ELECTRONIC EDUCATION IN THE FIELD OF ELECTRICAL ENGINEERING DISCIPLINES. COMBINED DIDACTIC INTERACTIVE PROGRAM SYSTEM

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Abstract: At present in the educational process of electrical engineering disciplines electronic learning program, providing control over reproductive educational-cognitive activity (the decision of standard problems) and universal modeling program systems, for instance Electronics Workbench, giving a chance of organizing productive, in particular research activity are basically used. However universal modeling program systems can not provide auto control over educational-cognitive activity because of the absence of the feedback with students. The combined didactic interactive program system, providing the closed directed auto control over both the reproductive and productive heuristic educational-cognitive activity of the student is offered.

Keywords: electrical engineering discipline, electronic learning program, universal modeling program systems, combined didactic interactive program system, reproductive and productive heuristic educational-cognitive activity.

ACM Classification Keywords: K.3.1 Computer Uses in Education, J.2 Physical Sciences and Engineering.

Introduction

At present there are two main trends of introduction of the information technologies in the education process of electrical engineering disciplines. The most wide-spread is using universal modeling program systems (UMPS) such as Electronics Workbench, Micro-Cap, Matlab. These systems designed by the leading world companies, possess a broad spectrum of possibilities. On their basis the laboratory practical studies on different educational disciplines: electrical engineering, the principles of circuits theory, electronics, electric measurements etc. can be rather easily realized. The other direction, gradually increasing its positions, is the creation of the author's didactic interactive program systems [Зайнутдинова, 2000]; in particular, electronic learning programs (ELP).

At the electrical engineering department at Astrakhan state technical university (ASTU) both these directions are used. For 15 years the work toward the elaboration of the unique ELP has been under way, since 2001 the virtual laboratory on the basis of Electronics Workbench has been promoted.

1. Electronic learning program «Electrical engineering-ASTU»

This program provides continuity and fullness of the didactic education cycle: gives a theoretical material, provides training educational activity and knowledge level control in realizing interactive feedback. During the elaboration the method of theoretical images, offered by L.H. Zaynutdinova [Зайнутдинова, 1999, a] was used. The High didactic features of the designed ELP were confirmed by the results of the pedagogical experiment and perennial practice of its use in the educational process at ASTU. The motivation of the education has been improved; the students' progress has been increased.

The following points should be referred to the merits of the electronic learning program «Electrical engineering - ASTU»:

- The possibility of the execution by students all the sections of the didactic cycle (the acquaintance with the theoretical information, drilling, control, feedback).
- The possibilities of mastering the basic notions of electrical engineering course and the algorithm of the standard problem solution from the very beginning (the requirements to initial knowledge in the field of electrical engineering is minimum).
- The registration of the user and automatic issue of the individual tasks.
- Visualization of the educational information presentation on the basis of the method of theoretical images.
- A friendly user interface. A person who has no any computer background can work with the program.

- Cyclic (closed) control over the educational-cognitive activity (the operation-by-operation control over student's actions, the multilevel interactive feedback, the furcated system of prompts).
- Saving teacher's time (the reduction of the expenses on routine operations of giving and controlling the educational tasks).

Due to the enumerated merits of the ELP "Electrical engineering - ASTU" and first of all due to the high visualization of the educational information presentation and high level of the control over the educational - cognitive activity (cyclic or closed control system) the high values of the activity assimilation coefficient Ac are reached.

The rigidly fixed limits of the educational activity should be referred to the demerits of the given ELP. To achieve the formulated aim a student follows the rigidly fixed problem solving algorithm input in the program. Any possibility of choosing any other method of solution is excluded. The student has no chance to fall outside the scope of the educational task block, in consequence of it only the reproductive algorithmic activity level is reached. In this paper we follow the classification of educational-cognitive activity levels and the indicators of its assimilation quality (assimilation coefficient Ac, in particular), offered by V.P. Bespalko [Беспалько, 2002].

2. Universal modeling program system Electronics Workbench (EWB)

The system greatly increases the possibilities of the experimental studies. The main merits of Electronics Workbench are:

1. Electrical circuits modeling. The System EWB is characterized by the simplicity of programming, the availability of the models of habitual measurers and broad set of elements. Such "virtual laboratory" allows to put together a complex experimental mounting and to fulfill a natural consequence of experiment making.
2. A friendly user interface. The program has a standard interface for the system Windows and is easily learned by the students who have a certain level of computer background.
3. Widening the limits of the experiment. If this system has a great set of elements and measurers with any diapason of measurements the possibility of the studied phenomenon increases in comparison of the usual physical experiment.
4. Reducing the material expenses on obtaining expensive laboratory equipment.
5. Saving student's time. The process of computer modeling the studied phenomena from constructing a scheme to processing the obtained data takes less time than in a usual real laboratory.
6. The possibility of formulating an individual educational task, corresponding to the student's preparation including rather a complex task, requiring productive heuristic activity level. The given program proposes student's educational-research activity.

