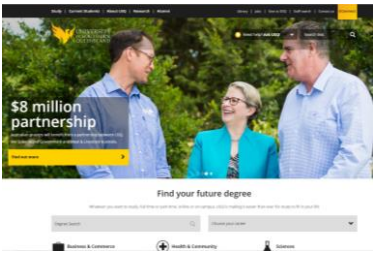

Fig. 6. University of Southern Queensland website

Open educational resources are usually hosted on the web servers of the universities that developed them. We analyzed some of these resources for the availability of computer science courses. We were interested in their

number, scope (how many hours they are designed for), authors, technologies for obtaining certificates, etc. Some results of our search are presented in Tables 1 and 2.

Table 1

Electronic open educational resources in computer science

Resource	Total number of training courses	Training IT-courses		Course language							
				Ukrainian		Russian		English		other	
		Quantity.	%	Quantity	%	Quantity	%	Quantity	%	Quantity	%
Coursera	1800	525	29,2	0	0	0	0	493	90	32	10
Edx	681	326	47,9	0	0	0	0	326	100	0	0
Udemy	1113	298	26,8	0	0	0	0	298	100	0	0
MIT	2829	639	22,6	0	0	0	0	639	100	0	0
Open Learn	819	175	21,4	0	0	2	0	175	100	0	0

Table 2

Computer science sections on open educational resources

Course0	Total	Quantity	Resource				
			Coursera	Edx	Udemy	MIT Open Course Ware	Open Learn
Programming	970	Quantity	201	132	144	252	98
		%	20,7	13,6	14,8	26	10,1
Graphics	403	Quantity	79	53	75	137	26
		%	19,6	13,1	18,6	34	6,4
Web design	218	Quantity	62	38	22	60	24
		%	28,4	17,4	10,1	27,5	11
Computer networks	122	Quantity	49	18	8	32	9
		%	40,2	14,7	26,2	2,6	7,4
Microsoft Office	38	Quantity	6	7	3	14	2
		%	15,8	18,4	7,9	36,8	5,3
Other	472	Quantity	128	78	46	144	16
		%	27,1	16,5	9,7	30,5	3,4

Their analysis indicates the active development and implementation of open educational resources in America and the EU[26]. That explains the majority of English-language projects. Computer science courses are

[26] Cobo C. Exploration of open educational resources in non-English speaking communities. *International Review of Research in Open and Distance Learning.* 2013. Vol. 14, No 2. P. 106-128. DOI: https://doi.org/10.19173/irrodl.v14i2.1493

primarily offered not as classical ones but as author's courses that touch on modern scientific achievements and are in demand by young people abroad. In organizing independent work, we offered to take one of the courses with a mandatory requirement to obtain a certificate of completion, preferably with a grade. Completing the course gave the student maximum points for independent work.

Further conversations with future computer science teachers about studying in such courses revealed that, on the one hand, such courses, in addition to the qualitative impact on the formation of the subject component of the future computer science teacher's readiness, require a disciplined attitude to the educational process. On the other hand, they made it possible to compare teaching methods, the level of lecture and practical material, didactic material, etc., that indirectly influenced the psychological component of the formation of the future computer science teacher's professional readiness.

3. Implementation of author's electronic textbooks

The developed model of training future computer science teachers based on EER included an obligatory component of information support for the course in electronic textbooks, manuals, and guidelines.

The study confirmed the practicality of using electronic textbooks (ET) as modern means of presenting educational information in the study of computer science disciplines, by which we mean an electronic educational resource with a systematic presentation of the discipline (its section, part), which, taking into account the development of information technology, equally and interconnectedly presents text, sound, graphic and other educational material, which ensures the continuity and completeness of the didactic cycle under the principles of education and the current curriculum.

The analysis of scientific and methodological literature contributed to the identification of didactic features of the construction of electronic learning materials, among which we mention the possibility of organizing various types of active work with fragments of electronic learning materials (illustrations, dynamic modeling, links to multimedia applications; questions for self-control and keys to check the correct answers)[27, 28].

Since the material in the EP is presented in a dosed manner and according to a certain logic of hyperlinks, we believe that the structure of the ET can be subordinated to the principles of modular learning:

[27] Darlene Waller. Current Advantages and Disadvantages of Using E-Textbooks in Texas Higher Education. *Focus On Colleges, Universities, And Schools*, 2013. Vol. 7, No 1. URL: http://surl.li/tzqmq

[28] Rosenberg M. Beyond E-Learning: New Approaches to Managing and Delivering Organizational Knowledge. *STEP Webinar June 21, 2005*. URL: http://www.performance-vision.com/step/webinars/STEPBeyondE-LearningHandout062105.pdf

1) a comprehensive didactic goal and a core module are defined; 2) integral goals and their corresponding submodules are specified; 3) a logic graph – the structure of a modular program is built; 4) the structure of intermediate goals is determined in each integral didactic goal; 5) based on the structure of intermediate goals, a logic graph – the structure of a specific module – is built. Therefore, for the development and further implementation of our e-learning materials, we clarified the purpose of the course, consumers of the electronic product, learning tasks that will be solved with its help, and by whom. The development of a modern ET platform required additional analysis of the course content to be presented in it from the standpoint of linearity or non-linearity of the structure, type of feedback, types of additional software for working with graphics, video, audio, and other formats, and the form of presentation of course modules on the monitor screen.

