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EDUCATIONAL SOFTWARE FOR THE DEVELOPMENT OF PRE-SERVICE PROFESSIONALS' SUBJECT COMPETENCE

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Abstract. The article presents the results of the approbation of the electronic textbook, which was created as a means of developing pre-service specialists' subject competence. The authors note that the e-textbook is an e-learning publication with a systematic presentation of learning content that corresponds to the educational program, includes digital objects of various formats and provides interaction. The advantages of electronic textbooks, features of development and use of Electrical Engineering electronic textbooks for vocational education were substantiated. The expediency of using an electronic book for the formation of pre-service specialists' subject competence in the electrical field of vocational training has been presented. The levels of formation of subject competence were determined, and the efficiency of using the e-learning tool, which increased the level of student's academic achievements, was proved. It was emphasized that the introduction of the developed Electrical Engineering electronic textbook gave grounds to state that the material offered in the book motivated the students to study and allowed them to solve learning problems successfully.

Key words: information technology, electronic textbook, distance learning, teaching, professional education, information and educational environment, digital learning, subject competence, electrical engineering.

Introduction. In today's society, when smart mobile devices are gaining popularity, the Internet is becoming a ubiquitous learning tool. Substantiation of the theory and methods of pedagogical activity for digital learning and flexible application of technological tools are key issues for distance education using modern information technologies. In recent years, various computer-based learning systems have emerged on the Internet and wireless technologies (Chiu, 2017:524–537). The ease of use and popularity of the Internet makes the application of digital educational materials quite promising and aimed at achieving a goal of national vocational education, namely forming a competitive specialist with a high level of professional competence. Currently, research on the implementation of mobile learning to ensure higher productivity of the educational process is quite active (Abdulla, 2019:12). Digital learning technology is the most convenient as a great number of students use portable devices because such a device is now available to everyone. Unlike the traditional mechanism for browsing the Internet, the user can connect to a server over the network to select digital learning materials for studying (Engbrecht, 2018:10). Tests will allow students to monitor their progress and the content of digital learning materials. The relevance of the material presented in the article is due, on the one hand, to the practical need to develop modern electronic learning tools and their implementation in the practice of vocational education, and, on the other hand – the presence of significant pedagogi-

cal and technological problems for quality design of such tools (Bin, Islam, Gu, Spector, and Wang, 2020: 2359–2375). In addition, didactically balanced and appropriate use in the training process. In today's society, when mobile devices are becoming popular, the Internet is removing the limitations of time and space and is becoming a ubiquitous learning tool. Substantiation of the theory and methods of pedagogical activity with the use of digital learning and flexible application of technological tools are key tasks for the interaction of interactive subjects (Bilousova, 2012).

Every year, students of vocational (technical) education institutions become more technologically literate. Digital technologies permeate all aspects of their lives: during play, communication and learning. Growing up with digital devices, students are constantly waiting for new technology that will be integrated into their personal experiences most of them in the professional and social aspects of their lives (Titova, Luzan, Sosnytska, Kulieshov, and Suprun, 2021). It proves that they strive to integrate the latest technologies into their educational lives as soon as possible. The academic environment can be described as a constant choice between traditional and innovative education, in a balance between strengthening the role of innovation and traditional ways of acquiring knowledge.

The electronic textbook is interpreted as an electronic educational publication with a systematic presentation of educational material that corresponds to the educational program, contains digital objects of various formats and provides interaction in the Regulation on electronic textbook № 440, which was approved by the order of the Ministry of Education and Science of Ukraine on May 2, 2018, and developed under the current legislative field (Laws of Ukraine "On Education", "On General Secondary Education", "On Vocational Education", "On Higher Education").

The study and analysis of scientific sources suggest that the e-textbook is an e-book that contains educational material for teaching and learning, which uses the benefits of personal computers, smartphones, netbooks, and tablets in the ability to: organize and reorganize, and unify information, using different ways of presenting new concepts and material, adapt to the needs of a particular person. We understand an electronic textbook in its accessible form as a computer file or electronic document that contains an extended explanation of the material and is intended for studying the course in the basic mode. The electronic textbook while retaining all the features of textbooks, is fundamentally new, namely: 1. Update information very quickly (efficiency of publication and editing of material); 2. To involve in the educational process pupils and students who for one reason or another cannot attend classes; 3. Use on any of the gadgets (accessibility); 4. To carry out safe research of the electrotechnical equipment, using simulators. Among the main requirements for electronic textbooks for the educational process are the following: scientific, accessible, problematic, visual learning, and sensory perception of the studied objects (Balalaieva, 2014: 113–117).