The absence of the possibility of habitual experiment perception should be referred to the demerits of the "virtual laboratory" on the basis of Electronics Workbench. Besides, the student is to possess the initial knowledge in the field of electrical engineering disciplines, to know the main electrical engineering notions, to have the practice of setting up circuits, the experience of working with measurers and also the certain computer background. Thus, UMPS can not train from the very beginning.

From the pedagogical point of view the main demerit of the universal modeling program Electronics Workbench and the similar ones is an absolute absence of the control over student's educational-cognitive activity. The absence of control can prevent the students from acquiring the knowledge on different subjects. At present it is possible to get over this demerit due to the fact that the teacher takes the control function over himself.

The differences in the technique of the control over the educational-cognitive activity with the application of the electronic learning program and universal modeling program systems are shown in table 1.

3. The comparison of the didactic possibilities of the electronic learning program «Electrical engineering-ASTU» and the universal modeling program systems Electronics Workbench

The analysis of table 1 shows the undoubted advantage of ELP in the aspect of organizing the auto control over student's educational-cognitive activity; however the frames of this activity are as a rule limited. ELP provides only the reproductive assimilation activity level. In other words, ELP provides a good student's preparation, but only in the field of solving the standard educational tasks. As to UMPS, Electronics Workbench systems in particular, they, being the most powerful instrument of the scientific study, allow the possibility of formulating and solving problems, requiring productive heuristic level of activity. However because of the absolute absence of the control over students' cognitive activity they can not be directly referred to didactic systems. In virtue of the performed analysis of psychology-pedagogical literature and the materials of scientifically-methodical conferences, devoted to using information technologies in electrical engineering education [Материалы, 1998, 2000, 2003], it is ascertained:

1) ELP provide mainly reproductive levels of educational information assimilation, with the possible organization of the auto control over students' educational activity;
2) UMPS as the most powerful instruments of the scientific research allow the possibility of formulating and problem solving on productive heuristic level of the activity assimilation;
3) UMPS do not provide auto control over cognitive activity and, therefore, can not be directly referred to didactic systems.

In virtue of the statements given above the actual problem of creating a combined didactic interactive program systems possessing the merits of electronic learning programs and universal modeling program systems becomes actual.

Table 1

The stages of laboratory-practical studies, pedagogical conditions	The electronic learning program «Electrical engineering-ASTU»	The universal modeling program systems Electronics Workbench
Giving the theoretical information	Is present	Is absent
Forming the individual educational practical tasks	Is done automatically without teacher's participation	The teacher is to make and give an individual task
Control over performing a task	Is Produced without teacher's participation, automatically	The teacher is to direct the process
Control over the coarse of performing the task	Step-by-step control, automatic	The teacher realizes the control
Helping, issuing prompts	Help and prompts are given automatically, as the student makes mistakes	The teacher is to help and give prompts
Analysis of an electric circuit, making calculations, drawing graphs, diagrams	Is done by the student (active student's participation)	Is done by the program EWB (the student has the role of an observer)
The estimation task performing level	Is produced automatically with taking into account all the made mistakes	The teacher is to give a mark
The requirements to the student's computer background level	The student who began working with the computer for the first time can work	"Beginning" or "intermediate" user
The requirements to the teacher's computer background level.	"Beginning" user	"Intermediate" or "professional" user
The requirements to the level of the student's initial theoretical background.	Minimum	The student is to have fundamental ideas, to know the basic notions.
Convenience of the conditions of teacher's work at the lesson.	High (the teacher is completely free from the routine work of giving and checking the tasks)	Low (the teacher is very busy)

4. Combined didactic interactive program system

In 2004 at the department of electrical engineering at ASTU the first CDIPS to the unit "Quadruples" in "Theoretical principles of electrical engineering" course was designed and tested. The tests showed the working capacity and pedagogical efficiency of the offered CDIPS [Зайнутдинова, Польский, 2005].

According to V.P. Bespalko "a didactic system is a type of the control over student's learning". In the paper [Беспалько, 2002] didactic systems are rated in order of different control methods:

1) correcting education on its final result (an open control) or stage-by-stage control (a closed control);
2) taking into account the students' individual peculiarities (the directed control) or group averaging (the diffused control);
3) the control operations with teacher's help (the manual control) or by means of technical facilities (the auto control).