We have implemented a project to create this type of electronic products that have a PDF version and is presented as a complexly structured educational resource and is positioned as a modern e-learning resource and as an ET (Figs. 7-11) with multimedia content, which includes visual support, animations, videos, a glossary and a testing module for self-checking in addition to theoretical material[29, 30, 31, 32, 33, 34, 35].

[29] Semenikhina E., Drushlyak M. Computer Mathematical Tools: Practical Experience of Learning to use them. *European Journal of Contemporary Education*. 2014. Vol. 9. P. 175-183. URL: https://repository.sspu.edu.ua/items/a332746d-3dd9-4d6e-b8a1-77c338bee1ab

[30] Semenikhina E. Development of Dynamic Visual Skills SKM MAPLE among Future Teachers. European Journal of Contemporary Education. 2014. Vol. 10, No 4. P. 265-272. URL: https://www.researchgate.net/publication/283396793_Development_of_Dynamic_Visual_Skills_SKM_MAPLE_among_Future_Teachers

[31] Semenikhina O. Programming as a Method of Forming Mathematical Knowledge in Conditions of Informatization Education. *Zhurnal ministerstva narodnogo prosveshcheniya*. 2014. Vol. 2, № 2. P. 93-98.

[32] Semenikhina O.V., Shamonya V.G., Udovychenko O.N., Yurchenko A.A. Electronic Textbook in the Context of Educational Trends and Modern Internet Technologies. *Zhurnal ministerstva narodnogo prosveshcheniya*. 2014. Vol. 2, № 2. P. 99-107.

[33] Semenikhina O., Drushlyak M. On the Results of a Study of the Willingness and the Readiness to Use Dynamic Mathematics Software by Future Math Teachers. *Proceedings of the 11th International Conference on ICT in Education, Research and Industrial Applications: Integration, Harmonization and Knowledge Transfer (ICTERI 2015)*. Lviv, Ukraine, May 14-16, 2015. P. 21-34. URL: http://ceur-ws.org/Vol-1356/

[34] Semenikhina O. To the Issue of Critical Choise While Using the DMS in Mathematics Education. *Zhurnal ministerstva narodnogo prosveshcheniya*. 2015. Vol. 3, № 1. P. 20-28.

[35] Semenikhina O., Drushlyak M. Organization of Experimental Computing in Geogebra 5.0 in Solving Problems of Probability Theory. *European Journal of Contemporary Education*. 2015. Vol. 11, № 1. P. 82-90. URL: https://www.researchgate.net/publication/277580609_Organization_Of_Experimental_Computing_in_GeoGebra_50_in_Solving_Problems_of_Probability_Theory

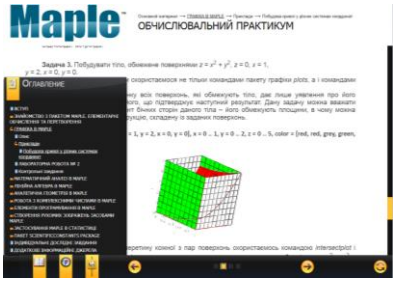

Fig. 7. Fragment of the ET "Computing Workshop"

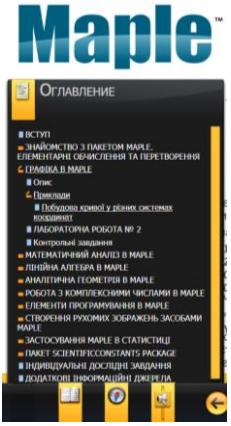

Fig. 8. Structure of the e-learning course "Computing Workshop"

Fig. 9. Fragment of the ET "Computer graphics"

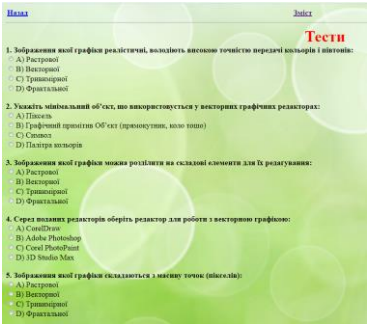

Fig. 10. The testing module of the ET "Computer Graphics»

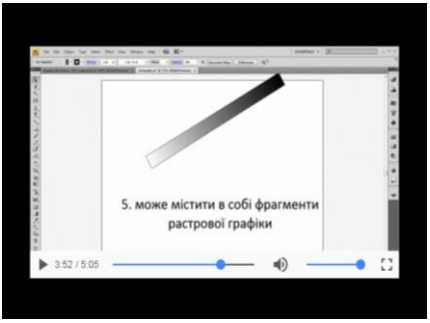

Fig. 11. Video fragment from the course "Computer Graphics"

We will also describe the process of involving e-learning in teaching computer science disciplines, using the example of studying the schematics of PC devices. The theoretical training for a bachelor's degree in the specialty 014.09 Secondary Education (Computer Science) involves the study of the normative discipline "PC Architecture." As the analysis of methodological systems for training specialists and future computer science teachers has shown, various forms, methods, and means of teaching are used to master it. Along with the traditional ones, we use an electronic textbook. Let us dwell on the methodological features of studying "Schematic Diagram of Computer Devices" utilizing the author's e-textbook.