To improve modern educational technologies, the government and enterprises have invested heavily in the research and development of digital learning platforms. Software and hardware have been developed, various materials have been created, and they have been actively implemented in educational institutions, which makes favourable conditions for students (Hernandez-de-Menendez, and R. Morales-Menendez, 2019: 713–728).

Subject competence in electrical engineering is a set of knowledge, skills and abilities within the subject, which allows an individual to solve problems through their attitude. The student's abilities and subject competence in electrical engineering, first of all, is a sign of the high quality of his/her educational skills, the ability to establish links between acquired knowledge of electrical engineering and the situation, and the ability to find a procedure (method) to solve the problem. Their skills formed during the study of electrical engineering as a discipline. The scientists state that the orientation of the educational process in electrical engineering in institutions of professional (vocational) education on the formation of students' subject competencies also means developing motivation to study electrical engineering (Chaikovska, 2012: 134–138).

In developing the electronic textbook, we understood the need to profess such goals of the educational process as deepening students' knowledge of electrical engineering, information technology, physics, subject competence formation, development of cognitive and creative interest in the chosen profession, new equipment and technology, shaping experimental knowledge, skills and abilities of organization and self-organization.

The purpose of the paper. The purpose of the article is to reveal the features of development, construction and application of electronic textbooks on electrical engineering for students of vocational education to form their subject competence and prove the effectiveness of e-learning, which increases the students' success.

Results. The e-textbook is available in various formats and meets the following requirements portability, copying, distribution and search in search engines. This textbook provides active cooperation with the student, which provides mutual feedback, simulation models, the solution to the problem, adequate formulation and presentation of opinions, structuring, location and method for presenting new knowledge and adaptation to individual style (Bilousova, 2012). While creating an Electrical Engineering electronic textbook we took into account the basic principles of teaching. Firstly, learning is faster, and information is better absorbed if the student shows an active interest in the subject being studied – the level of motivation increases. Secondly, training will be effective if the forms of acquired knowledge and skills are such that they can be transferred to real-life conditions without additional coordination. Thirdly, learning is faster if the student learns about the result of each of his/her answers immediately. Correct answer or not – the student must receive confirmation immediately. Delay, even a small one, slows down the learning process. Fourthly, the assimilation of new material is accelerated if the discipline program is built on the principles of consistent complication of the material. You need to start with the simplest tasks. The level of difficulty is constantly increasing until the desired level of experience and skills is achieved. Fifthly, knowledge of the results of their work stimulates the next task. Difficulties must arise consistently, and their successful overcoming will develop a high level of activity. Sixth, since learning in itself is individual, the learning process should be organized so that the student could pass the program following their characteristics (Shepetko, 2010). To illustrate, consider the structure of the developed electronic textbook for the *Electrical Engineering* course to train specialists in repairing and maintenance of electrical equipment and solar power plants (Svyrydiuk, 2018).

The advantages of the electronic textbook are preservation of a large amount of information, which allows you to work without distraction with the training material; the bilateral nature of the learning process, its integrity, as the interaction of teacher and student with the control of the level of knowledge; quick search and the ability to return at any time to the desired section, topic, laboratory work, simulator of various processes, test tasks, knowledge control, which is carried out using the function of quick movement in the textbook; multimedia, which means the simultaneous use of different forms of information and its processing, namely: diagrams, tables, block diagrams, video clips, dynamic illustrations that demonstrate the process of performing algorithms in step-by-step mode or at different speeds; self-control, as the electronic textbook allows you to check the level of knowledge, skills and abilities developed after the topic or section, promotes objectivity and minimizes subjective approaches to evaluation; the use of dynamic models that are valid programs and allow for certain modifications to study the model's response to these actions; consolidation of educational material, which takes place with the help of tabs – homework, which consists of a library of reference notes (schematic representations of sections of educational material); mobility, which will help the student to use their time rationally. The use of an electronic textbook makes it possible to rethink traditional approaches to the study of educational material in electrical engineering. New approaches to teaching contribute to the systematic acquisition of knowledge, the formation of practical skills; improving the quality of professional training, and using the acquired knowledge to solve problems (Shupik, 2014).