Traditionally in the field of teaching different disciplines the didactic system, providing the open, diffused and manual control over student's educational-cognitive activity is used more often. Lectures and practical classes can be referred to such didactic systems. A teacher in such a "traditional system", according to V.P. Bespalko, «manually uses the open control in diffused information space. By quality of training the given didactic system is weak» [Беспалько, 2002, p. 181]. Among the perspective directions of the didactic system development V.P. Bespalko distinguishes «the program control system». The foundation of it is a special adaptive program, controlling student's educational-cognitive activity, taking into account his individual peculiarities and correcting training by means of stage-by-stage control. Some analogue of V.P. Bespalko's « program control systems » for the field of general technical disciplines are the didactic interactive program systems analyzed in the paper [Зайнутдинова, 2000], – first of all ELP and intellectual training systems. Herewith ELP have become the most wide spread in the field of electrical engineering disciplines at present. We determined that most of the ELP used in the educational process at technical higher schools, provide the organization and control only over the reproductive educational-cognitive activity of the students. The realization of nonstandard, but herewith automatically stage-by-stage controlled individual training tasks, corresponding to the productive heuristic level of activity, is not provided in them.

Meanwhile the well-known researchers of modern education [Попков, Коржуев, 2004] distinguish the task of mastering technologies of taking the optimum decisions, developing the skill of adapting to different changes, forecasting the course of the development of different situations as the prior. In other words, the student's cognitive activity must have a productive nature.

Turning to the problem of using computer technologies in the educational process of electro engineering disciplines allowed us to draw a conclusion about the presence of the contradiction between the directivity of the modern educational system on the development of productive educational-cognitive activity of the student and the absence of corresponding didactic interactive program systems, providing the organization and auto control over this activity and guaranteeing a sufficient level of its assimilation.

The revealed contradiction has defined the problem of the present study. In the capacity of one of the possible decisions of these problems we are the first to offer creating a new type of the didactic interactive program system on electrical engineering disciplines which can be defined as follows: «A combined didactic interactive program system» (CDIPS) is a training program system of the complex purpose, providing the organization of the reproductive (recognition and reproduction) and productive heuristic educational-cognitive activity of the student under conditions of gradualness and maturity of education under the closed directed auto control.

5. The Structure of the electronic learning program and the combined didactic interactive program system in the aspect of realizing an interactive educational dialogue

The questions of organizing the dialogue between the computer training program and a student in one way or another are touched in many papers, devoted to the use of modern information technologies [Роберт, 1994]. To our mind, it is necessary to distinguish two peculiarities:

- an educational dialogue is not a not merely an information exchange; the purpose of the educational dialogue is acquiring by the students the most profound and adequate knowledge of the essence of the material under discussion ;

- providing flexibility and clarity of the student's dialogue with the computer training program is possible if there is a rational organization of the user interface (the realization of the possibilities of quick mastering the rules of the work with the program even for a beginning user).

Meanwhile, many researchers and developers of computer training programs in our opinion don not pay enough attention to the didactic possibilities of the interactive dialogue. Thus, for instance in the paper [Масалитина и другие, 2000] it is said that the analysis of computer training programs, used in the educational process, shows the limited possibilities of most of them in the aspect of forming student's knowledge. Such programs more often give educational information (a theoretical material, tasks) and by means of a testing system check mastering the distinct methods by the student. The insufficiency of controlling influence of the similar programs on the student's cognitive activity is noted.

N.F. Talyzina's research works are devoted to the problems of increasing the efficiency of the control over the process of educational-cognitive activity assimilation. Thus for instance, in the work [Талызина, 1984] it is offered to synthesize the general theory of control (cybernetics) and the adequate to its requirements psychology-pedagogical education theory. The choice of the control type takes into account:

- the rational structure of the person's cognitive activity;
- the complicacy of the educational process, its dependence upon many factors.

N.F. Talyzina draws a conclusion about the unproductiveness of the control over the educational process according to the final results of the assimilation, as there is no unambiguous connection between them and the cognitive activity leading to them. The structure of the cyclic (closed) control is offered : a) the purpose of control is indicated; b) the initial level of the operated process is fixed; c) the program of influences, providing the main transient process conditions is defined; d) obtaining information according to the system of parameters about the condition of the controlled process at each moment of the control (feedback) is provided; d) the information conversion obtained through the feedback channel is produced; correcting influences are worked out and realized.