The study of the topic should begin with the fact that the modern educational process can only be built using specific models. A model is a simplified representation of an actual structure or phenomenon for a particular purpose. Given the importance of human visual perception, graphical models occupy a significant place among various models. Humanity often uses diagrams that illustrate certain principles of operation or phenomena with varying degrees of detail to simplify the description and better understand the peculiarities of information systems. Given the complexity of devices (the number of active elements reaches billions), the study of computing technology requires a different scale of detail to combine into a schematic block. In this case, such schemes (blocks) are classified by the degree of detail.

Schematic diagrams are diagrams that show every part with all the connections. Such a diagram tracks the flow of electric charge carriers while processing each bit of information. At this stage, we use the corresponding image of the ES – an example of a schematic diagram.

Next, we note that since modern processors and memory cells have billions of active transistor elements, it is often impossible to show and read a schematic diagram of a modern processor. Therefore, models called flowcharts or block diagrams are used. Again, it is worth visualizing the educational material with a relevant example from the ET and allowing students to familiarize themselves with the accompanying test content of the ES. In block diagrams, large sections of the schematic diagrams are combined into blocks according to their logical purpose, which are connected by pointers to the flows of data and energy. As a rule, a block diagram shows the energy interaction of various computer components.

Finally, an architecture is a schematization that ignores the energy interaction and shows only the logical flow of data through the device. In an architecture, the parts and nodes from the flowcharts that have a specific functional purpose in data processing are combined into separate blocks. In the e-textbook, we provide interactive visualizations to support this learning material. If you consider the architecture of a PC, you can imagine a device

with a central processor on top of it, connected directly by a high-speed north bridge (northbridge). The north bridge can serve only two high-speed devices – electronic memory and a video system. It is also worth noting that modern microprocessors combine the north bridge and the video system on a single chip. In the future, electronic memory is planned to be added.

A more detailed analysis of the architecture of the central processor allows us to distinguish, first of all, the bus interface, which consists of three buffers:

A data bus buffer for three states (input, output, or high-impedance state)

An address bus buffer for two states (output or high-impedance state)

Two command bus buffers (receiving and transmitting)

It is worth noting that the receive and transmit buffers of the command bus operate continuously, and multiplexing, as in the data and address buses, is not typical for the command bus.

The register block should be highlighted among the processor's structural units. It consists of two parts – a block of general-purpose registers and a block of particular registers. General-purpose registers can be used in a single mode (32-bit) or combined in series (64-bit).

The special registers are the instruction address register and the edge address register. All registers are connected by a switch, which allows data to be transferred from any register to any register within one machine cycle. An arithmetic logic device and a floating-point device are connected to the switch. The operation of these devices is coordinated by the microprocessor control unit, which compiles the commands issued in the Cisc or Risc systems. Such a translation also occurs if there are commands with the extra-long command word vliw.

The microprocessor control unit receives data from the command decoder, which, in turn, receives commands from the command queue. In modern processors, the queue and decoder are supplemented by a pipeline, and the command queue is, in fact, the command cache of the command-level processor.

We combined these visualized objects in Fig. 12 (more detail here[36]). After getting acquainted with the theoretical information about the logical structure of PC devices, students are asked to reproduce various schematics from memory, compare them with those proposed in the electronic textbook, analyze errors, if any, and then answer the interactive test questions[37].

[36] Семеніхіна О.В., Шамоня В.Г., Удовиченко О.М., Юрченко А.О. Інформатика в схемах і таблицях : навч. посібн. Суми : Видавництво «МкДен», 2013. 76 с.

[37] Шамоня В.Г., Удовиченко О.М. Використання електронних освітніх ресурсів у підготовці бакалаврів, майбутніх вчителів інформатики (на прикладі вивчення схемографіки пристроїв ЕОМ засобами електронного підручника). *Гуманізація навчально-виховного процесу : Збірник наукових праць*, 2017. № 4(84). С. 190-203.

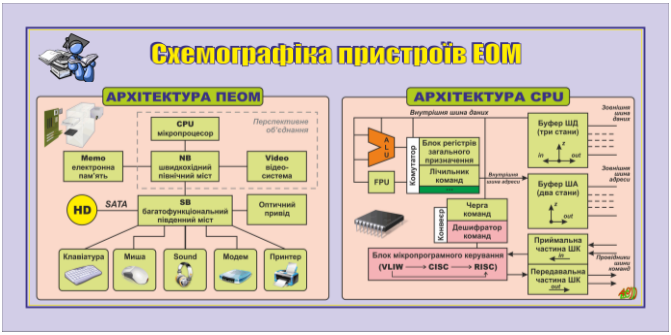

Fig. 12. Visual support of the topic "Schematic diagram of computer devices"

Preliminary preparation for the study of the topic involves familiarization with theoretical material at home, so the lecture is often based on a dialogic basis with the use of cognitive graphics and encourages visual thinking and generalization of previously acquired knowledge (Fig. 13)[38]

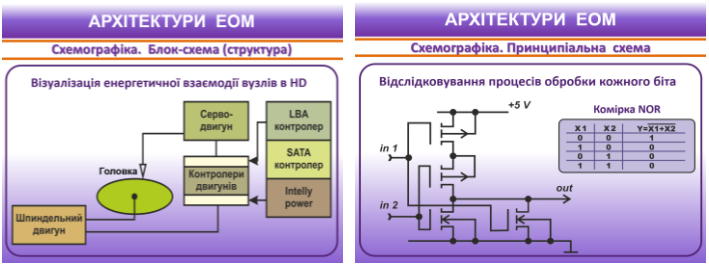

Fig. 13. Fragments of the presentation on the topic "Device schematics"

For independent work, students are encouraged to build visual models of architectures of home automated devices (computers, tablets, phones, etc.).

