Computer Visualization of Logic Elements of the Information System Based on PROTEUS

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Abstract. The article considers the possibility of a computer visualization of the code decoder work in Proteus, which is used in a laboratory workshop when studying the topic "Digital logic" of the discipline "Architecture of Information Systems" (the field of study "12 Information technologies" and "01 Education, 014 Secondary education. Computer science"). Modelling and simulation during the laboratory work contribute to the awareness of the importance of visualization as a means of positive impact on the level of future IT-specialists' educational achievements. This was confirmed by the analysis of the obtained results at the significance level of 0.05 according to Student's test.

Keywords: computer visualization, logical elements of information system, virtual laboratory, Proteus, modelling of electrical circuits, IT spesialists' preparation

1   Introduction

Modern university training necessarily involves mastering information technologies for the use in educational and future professional activities. A large amount of training time is devoted to mastering both common software (text and table processors, multimedia data processing software) and specialized one. Such mastery involves not only the study of computer tools proposed by developers, but also the use of accompanying learning materials, which usually describes the practical aspect of the use of information technology. The theoretical basis of the processes that occur in this case is often not only not displayed, but also not mentioned, because it is difficult to perceive and in most cases secondary to the problem that is solved in a particular training course.

At the same time, the ability to correctly use information technology is often impossible without understanding the theoretical foundations of the functioning of the hardware or, even, the information system as a whole. Therefore, in the training of specialists of the field of study "12 Information technologies" and "01 Education (014 Secondary education. Computer science)" we consider it necessary to focus not only on the side of "consumption" of technical or specialized software, but also on the side

of understanding the logical, physical and mathematical foundations of its functioning. We see such accents in the special presentation of educational material through its visualization in virtual laboratories [1-5].

The purpose of the paper is to highlight the authors' experience of computer visualization of logic elements of the information system based on ISIS Proteus.

2 Proteus as Means of Visualization of Logical Elements in Information Systems

Today there are a large number of virtual laboratories that are used to construct and analyze complex electronic circuits and simulate their work. Among them are ORCAD, PICAD, EasyEDA, 123DCircuits, Electronics Workbench, LabVIEW, Micro-Cap, NI Multisim, Proteus and others. After an analysis of their available computer tools and the need for dynamic visualization of signal processing, we elected Proteus [6], where developers have the ability to simulate the operation of various devices from the diode to microcontrollers and microprocessors. In Proteus, one can create and edit the parameters of the electrical circuits' components; use different virtual devices that are implemented as mathematical models that imitate their structural and functional principles of operation (generators, meters, etc.) in order to generate signals and indication of influence. In this software, it is also possible to simulate analog, digital and analog-digital devices. In our opinion, its computer tools allow to visualize the ideas contained in the training course: temporal and spectral characteristics of the signals, transitions and transmitting characteristics of the two-port, logical states of digital elements inputs and outputs, etc. Note that this software is currently proprietary.

Let us give the example of the computer visualization of the code decoder work, which is used in a laboratory workshop when studying the topic "Digital logic" of the discipline "Architecture of Information Systems" (Fig. 1). Launching the simulation allows the student to verify the correctness of the circuit work, and the teacher to check the correctness of its composition.
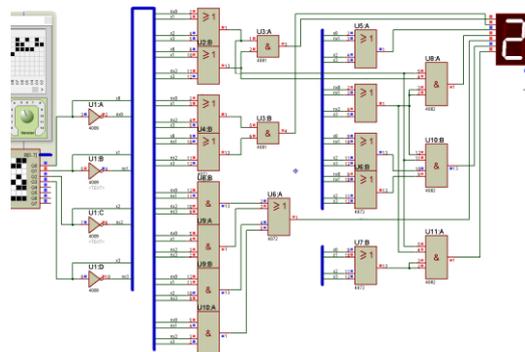

Fig.1. Visualization of a seven-segment decoder work (input code 0010 corresponds to the Arabic number "2" on the decoder)

3 Confirmation of the Use of Proteus in the IT Specialists' Preparation

According to our experience, the laboratory works of this type based on Proteus allows to demonstrate the logic of the basic elements work based on the construction of logical functions of processing binary signals through the visualization of processes occurring in the information system.

This is confirmed by the statistics data that we collected during 2016-2018. Students, future computer science teachers, were involved in the pedagogical experiment. The control group (CG, 54 students) studied the course "Architecture of the information system" only theoretically. The experimental group (EG, 49 students) held a laboratory workshop along with the study of the theoretical course. They built a visual model of the basic elements in Proteus. The course "Architecture of Information Systems" is studied at the third year of study. There was no bias in the choice of participants in the experiment.

The normality of the distribution of students' educational achievements were tested and confirmed by Pearson's χ^2-test (the distribution of educational achievements was analyzed) according to the results of the course study in both groups for correct comparison of average values. Also it was statistically confirmed the "identicality" of the total average values of students' educational achievements on the results of studying the courses "Computer science", "Programming", "Fundamentals of microelectronics" (Table 1) before the beginning of the experiment. At the significance level of 0.05, it was confirmed that at the beginning of the experiment students' groups were statistically identical. The results of semester control (exam) were collected after the course "Architecture of the information system". Student's criterion was applied to assess the average values. The statistical non-identicality between the average values of both groups was confirmed at the significance level 0.05. This is explained by our workshop based on Proteus (Table 1, Fig. 2).