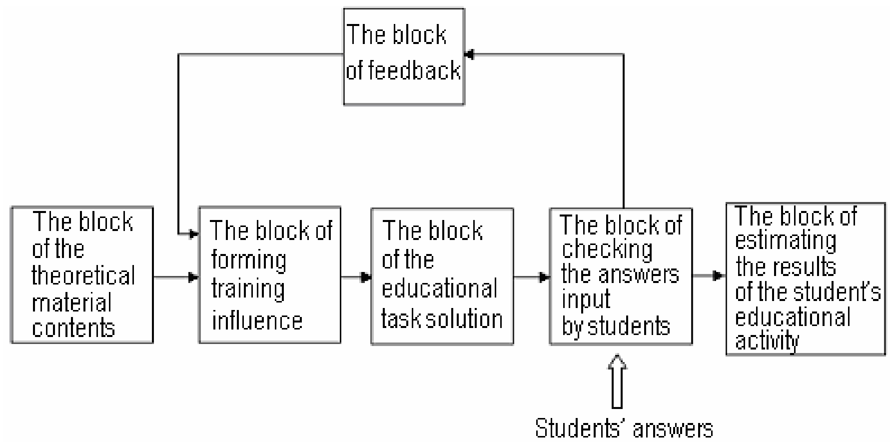

Figure 1. The Structure of the electronic learning program
in the aspect of the interactive educational dialogue realization by L.H. Zaynutdinova

The given structure formed the foundation and was developed in the work [Зайнутдинова, 1999, b] as applied to ELP on general technical disciplines (figure 1). It is noted, that the automated control over the educational process is a deep aspect, the essence of the interactive educational dialogue.

The following structure components: the block of the educational discipline contents (the theoretical material), the block of forming training influences, the block of the educational task solution, the block of the control over the students' educational activity, the block of estimating the results of this activity and the block of feedback are represented . The block of forming training influences provides giving the individual tasks to the students with invoking the data from the block of the theoretical material contents. The variety of the individual training tasks is provided by the casual generation of the numerical values of the initial data and casual variety of the individual types of the problems. In the process of solving a problem the student inputs all the intermediate results of his solution in the computer. Then the block of checking answers compares the answers input by the students, with the answer of standard, worked out by the block of the educational task solution. So the intermediate control over the results of student's educational activity takes place. Relying on this control with the help of the block of estimating the results of student's educational activity a final mark is formed, taking into account the number of the correct and wrong answers, the number of the efforts and other factors. The block of feedback provides the interactivity of the ELP. Such a level of the student's interaction with the program, when watching, control and the correction on the assimilation of the educational-cognitive activity are realized is reached. Thus, for instance, analyzing student's actions, the program issues one or another controlling influence (a prompt, an explanation, a new question or a task etc.). The feedback is the main condition of providing the closed control over student's educational-cognitive activity.

In realizing the feedback the contradiction between the necessity of forming various training influences and increasing because of this difficulty of realizing the control over the educational activity appears. For solving the given problem it is necessary to define properly such a volume of the fragment of the student's educational activity, which will be possible to be put in correspondence with the certain training influence and the results of the execution of which will be possible to be controlled by means of ELP. It was shown by L.H. Zaynutdinova that for the field of general technical disciplines the organization of such an interactive educational dialogue is worth while, when the controlled step of training corresponds to the execution of one operation. In other words, it is necessary to realize an operation-by-operation control over all the student's actions. As a result of such an approach the possibility of the operative formation of the unambiguous correcting training influences appears. This, in turn, allows training the student precisely the solution method. The considered system rigidly fixes the borders of the educational activity with the use of ELP. The student strictly follows the fixed solving problem algorithm installed in the program. Any possibility of choosing any other solution method is excluded. As a result the ELP provides a good preparation of the students only in the field of solving standard training tasks; only reproductive algorithmic level of educational-cognitive activity is reached [Зайнутдинова, Польский, 2005].

Herewith the questions of organizing the control over the process of the assimilation of students' heuristic educational-cognitive activity remain open. The analysis of the materials of the international scientific-methodical conference "New information technologies in electrical engineering education" (NITE) [Материалы, 1998, 2000, 2003] also shows that least developed are those directions of using computer training programs, which are connected with the control over students' productive educational-cognitive activity. Recall that formulating the tasks, requiring the productive heuristic activity level is possible by means of UMPS. For instance, in the work [Прокубовская, 2002] computer modeling is considered as the means of the development of independent cognitive activity of the students in higher schools. However because of the absolute absence of the control over the cognitive activity of the students in higher schools UMPS can not be directly referred to didactic systems.