The preparation of the seminars involves analyzing the following issues:

1. Use the mathematical apparatus of the perfect disjunctive standard form and the ideal conjunctive normal form to build schematic diagrams and block diagrams of arbitrary logic devices.

[38] Семеніхіна О.В., Шамоня В.Г., Удовиченко О.М., Юрченко А.О. До питання про урахування законів зорового сприйняття у навчальному процесі. *Проблеми та інновації в природничо-математичній, технологічній і професійній освіті*: матеріали V-ї Міжнародної науково-практичної онлайн-інтернет конференції (м. Кропивницький, 10-13 жовтня 2017 р.). Кропивницький: РВВ ЦДПУ ім. В. Винниченка, 2017. С. 77-78. URL: https://repository.sspu.edu.ua/items/da4e8d73-3411-4a31-9655-d7c0a27a2ec1

2. Building architectural diagrams according to a given block diagram.

3. Transformation (enlargement or detailing) of architectural schemes.

4. Interaction of nodes within the CPU according to its given architecture.

The study results of the topic "Schematic diagram of computer devices" are implemented in computer testing format. Among the questions are the following.

– What is the difference between a message and a signal?

A. Power.

B. Spectrum.

C. Time characteristics.

D. The purpose of the purpose.

E. There is no correct answer.

– Specify the essential logical elements:

A. NOR or NAND.

B. NOR and NAND.

C. NOR and NOT.

D. NAND and NOT.

E. There is no correct answer.

– Indicate the conditions for the expediency of using DNF to construct an arbitrary function:

A. The number of zeros is less than the number of ones.

B. The number of ones is less than the number of zeros.

C. The number of ones is equal to the number of zeros.

D. The number of ones is independent of the number of zeros.

E. There is no correct answer.

– What is the principle of increasing the bit capacity of an adder?

A. By combining the outputs.

B. By combining the inputs.

C. By combining the carry output from the lowest bit.

D. By combining the outputs of the transfers.

E. There is no correct answer.

In the process of studying the schematics of PC devices, the electronic textbook is used both in the lecture to provide high-quality multimedia support for the text part and in the organization of independent work when it is possible to get acquainted with the interpretation of the topic by other authors, PC developers, architectures, etc. through additional links.

Trial testing of students at home makes it possible to prevent typical mistakes and ensure memorization and partial understanding of the introductory provisions of the theory of computer circuitry.

When developing the eLearning tool, we provided it for its use on mobile devices. That makes it possible to visualize the material for the general

public through a multimedia projector and individually, allowing you to build individual learning paths and implement e-learning, m-learning, and b-learning technologies.

The ET content in computer science disciplines should correspond to modern ideas about a particular field of computer science. From this point of view, both the science of computer science and special courses in the study of specialized software products cannot be considered classical stable disciplines – the constant development of information technology causes changes in the content and approaches to learning. That requires continuous updating of the content part of the e-learning course – updating of generalizing schemes, models, and tables that would demonstrate the main ideas of the course, illustrate the processes of information transformation that are closed to ordinary people, etc. The solution to this problem is based on the principle of openness in developing one's EER.

Development and implementation of EER.

While working on the research, we found that the pedagogical purpose of using electronic educational resources can be

- propaedeutic familiarization with lecture material;
- classroom lecture for self-study;
- admission to laboratory classes;
- virtual laboratory workshop;
- self-control, etc.

The pedagogical goal is to familiarize students with the lecture material. The simplest and most effective way to solve this problem is an electronic complex in text format (in particular, a Word copy of the digital reference outline of the lecture material). In this case, it is important to provide space for notes on each page to allow students to record questions about unclear parts of the material.

This approach lets you come to class with printed text and ready-made questions. There is no need to read the lecture material in full in the classroom – the teacher only needs to focus on the main points and answer questions that students have during the pre-lecture study of the lecture material. This approach is efficient when you need to cover a large amount of material in a short period.

For example, a few hours are allocated to study the course "Computation Methods," but there is a lot of educational material. In this case, it is worth using the following ideas to save class time (Fig. 14).

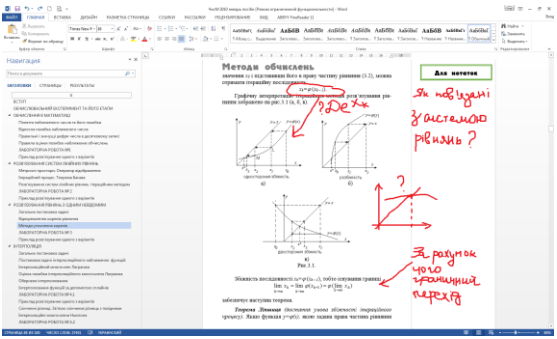

Fig. 14. Fragments of the EP "Methods of Computation", where notes are provided

The learning task is self-study by repeatedly listening to the training material. In this case, a video lecture (in particular, in MP3 format) can be offered as a technical solution. It is a recording of a lecture on a digital video camera without computer processing before and after filming. That is the easiest way for a teacher to create a bank of lectures. As a rule, such a technical solution is used when a lecture is conducted as a monologue, without demonstrations, without additional drawings, without mathematical proofs, without drawing pictures.

