The use of electronic textbooks in the learning process: a statistical analysis


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Abstract - With the active introduction of information technology in the educational sphere, approaches to the textbook as the main means of presenting educational material have changed. Along with printed publications, electronic ones began to be actively used, which in their development have already gone from a simple text document to a complexly structured system that includes various ways of presenting educational material (text, audio, video, graphics). Their use today requires detailed study and reasonable implementation in professional training of specialists. The purpose of the article is to describe a pedagogical experiment on the effectiveness of using an electronic textbook in the training of computer science teachers. To achieve this goal, the methods of mathematical statistics for the quantitative and qualitative analysis of the results of the pedagogical experiment ($\chi^2$ Pearson, Student) were used. The corresponding results for the author's ET "Information Systems" by criteria $\chi^2$ Pearson, Student are given. Calculations for the positions are described: 1) availability (clarity) of the author's ET; 2) evaluation of the results of independent work based on the author's ET.

Keywords - electronic textbook; electronic educational resources; professional training; computer science teacher; learning process.

I. INTRODUCTION

Modern education faces the challenges of the information society, which cause the active introduction of modern technologies in the process of specialists’ training. Young people actively use portable, mobile devices, computer equipment, and therefore resources, which in their bases provide for such use, become popular. This led to the emergence of electronic educational resources (EER), which are now understood as educational, scientific, information, additional materials and tools developed in electronic form and presented on media of any type or placed in computer networks, and which are reproduced using electronic digital technical tools and are necessary for the effective organization of the educational process, in terms of its content with quality teaching materials [7].

Various aspects of the problem of training computer science teachers to the professional activity were considered in the works of L. Breskina (professional training based on network information technologies) [15], V. Demianenko (teaching hardware and system software) [16], O. Zhmud (formation of specific competence in computer architecture and configuration of computer systems) [17], M. Zolotchevska (preparation for the research methods use) [18], S. Ovcharov (an individual and differentiated approach in professional training) [19], V. Oleksiuk (methodological bases of application of educational network complexes) [20], V. Bykov, V. Lapinskyi, A. Gurzhia, V. Vember devoted their works to the issue of implementation of EER in the educational process, and the works of O. Baliykina, N. Kononets, V. Hasov, O. Grytsenchuk, O. Gurkova, I. Pustovalov, T. Yakovenko, V. Yasynskyi and others are devoted to e-books in particular.

At the same time, we have found that the training of computer science teachers using EER technologies is not enough considered in the Ukrainian educational space. ET as a means of modern education is described in the system of training of social pedagogues, teachers of history [2], the Ukrainian language [8], agro-technicians [14] etc., and the question remains open for bachelors, computer science teachers training, on the basis of EER, including ET, as electronic educational resource, which provides: program compliance; consistency, scientific character and completeness of educational material presentation; accounting for psychological and pedagogical characteristics of the subjects of training; simultaneous presentation of educational material in various forms; the level of development of information technologies in the ways of presentation of educational material and organization of work with the resource; continuity and completeness of the educational cycle; individualization and differentiation of training [12].

Based on modern trends in the field of education and understanding the need and demand for ET, we have implemented a project to create such type of electronic product, which has its own pdf-version, as well as presented in the form of a complex structured educational resource and is positioned by us as a modern ET with multimedia content, which includes, in addition to theoretical material, visual support (in the form of diagrams, tables, animation, video), glossary and test module for self-testing.

MIPRO 2020/CE

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The aim of the article is to describe the pedagogical experiment on the effectiveness of the electronic textbook in the training of computer science teachers.

Theoretical training of bachelors in the specialty 014.09 Secondary education (Computer Science) provides for the study of a number of Computer sciences disciplines. As the analysis of methodological systems of training of specialists, future computer science teachers has showed that various forms, methods and means of training are applied for their studying. Along with the traditional we use an electronic textbook “Information systems”. Its structure is indicated in works [9; 10; 11].

To achieve this goal, the following methods were used: theoretical: analysis of special literature on the introduction of electronic educational resources; generalization and systematization of domestic and foreign experience in the use of electronic textbooks in the training of computer science teachers, personal pedagogical experience in the use of electronic educational resources in the educational process; methods of mathematical statistics for quantitative and qualitative analysis of the results of the pedagogical experiment.

II. PRESENTATION OF THE MAIN MATERIAL

We have conducted a study of the feasibility of using the author’s ET in independent work on the basis of the nonparametric method of $\chi^2$ Pearson.

The results of training in two groups were investigated:

Group I – the study of the course “Information systems” was carried out on the basis of EER, in particular, the students were offered lectures-presentation, author’s ET “Information systems” with built-in dictionary, graphics, text content, fragments of videos, tests for self-testing of residual knowledge; provided a list of additional electronic publications and videos, links to open educational resources that are related to this course.