Table 1. Comparison of averages in EG and CG at the significance level 0.05 by Student's test

|	Sample volume	The total average values bofore the course	Experimental value of the t-criterion at the beginning of the experiment	Average values after the course	Experimental value of the t-criterion at the end of the experiment
EG	49	217, 4	1,66 (<1.98) Conclusion: groups are statistically identical	73,5	2,29 (>1.98) Conclusion: groups are statistically non-identical
CG	54	215,7		69,0	
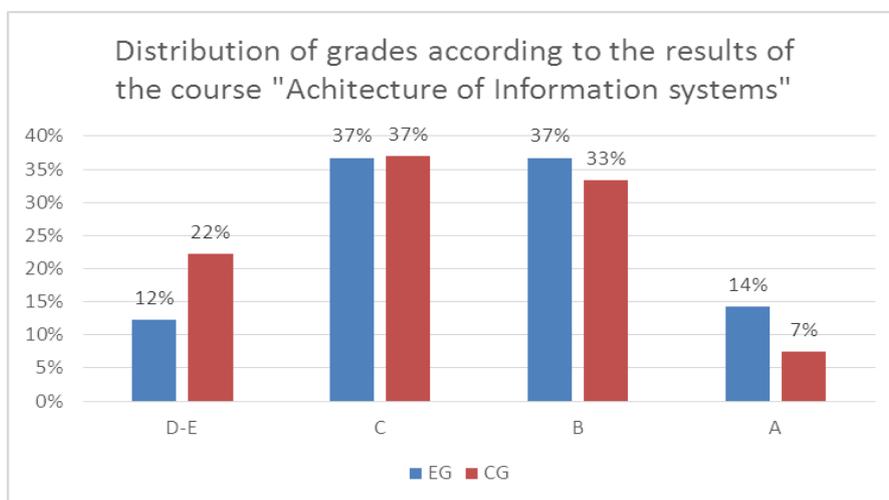
Fig. 2. Diagram of the distribution of grades after the course (the average value in the EG was statistically above the average value in CG)

Quantitative analysis of the experimental results revealed the following.

The percentage of persons (EG) who mastered the course "Architecture of the information system" at the level of 60 points per semester is smaller compared to KG (12% versus 22%). At the same time, the percentage of persons (EG) who mastered this course at the level of 90 points and above per semester is larger compared to KG (14% versus 7%). This is due to the increased motivation to master specialized software and the ability to visualize different processes at the micro level, which are perceived as such faster.

The percentage of students who mastered the course "Architecture of the information system" at the level of 75-85 points per semester is approximately the same for the EG and KG groups. We explain this by the normal distribution and the same starting level of students' preparation in both groups.

It should be noted that we did not find the description of such pedagogical experiments with the use of Proteus in the special pedagogical literature.

According to the results of the experiment, we propose the following didactic recommendations.

1. It is useful to give time to study the interface and the main features of Proteus at the first lesson.

2. It is important to foresee 4 hours for each laboratory work so that process simulation was systematic and gradual. We offer the following sequence of studying the topics: calculation of the differential resistance of the diode; nonequilibrium and equilibrium bridges; measurement of bipolar transistor parameters; amplifier, etc.

3. It is important to foresee an independent work related to the simulation of the circuits of work of appliances, and then the implementation of the constructed circuits under the direction of the teacher. In particular, we propose the development of a digital clock, which is created by the students themselves.

4 Conclusion

The use of virtual laboratories as a means of computer visualization of hidden (closed) processes in the information system shifts the emphasis of training from the theoretical and experimental planes to the intellectual one or detailed understanding of the results. This does not require additional maintenance and financial costs. The work is safe in contrast to real physical experiments. The software provides universality and flexibility in the organization of a virtual experiment with the ability to test the functioning of the constructed circuits with certain restrictions (time, finance, additional equipment, etc.).

To visualize the closed processes, which take place in the information system, we have chosen Proteus software, because it provides for the construction of electrical circuits of varying complexity, modelling of analogue, digital and analogue-digital devices, etc. This allows using it as a basis for the organization of a laboratory workshop of the course "Architecture of information systems". The developers of the software provide for experiments on virtual devices, which, as a rule, are absent in the real laboratory, as well as the opportunity to explore idealized processes that cannot be investigated in real conditions.

Visualization of processes in Proteus allows not only to demonstrate the logic of the basic logical elements of the information system, but also to accelerate the testing of students' knowledge and skills, to deepen their competence in the field of information technology based on the activity approach.

Visualization of the logical foundations of information systems in general allows not only to be acquainted with the ideas of information process, but also to understand the logical relations, summarize and systematize their own ideas about the information world.

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