This format of the e-learning tool has caused and continues to cause a lot of complaints since the learner cannot ask the lecturer questions. However, from a technical point of view, the quality of this kind of digital resource can be improved by using hardware and software capabilities[39, 40]. For example, we have created a bank of lectures on the course "Fundamentals of Microelectronics" (author-developer of the course – PhD, Associate Professor V. Shamonia) to support distance learning. Footage of one of these lectures is shown in Fig. 15.

[39] Eason G. Digital textbooks open a new chapter. *BBCNews, 2011*. URL: http://www.bbc.co.uk/news/business-15175962

[40] Mango O. iPad use and student engagement in the classroom. *The Turkish Online Journal of Education Technology*, 2015. Vol. 14 (1). P. 53-57. URL: https://files.eric.ed.gov/fulltext/EJ1057341.pdf

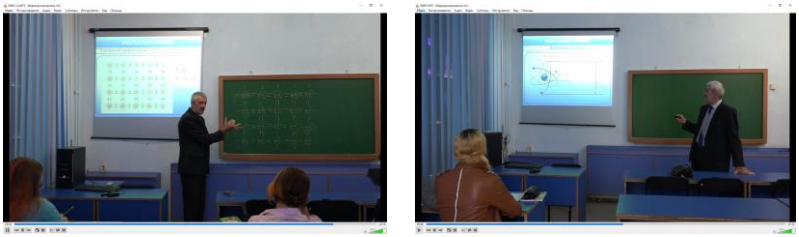

Fig. 15. Fragments of the video lecture "Fundamentals of Microelectronics" (Lecturer – Ph.D. (Physics and Mathematics Sciences), Associate Professor V.Shamonia)

The educational task is to organize self-study in disciplines using constructions, proofs, and demonstrations (natural sciences).

The technical solution, in this case, can be an audio lecture with synchronized slides, namely a full-text pre-recorded audio lecture (with or without the lecturer's face) using a controlled (synchronized with the lecturer's text) slide show (in particular, a PowerPoint presentation). Such an electronic product is built in HTML format. Activation of a specific content entry automatically changes all the product's screen windows, displaying the corresponding images (the lecturer's image, a slideshow of the educational material, etc.).

The production of such an e-learning resource requires special preliminary preparation, which includes writing a complete lesson text with a storyboard, creating a presentation for the text with customized animation, recording audio, and synchronizing it in a particular software product. The production process looks cumbersome, but this product has some disadvantages from the previous E-Learning Management System format. The created presentation with customized animation can accompany a lecture class. Thus, we have developed lecture presentations for self-study of the particular course "PC Architecture." (Fig. 16).

Learning objective: self-study using distance technologies. Technical solution: an electronic educational and methodological complex in an e-course format in a particular software shell.

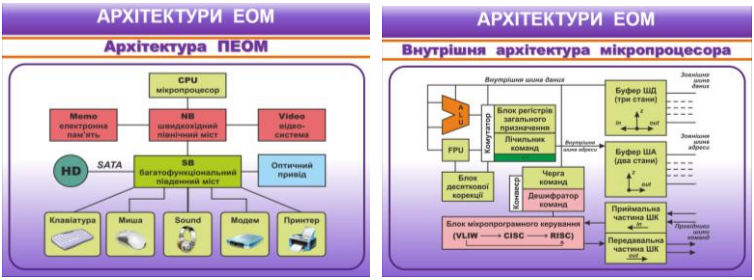

Fig. 16. Fragments of a lecture presentation on "PC Architecture"

The work is carried out according to a particular technological scheme map, which specifies the requirements, formats, and volumes of specific components of the distance course. The primary purpose is to serve as an educational and methodological tool for organizing distance learning technologies. It requires additional organizational measures (preliminary training on working with the shell) and access to the Internet.

An example of such an electronic tool is an electronic computer science textbook we developed for studying "Information Systems" (Figures 17–20). In this case, no additional training is required, as the e-learning tool is created using a simple navigation system, and each student can master the navigation of this e-learning tool.

Fig. 17. Title page of ET "Information Systems"

Fig. 18. The page on the topic "Data Structures", ET "Information systems»

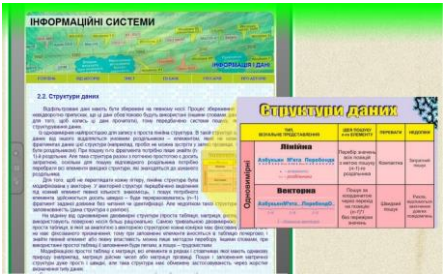

Fig. 19. Page of the theoretical part of the topic "Data structures", ET "Information systems»

Fig. 20. The page of knowledge control on the topic "Data structures", EP "Information Systems»

Educational task – propaedeutic preparation for a laboratory workshop. The technical solution is an electronic teaching and learning complex in the format of electronic instructions containing videos that "copy off the screen" mouse movements, keyboard commands, etc. Visually, it looks like this. First, you should watch the laboratory workshop in videos (you can watch it in detail an unlimited number of times). After that, complete the tasks (solve a problem, model an object, etc.) and send the results by e-mail in the form of reports to the website or by message to the teacher.

We used such EER most often during the laboratory computing workshop (Fig. 21).