Group II – the study of the course “Information systems” was supposed to use lecture notes written by students at the teacher, the printed version of the textbook “Information systems”, graphic designs in the form of tables and diagrams, as well as additional literature available in the library.

The composition of the groups contained 109 and 94 respondents among students and 12 and 15 respondents-teachers, respectively.

Evaluation of the results of the experimental training took place in several positions: the level of performance of students modular and semester control measures; answers of students and teachers to oral control questions; conversations with teachers and students regarding the accompanying educational materials.

Consider the method of comparing the answers of teachers to the question: “Is a textbook accessible (understandable) as a whole for self-mastery, that is, does the textbook help to learn the training material during the self-study of some topics?”

The inclusion of such a question in the questionnaire is explained by the fact that in order to identify the availability of educational materials, in particular ET, a specific list of topics for self-study by students of both groups was determined. Based on the comparison of the opinions of the experimental group teachers, we tested the hypothesis of no differences in the availability of the ET and its printed version.

The opinion of teachers on the quality of educational materials as accessibility was measured on a scale of names, which has two categories: yes and no. Both teacher samples were random and independent. Therefore, all conditions for the application of the $\chi^2$ criterion are fulfilled in the experimental conditions. Since the scale of names has only two categories, we use a variant of the two-sided criterion, which is applied for cases where the results are summarized in a table of type 2x2.

The answers of the teachers (12 of them used ET) were divided in the following way (table 1).

<table>
<thead>
<tr>
<th>Sample №1</th>
<th>Sample №2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_{11} = 7$</td>
<td>$O_{21} = 5$</td>
</tr>
<tr>
<td>$O_{12} = 5$</td>
<td>$O_{22} = 10$</td>
</tr>
</tbody>
</table>

Denote: $p_1$ – the probability that the teacher of the group №1 considers the ET available, $p_2$ – the probability that the teacher of the group №2 considers the printed textbook available.

Based on the data from the previous table, we check the null hypothesis:

$H_0: p_1 = p_2$, that is both versions of the textbooks are available.

Then the alternative hypothesis will be:

$H_a: p_1 \neq p_2$, that is some of the tutorials are less accessible.

All values of absolute frequencies in the table are not less than 5, but all values are less than 10. Therefore, according to the terms of calculation of the criterion we have [3]:

$$T_{exp} = \frac{N \left( \left| O_{11}O_{22} - O_{12}O_{21} \right| - \frac{N}{2} \right)^2}{n_{11}O_{11}O_{22} + n_{21}O_{12}O_{21}} = \frac{27 \left( \left| 7 \cdot 10 - 5 \cdot 5 \right| - \frac{27}{2} \right)^2}{12 \cdot 15 \cdot 12 \cdot 15} = 0.83$$

With the conditions of application of the bilateral criterion $\chi^2$ (degrees of freedom – 1, the significance level of 0.05) we find $T_{crit} = 3.84$. Because $T_{exp} < T_{crit}$, then accept the null hypothesis about the availability of both textbooks to study the course “Information systems”. In other words, the results of the questionnaire of teachers of the two samples do not provide sufficient grounds for rejecting the assumption of the same availability of
For the level of significance $\alpha = 0.05$ and the number of degrees of freedom $\nu = 4 - 1 = 3$ find the critical value of statistics: $T_{crit.} = 7.815$.

We got a situation, where $T_{crit.} < T_{exp.} (7.815 < 8.28)$, therefore, we must accept the alternative hypothesis that the sample averages differ significantly and this cannot be explained by random reasons.

In other words, the results of self-study of the special course “Information systems” on the basis of the author’s ET give grounds not to reject the alternative hypothesis that students who were studying using an electronic textbook, learned the course better (with a high average score).

The results are divided into levels in the following way (table 3).

A significant difference between the averages is confirmed by the Student’s criterion at the same level of significance, which is confirmed by calculations in Excel (table 4).

TABLE 2. DISTRIBUTION OF STUDENTS’ ANSWERS

<table>
<thead>
<tr>
<th>Levels</th>
<th>Unsatisfactory</th>
<th>Satisfactory</th>
<th>Good</th>
<th>Excellent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample №1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>$O_{11} = 4$</td>
<td>$O_{12} = 15$</td>
<td>$O_{13} = 20$</td>
<td>$O_{14} = 11$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample №2</td>
<td>$O_{21} = 8$</td>
<td>$O_{22} = 20$</td>
<td>$O_{23} = 20$</td>
<td>$O_{24} = 2$</td>
<td></td>
</tr>
<tr>
<td>$n_1 = 12$</td>
<td>$n_2 = 35$</td>
<td>$n_3 = 40$</td>
<td>$n_4 = 13$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the table, $O_{ij}$ means the number of works of the $i$-th sample, who got the mark $j$.