To determine the level of formation of subject competence in the *Electrical Engineering* discipline and prove the effectiveness of the use of this e-textbook has experimented with 5 Ukrainian institutions of vocational education, State Vocational-technical educational institution "Bila Tserkva Vocational Lyceum", Higher Vocational School No 34 Vynohradiv, State Educational Institution "Korsun-Shevchenkivsky Vocational Lyceum", Ovruch Vocational Lyceum, State Educational Institution "Uman Vocational Agricultural Lyceum" during 2018–2021. The experiment involved 547 students among the professions an electrician for repair and maintenance of electrical equipment, mechanics for the repair of wheeled vehicles, electric welder, electricians, locksmith-electricians for the repair of electrical equipment, electricians for lighting and lighting networks, radio mechanics for maintenance and repair of radio equipment machinist of agricultural production of category "A1"; "A2". 291 students were enrolled in the experimental groups, and 256 students were included in the control groups. Learning in the experimental groups took place using the *Electrical Engineering* e-textbook and in the control group, students used only traditional teaching aids. It has been distinguished four levels to determine the level of subject competence shaping. At the initial level, the student with the teacher's assistant reproduces fragments of educational material on electrical engineering and unconsciously performs some practical tasks. Makes significant mistakes when answering and performing applied tasks. At the average level, the student without sufficient understanding reproduces the educational material on electrical engineering and performs practical tasks with the occasional teacher's assistant. The student makes some errors in the definition of basic concepts. He/she can partially analyze the training material and conclude. The student uses certain types of technical, design, and technological documentation. While answering and performing practical tasks, he/she makes many mistakes that can be partially corrected. At a sufficient level, the student has (in oral, written and graphic forms) the educational material on electrical engineering and uses it in performing practical tasks in both typical and somewhat difficult conditions. The students define basic concepts, analyze, compare and systematize information, establish a connection with the chosen profession and draw conclusions. Their answer is generally correct, logical and well-founded. The student performs practical tasks according to a typical algorithm, in consultation with the teacher. Consciously he/she uses reference information, technical and design and technological documentation. When answering and performing practical tasks, he/she makes insignificant mistakes that he can correct. At a high level, the student has full-generalized knowledge of educational material on electrical engineering and can use them effectively to perform all the practical tasks provided by the curriculum. The student's answer is complete, correct, and logical and contains analysis, systematization, and generalization of educational material. He/she establishes causal and interdisciplinary links. Makes reasoned conclusions. Th student correctly and consciously uses all types of reference information, technical, design, and technological documentation within the curriculum. He/she performs practical tasks correctly, in full, both using a typical algorithm and with a self-developed algorithm. The answer and performance of tasks admit some insignificant inaccuracies, which independently detects and corrects. The student shows cognitive and creative interest in the chosen profession, new equipment and technology.

After the introduction of e-learning in the educational process of experimental groups in electrical engineering, lessons took into account a qualitative indicator of knowledge, skills and abilities of students within the subject (subject competence in electrical engineering) control (learning process was carried out using paper textbooks) and experimental (learning process was carried out using an electronic learning tool, namely the *Electrical Engineering* electronic textbook) groups.

In this paper, we will use the nonparametric Kolmogorov-Smirnov criterion. For non-parametric criteria, information on the type of population distribution is not required. Consider the hypothesis that the distributions of samples of student outcomes before and after experimental training correspond to one general population. We also introduce the alternative hypothesis that the corresponding

samples of results belong to different probability distribution laws. To construct the empirical distribution functions corresponding to the control and experimental groups, we calculate the accumulation indicators.

Table I.

Accumulation rates for control and experimental groups

Levels of experiment results	Group types		Accumulation indicators	
	CG	EG	CG	EG
Sufficient level	54,3	58,7	0,543	0,587
Average level	36,72	29,01	0,9102	0,8771
High level	8,98	12,29	1	1
Total	100	100	–	–

Using accumulation indicators, we construct empirical distribution functions $F_{кг}(x)$ and $F_{ег}(x)$ for the control and experimental groups, respectively in Fig.1.

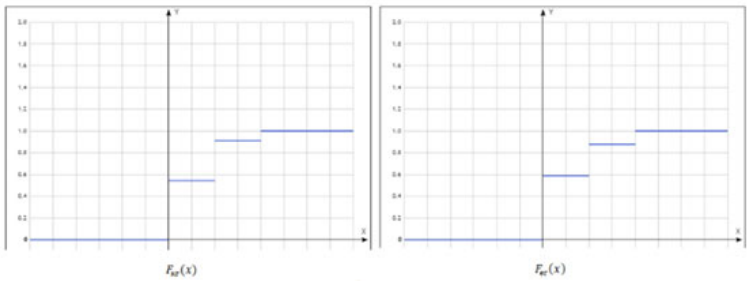

Fig. 1. Graphs of empirical distribution functions for control and experimental sampling of values