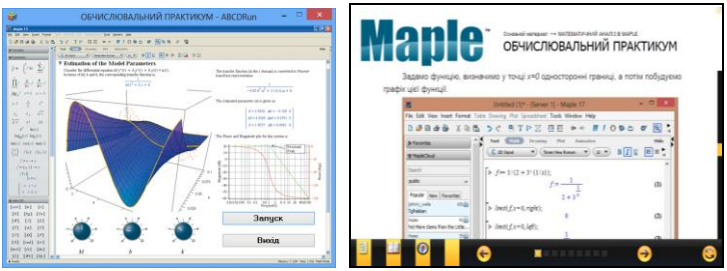

Fig. 21. The pages of the Computing Workshop

Thus, to develop and implement EER in the training of computer science teachers, it is necessary to clarify the purpose of the course, consumers of the electronic product, learning tasks that will be solved with its help, and by whom. Also, the development of a modern E-Learning Management System based on EER requires additional analysis of the content of the course to be presented in it from the standpoint of linearity or non-linearity of the structure, type of feedback, types of additional software for working with graphics, video, audio, and other formats, the form of presentation of course modules on the monitor screen.

CONCLUSIONS

The modern market of computer technologies determines the requirements for training qualified specialists, which is especially true for future computer science teachers. At the same time, it offers electronic educational resources, which are currently actively, but often unsystematically, used by learners. In the system of electronic educational resources, we distinguish an electronic textbook as an electronic educational resource that provides for compliance with the course program; systematic, scientific, and complete presentation of educational material, taking into account the psychological and pedagogical characteristics of the subjects of study, simultaneous presentation of educational material in various forms, the level of development of information technology in the methods of presenting educational material and organizing work with the resource, continuity, and completeness of the educational cycle, individualization, and differentiation of learning.

Preparation of a computer science teacher is a complex, multifaceted process, the result of which is the readiness of a future computer science teacher for professional activity – a complex integrated personal formation, the essence of which is a set of interrelated components: subject (mastering special computer science knowledge), methodological (mastering the techniques and methods of teaching computer science) and psychological (the presence of personal qualities necessary for a specialist), which ensures the current implementation of pedagogical activity and is the basis for

The orientation of modern educational technologies to a high level of automation and the use of electronic educational resources in teaching requires scientifically based support and the availability of appropriate

education and methodological support, which determines the relevance of improving the professional training of future computer science teachers towards the active use of electronic educational resources as leading teaching tools. Such improvement involves constructing theoretical substantiation and implementing a model for training future computer science teachers for professional activity using electronic educational resources.

The implementation of the model of training future computer science teachers for professional activity using electronic educational resources will be successful if modern conceptual approaches and principles of the educational process are taken into account; it is advisable to combine traditional teaching methods and innovative technologies that involve the use of electronic educational resources not only in the educational process but also for professional growth and improvement, the organization and management of the educational process; the latest forms of organization and conduct of training are widely used.

The study claims to partially solve the problem of training future computer science teachers. Further scientific research is needed to solve the problem of using electronic educational resources to improve the efficiency of independent learning and research work of future teachers of computer science; development of professional competencies of a teacher of computer science utilizing electronic educational resources in non-formal and informal education.

SUMMARY

Today, the leading strategy for developing Ukrainian society is to join the European one. A prerequisite for this process is the introduction of new paradigms in higher education, which has undeniable achievements in the training of specialists, including in computer science. It's reassuring to note that electronic educational resources (EER) are not just passive tools but actively contribute to this process, rapidly penetrating all spheres of society, including education, where they are actively used to learn. The involvement of EER in the professional training of future computer science teachers is an essential prerequisite for successfully implementing their professional activities, so this study aims to model the process of training future computer science teachers using EER. Implementing the model involves the preliminary selection/ improvement/ development of electronic educational resources used in teaching normative and variable disciplines. At the same time, we actively implemented the ideas of modular teaching technologies (in particular, the development of the author's electronic educational resources is subject to the principles of quantization of educational material, scientificity, availability of guiding and cognitive information, phasing, return to previously studied, feedback), the use of open educational resources for the organization of independent work.