Denote $p_{1j}$ – for the probability of performing the work by the student of the first sample on the mark $j$; $p_{2j}$ – the probability of performing the work by the student of the second group on the mark $j$.

Then check the hypothesis

$H_0$: $p_{1j} = p_{2j}$ for all four categories

(that is $p_{11} = p_{21}$, $p_{12} = p_{22}$, $p_{13} = p_{23}$, $p_{14} = p_{24}$)

alternative:

$H_a$: $p_{1j} \neq p_{2j}$ at least for one of four categories.

To calculate the statistics, we use the formula [2]

$$T = \frac{1}{n_1 n_2} \sum_{j=1}^{4} \frac{(n_1 O_{1j} - n_2 O_{2j})^2}{O_{1j} + O_{2j}},$$

$$T = \frac{1}{50 \cdot 50} \left( \frac{(50 \cdot 8 - 50 \cdot 4)^2}{4 + 8} + \frac{(50 \cdot 20 - 50 \cdot 15)^2}{15 + 20} + \frac{(50 \cdot 20 - 50 \cdot 20)^2}{20 + 20} + \frac{(50 \cdot 2 - 50 \cdot 11)^2}{11 + 2} \right) = 8.28$$

III. DISCUSSION

The introduction of computer-aided learning at universities is in line with the innovative processes that are taking place in Ukraine to modernize the education system. The current computer market places particular demands on the professionals’ training and offers, at the same time, electronic educational resources that are currently actively, but often not systematically, used by students.

Orientation of universities to a high-level automation of the educational process and the use of electronic educational resources in teaching requires scientifically substantiated support and availability of appropriate educational and methodological support, which actualizes the improvement of future computer science teachers’ training towards active use of electronic educational resources.

TABLE 3. DISTRIBUTION OF STUDENTS BY LEVELS

<table>
<thead>
<tr>
<th>Levels</th>
<th>Actual (0–60)</th>
<th>Operational (61–74)</th>
<th>Analytical-synthetic (75–82)</th>
<th>Creative (83–100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample №1</td>
<td>$O_{11} = 4$</td>
<td>$O_{12} = 15$</td>
<td>$O_{13} = 20$</td>
<td>$O_{14} = 15$</td>
</tr>
<tr>
<td>Sample №2</td>
<td>$O_{21} = 8$</td>
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<td>$O_{23} = 20$</td>
<td>$O_{24} = 2$</td>
</tr>
<tr>
<td>$n_1 = 12$</td>
<td>$n_2 = 35$</td>
<td>$n_3 = 40$</td>
<td>$n_4 = 13$</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 4. ESTIMATION OF AVERAGES FOR STATISTICAL ANALYSIS OF EFFICIENCY OF ET USE (AFTER EXPERIMENT)

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Experimental group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>76.14</td>
<td>79.76</td>
</tr>
<tr>
<td>Observation</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Hypothetical average difference</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>t-statistics</td>
<td>-2.123923442</td>
<td>0</td>
</tr>
<tr>
<td>t critical double-sided</td>
<td>1.984984312</td>
<td>0</td>
</tr>
</tbody>
</table>
We consider the ET as a means that is more comfortable for young people to use. Our ET is not only filled with text, but is also accompanied by a large number of diagrams, tables and figures. Such visual support helps to better memorize and understand the learning material. Its use, on the one hand, is a means of teaching at the university, and on the other, it demonstrates to future teachers a means of their professional activity.

The described ET received praise from teachers who were involved in the pedagogical experiment. Thanks to their advice, in particular, tests of various topics were added to it, and the topic "Office software package" was excluded.

The analysis of the results of the pedagogical experiment confirms the opinion that it is advisable to involve electronic rather than paper textbooks in the educational process. At the same time, the development of an ET requires the work of a whole team (IT specialists, psychologists, teachers) and is time consuming.

Currently, a similar experiment is underway to implement an electronic computer-based textbook based on the use of QR codes. Preliminary results give a positive assessment of academic achievement compared to traditional learning.

IV. CONCLUSION

As the pedagogical experiment shows, training of computer science teachers based on EER, in particular, ET, is effective. Students often turn not to print, but to electronic educational resources while preparing for classes, which provide consistency and thoroughness of knowledge, the development of visual memory and visual thinking, and therefore the author’s electronic textbook is an effective electronic resource in the training of computer science teachers.

The study does not claim to be a definitive solution to the problems of using the ET in the educational process.

Further scientific research is directed to the solution of the problem of organizing students' independent work on the basis of the ET.

REFERENCES