To estimate the maximum deviation between the functions $F_{кг}(x)$ and $F_{ег}(x)$), we calculate the modulus of differences between the values of the function at the corresponding intervals of constancy:

$$\Delta_0 = |0 - 0| = 0.$$

$$\Delta_1 = |0{,}543 - 0{,}587| = 0{,}044;$$

$$\Delta_2 = |0{,}9102 - 0{,}8771| = 0{,}0331$$

$$\Delta_3 = |1 - 1| = 0;$$

The corresponding calculations allow us to state that the equality holds:

$$A = \sup |F_{кг}(x) - F_{ег}(x)| = 0{,}044;$$

Since the sample sizes of the control and experimental groups are equal to $k = 256$ and $l = 293$, respectively, the value of the Kolmogorov-Smirnov statistics is equal to:

$$B = A \cdot \sqrt{\frac{kl}{k+l}} = 0{,}044 \cdot \sqrt{\frac{256 \cdot 293}{256 + 293}} \approx 11{,}66.$$

The quantile of the Kolmogorov function, which corresponds to the confidence level $p = 0.9$, is equal to $K(p) = 1.23$. Because inequality holds $B > K(p)$, then the hypothesis is the distributions of the samples of students' results before and after the experimental training correspond to one general population should be rejected. Thus, it is necessary to accept the alternative hypothesis that the corresponding samples of results belong to different probabilistic distribution laws. The latter fact, in simple language, shows that experimental training has had an "effect." The question of which one is open. In this case, it is natural to use considerations standardly in appropriate situations, based on the analysis of changes in indicators on the main gradations of scaling. The ratio of performance indicators (Table I) suggests that the percentage of students who reached a high and sufficient level increased by 3.31% and 4.4%, respectively, while there is a decrease in the average by 7, 71% (Fig. 2).

As the results of the study in Fig. 2 noticeable positive dynamics of students' knowledge and skills in electrical engineering (subject competence) in experimental groups in comparison with control. The increase in students with a high level of knowledge and skills in the experimental group compared to the control is 3.31% at a sufficient level, and 4.4% of students at a high level in the experimental group showed a better level of learning, respectively, decreased by 7.71% with an average level of knowledge. That is, the qualitative indicator of knowledge in the control group was 63.28%, and in the experimental – 70.99%, these data prove that the use of the author's electronic textbook increases the level of subject competence of students of vocational (technical) educational institutions during classes, on theoretical preparation and homework. The introduction of the developed author's Electrical Engineering electronic textbook gives grounds to state that the material offered in the e-textbook allows students to solve the tasks successfully, which motivates them to study the following topics to solve the proposed problems. Students who were motivated to learn the material (rather than just getting good grades), provided that their learning work was interesting and informative, were more interested in learning and understanding the material.

Conclusions and prospects of further research. The research was based on the idea that digital learning was evolving, identifying and orienting learners' needs in a way that suited their interests, style, and ability, and was provided anytime, anywhere. The conclusion was made about the training, which was integrated into the latest educational environment. Students can use the same technologies they use for communication and entertainment outside of educational institutions – smartphones, tablets and laptops. It allowed students to engage in new learning technologies that are adapted to their needs and skills. Thus, the results of the author's e-textbook approbation at five institutions of vocational (technical) education proved the effectiveness of using e-textbook on students' success in comparison with control groups. It proved the higher level of the formed subject competence of students in the *Electrical Engineering* subject. The

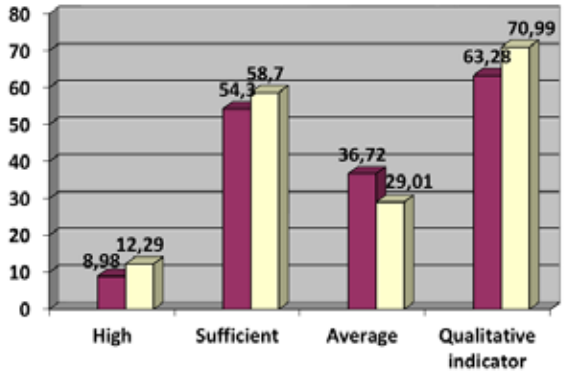

Fig. 2. Quantitative and qualitative indicators of student achievement in control and experimental groups

development and implementation of an electronic textbook make it possible to intensify the educational process, make it personally oriented, provide interaction and shape subject competence. The analysis of the research results showed that the developed electronic textbook was effective for the formation of students' subject competence. Further scientific research could be connected with the disclosure of the methods of conducting laboratory-practical classes through an electronic textbook.

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