BIBLIOGRAPHY

1. Bates T. National strategies for e-learning in post-secondary education and training. Paris, 2001. 132 p. URL: http://unesdoc.unesco.org/images/0012/ 001262/126230e.pdf
2. Bennet L., Londoni M. E-books in academic libraries. *The Electronic Library*. 2005. Vol. 23, No 1. P. 9-16. DOI: https://doi.org/10.1108/ 02640470510582709.
3. Budianskyi D.V., Drushlyak M.G., Semenikhina O.V., Kharchenko I.I., Horbachuk V.O., Chashechnikova O.S. Electronic Resources Typology In The Formation Of Specialist's Rhetoric Culture. *Information technologies and learning tools*. 2021. Vol. 81. Is. 1. P. 82-96. DOI: https://doi.org/10.33407/itlt.v81i1.4292
4. Cobo C. Exploration of open educational resources in non-English speaking communities. *International Review of Research in Open and Distance Learning.* 2013. Vol. 14, No 2. P. 106-128. DOI: https://doi.org/10.19173/irrodl.v14i2.1493
5. Darlene Waller. Current Advantages and Disadvantages of Using E-Textbooks in Texas Higher Education. *Focus On Colleges, Universities, And Schools*, 2013. Vol. 7, No 1. URL: http://surl.li/tzqmq
6. Drushlyak M.G., Semenikhina O.V., Kondratiuk S.M., Krivosheya T.M., Vertel A.V., Pavlushchenko N.M. The Automated Control of Students Achievements by Using Paper Clicker Plickers. *Proceedings of 43 International convention on information and communication technology, electronics and microelectronics (MIPRO-2020)*, Opatija, Croatia, 2020. P. 688-692. DOI: https://doi.org/10.23919/MIPRO48935.2020.9245281
7. Eason G. Digital textbooks open a new chapter. *BBCNews, 2011*. URL: http://www.bbc.co.uk/news/business-15175962
8. edX: Build new skills. Advance your career. URL: www.edx.org
9. Hylén J. Open Educational Resources: Opportunities and Challenges. *Educational Research and Innovation*. Paris, France : OECD Publishing, 2006. URL: http://www.oecd.org/edu/ceri/37351085.pdf
10. Kiv A.E., Semerikov S.O., Shyshkina M.P., Striuk A.M., Striuk M.I., Yechkalo Y.V., Mintii I.S., Nechypurenko P.P., Kalinichenko O.O., Kolgatina L.S., Vlasenko K.V., Amelina S.M., Semenikhina O.V. 9th Workshop on Cloud Technologies in Education: Report. *CTE Workshop Proceedings* [Online], 2022. Vol. 9, p.i-lxxvii. DOI: https://doi.org/10.55056/cte.75
11. Mango O. iPad use and student engagement in the classroom. *The Turkish Online Journal of Education Technology*, 2015. Vol. 14 (1). P. 53-57. URL: https://files.eric.ed.gov/fulltext/EJ1057341.pdf
12. Mariz C., Stephenson J., Carter M. Interactive whiteboards in education: A literature scoping survey. *Australian Educational Computing*. 2017. Vol. 32, No 1. URL: https://journal.acce.edu.au/index.php/ AEC/article/view/135/pdf
13. McGreal Rory. Why open educational resources are needed for mobile learning. *Increasing Access through Mobile Learning*, 2014. P. 49-

59. URL: http://en.copian.ca/library/research/commonwealth_ of_learning/ perspectives/perspectives.pdf

14. MIT OpenCourseWare | Free Online Course Materials. URL: https://ocw.mit.edu/

15. Orr D., Rimini M., Damme D. Open Educational Resources: A Catalyst for Innovation. Paris, France : OECD Publishing, 2015. 146 p. DOI: https://doi.org/10.1787/9789264247543-en

16. Ostroha M., Drushlyak M., Shyshenko I., Naboka O., Proshkin V., Semenikhina O. On the use of social networks in teachers' career guidance activities. *E-learning in the Time of COVID-19.* 2021. Vol. 13. P. 266-277. DOI: https://doi.org/10.34916/el.2021.13.22

17. Petruk V., Rudenko Yu., Yurchenko A., Kharchenko I., Kharchenko S., Semenikhina O. Analysis of the Results of the Pedagogical Experiment on the Integrated Analysis of the Average and Dispersions. *International Journal of Modern Education and Computer Science (IJMECS)*. 2022. Vol. 14, No. 6. P. 25-34. DOI: https://doi.org/10.5815/ijmecs.2022.06.03

18. Rosenberg M. Beyond E-Learning: New Approaches to Managing and Delivering Organizational Knowledge. *STEP Webinar June 21, 2005*. URL: http://www.performance-vision.com/step/webinars/STEPBeyondE-LearningHandout062105.pdf.

19. Rudenko Yu., Naboka O., Korolova L., Kozhukhova Kh., Kazakevych O., Semenikhina O. Online Learning with the Eyes of Teachers and Students in Educational Institutions of Ukraine. *TEM Journal.* 2021. Vol. 10, Iss. 2. P. 922-931 DOI: https://doi.org/10.18421/TEM102-55

20. Semenikhina O. To the Issue of Critical Choise While Using the DMS in Mathematics Education. *Zhurnal ministerstva narodnogo prosveshcheniya*. 2015. Vol. 3, № 1. P. 20-28.

21. Semenikhina O., Drushlyak M. Organization of Experimental Computing in Geogebra 5.0 in Solving Problems of Probability Theory. *European Journal of Contemporary Education*. 2015. Vol. 11, № 1. P. 82-90. URL: https://www.researchgate.net/publication/277580609_ Organization_Of_ Experimental_Computing_in_GeoGebra_50_in_Solving_Problems_of_Probabil ity_Theory

22. Semenikhina O.V., Shamonya V.G., Udovychenko O.N., Yurchenko A.A. Electronic Textbook in the Context of Educational Trends and Modern Internet Technologies. *Zhurnal ministerstva narodnogo prosveshcheniya*. 2014. Vol. 2, № 2. P. 99-107.

23. Semenikhina E. Development of Dynamic Visual Skills SKM MAPLE among Future Teachers. European Journal of Contemporary Education. 2014. Vol. 10, No 4. P. 265-272. URL: https://www.researchgate.net/publication/283396793_Development_of_Dyn amic_Visual_Skills_SKM_MAPLE_among_Future_Teachers

24. Semenikhina E., Drushlyak M. Computer Mathematical Tools: Practical Experience of Learning to use them. *European Journal of Contemporary Education*. 2014. Vol. 9. P. 175-183. URL:

https://repository.sspu.edu.ua/items/a332746d-3dd9-4d6e-b8a1-77c338bee1ab

25. Semenikhina O. Programming as a Method of Forming Mathematical Knowledge in Conditions of Informatization Education. *Zhurnal ministerstva narodnogo prosveshcheniya*. 2014. Vol. 2, № 2. P. 93-98.

26. Semenikhina O., Yurchenko A., Sbruieva A., Kuzminskyi A., Kuchai O., Bida O. The Open Digital Educational Resources In IT-Technologies: Quantity Analysis. *Information technologies and learning tools*. 2020. Vol. 75. No 1. P. 331-348. DOI: https://doi.org/10.33407/itlt.v75i1.3114

27. Semenikhina O., Drushlyak M. On the Results of a Study of the Willingness and the Readiness to Use Dynamic Mathematics Software by Future Math Teachers. *Proceedings of the 11th International Conference on ICT in Education, Research and Industrial Applications: Integration, Harmonization and Knowledge Transfer (ICTERI 2015)*. Lviv, Ukraine, May 14-16, 2015. P. 21-34. URL: http://ceur-ws.org/Vol-1356/

28. Semenog O., Semenikhina O., Oleshko P., Prima R., Varava O., Pykaliuk R. Formation of Media Educational Skills of a Future Teacher in the Professional Training. *Revista Românească pentru Educaţie Multidimensională*. 2020. Vol. 12. Is. 3. P. 219-245. DOI: https://doi.org/10.18662/rrem/12.3/319

29. Shamonia V., Semenikhina O., Proshkin V., Lebid O., Kharchenko S., Lytvyn O. Using the PROTEUS virtual environment to train future IT professionals. *CEUR Workshop Proceedings*. 2020. Vol. 2547. P. 24-36. URL: http://ceur-ws.org/Vol-2547/paper02.pdf

30. Shyshenko I., Martynenko O., Chkana Ya., Spas T., Udovychenko O., Semenikhina O. A mathematics teacher's training to create a maker space in mathematics lessons by means of GeoGebra. *45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO 2022)*. Opatija, Croatia, 2022. P. 909-914. DOI: https://doi.org/10.23919/MIPRO55190.2022.9803433

31. Yachmenyk M., Kharchenko I., Semenog O., Kyrylenko N., Ostroha M., Bohoslavskyi S., Semenikhina O. The Formation of Infomedia Literacy of Students in a Media Tournament. *46th MIPRO ICT and Electronics Convention (MIPRO-2023)*, Opatija, Croatia, 2023. P. 660-665, DOI: https://doi.org/10.23919/MIPRO57284.2023.10159736

32. Yurchenko A., Drushlyak M., Sapozhnykov S., Teplytska S., Koroliova L., Semenikhina O. Using online IT-industry courses in the computer sciences specialists' training. *International Journal of Computer Science and Network Security*. 2021. Vol. 21, No. 11. P. 97-104. DOI: https://doi.org/10.22937/IJCSNS.2021.21.11.13

33. Буряк В. К. Організація модульного навчання. *Вища школа*. 2009. № 7. С. 18-31.

34. Крисько В. Сутність і зміст педагогічного процесу та педагогічної діяльності. Педагогіка і психологія : підручник. 2015. URL: https://stud.com.ua/36254/psihologiya/sutnist_zmist_pedagogichnogo_protsesu_pedagogichnoyi_diyalnosti

35. Курлянд З.Н. Особливості педагогічного процесу у вищому навчальному закладі. Педагогіка вищої школи : навч. посіб. URL: https://westudents.com.ua/glavy/50271-14-osoblivost-pedagogchnogo-protsesu-uvischomu-navchalnomu-zaklad.html

36. Мулеса П., Семеніхіна О. Педагогічні умови підготовки майбутніх учителів математики та інформатики до використання засобів віртуальної наочності у професійній діяльності. *Фізико-математична освіта*. 2023. Том 38. No 2. С. 37-42. DOI: https://doi.org/10.31110/2413-1571-2023-038-2-006

37. Семеніхіна О.В., Шамоня В.Г., Удовиченко О.М., Юрченко А.О. До питання про урахування законів зорового сприйняття у навчальному процесі. *Проблеми та інновації в природничо-математичній, технологічній і професійній освіті*: матеріали V-ї Міжнародної науково-практичної онлайн-інтернет конференції (м. Кропивницький, 10-13 жовтня 2017 р.). Кропивницький: РВВ ЦДПУ ім. В. Винниченка, 2017. С. 77-78. URL: https://repository.sspu.edu.ua/items/da4e8d73-3411-4a31-9655-d7c0a27a2ec1

38. Семеніхіна О.В., Шамоня В.Г., Удовиченко О.М., Юрченко А.О. Інформатика в схемах і таблицях : навч. посібн. Суми : Видавництво «МкДен», 2013. 76 с.

39. Словник синонімів української мови : в 2 т. / А.А. Бурячок, Г.М. Гнатюк, С.І. Головащук та ін. Київ : Наукова думка, 2006. 1040 с.

40. Шамоня В.Г., Удовиченко О.М. Використання електронних освітніх ресурсів у підготовці бакалаврів, майбутніх вчителів інформатики (на прикладі вивчення схемографіки пристроїв ЕОМ засобами електронного підручника). *Гуманізація навчально-виховного процесу : Збірник наукових праць*, 2017. № 4(84). С. 190-203.

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