Reasoning from the merits of ELP (in the aspect of the auto control realization) and UMPS (in the aspect of the possibilities of formulating the tasks of the heuristic level) the present work is the first to offer creating such a didactic interactive program system, which with the closed directed auto control will guarantee the first (b1), the second (b2) and the third (b3) levels of the assimilation of the educational-cognitive activity determined by the certain contingent of students with regard to the gradualness and maturity of the education. We call the new system a combined didactic interactive program system (CDIPS), as it is an interconnected combination of the ELP and UMPS.

The structure of the CDIPS offered in the present study is shown in figure 2.

The control over the students' educational-cognitive activity within the framework of CDIPS in performing the tasks of the first and the second levels is realized in the same way, as in ELP. Watching, control and correction on the assimilation of the educational-cognitive activity is realized by means of the block of feedback. Herewith it is necessary to distinguish the feedback types with the difficulty level of the task. Thus, for instance, in the work [Роберт, 1994] the suggestive feedback (from the English "suggest" – to offer, advise), in general case expecting such a reaction to the student's actions, when the possibility to get the advice proposed by the program, the recommendation about the further actions or commented acknowledgement (demolishing) of the proposed hypothesis or suggestion is provided was considered. In fact the suggestive inverse feedback was considered along with the control by the final result [Роберт, 1994]. In the paper [Талызина, 1984] such an approach corresponds to the control on the principle of "the black box", when the feedback, and consequently, the process regulation are realized only with regard to the "output" process.

Meanwhile, within the framework of ELP feedback messages expect giving the concrete and unambiguous statements (formulae, rules, laws and so on) in performing each operation. So the program reacts to errors and uniquely corrects the course of performing a task. From the point of view of the work [Талызина, 1984] such feedback has the information about the process of obtaining the intermediate results (is realized on the principle of "the white box").

In our view, the feedback, used in the electronic learning program by L.H. Zaynutdinova, should be classified as the declarative feedback. We shall enumerate its main features:

- the realization of operation-by-operation control over all the student's actions;

- the operative formation of the concrete correcting training influences.

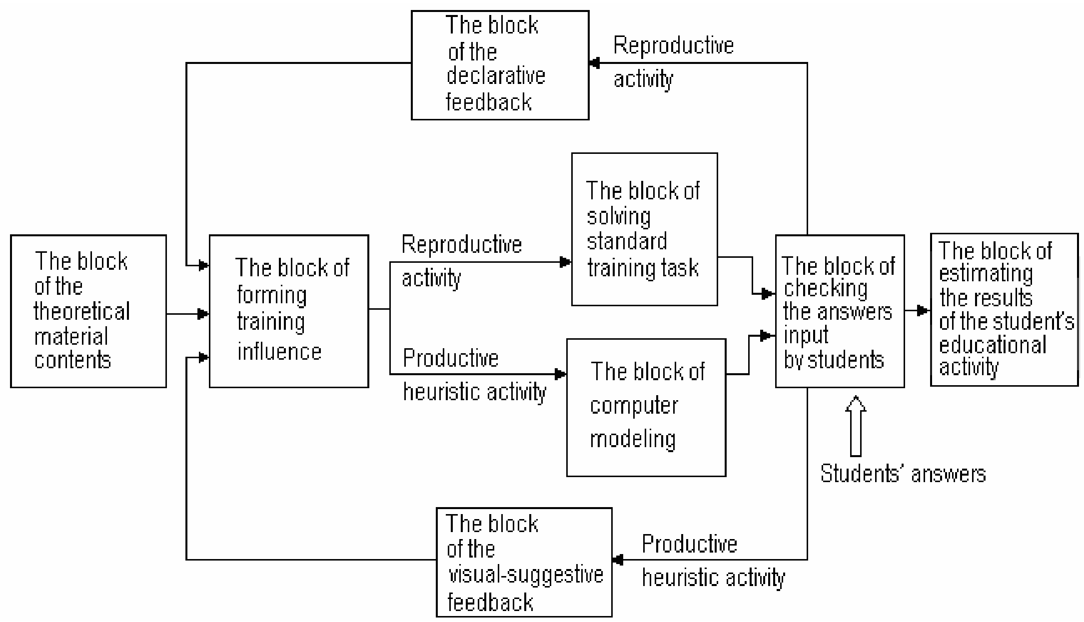

Figure 2. The structure of the combined didactic interactive program system
in the aspect of realizing interactive educational dialogue

The given approach, in our view, is justified for the reproductive educational-cognitive activity therefore within the framework of CDIPS the declarative feedback is realized for the tasks of the first and second levels.

The distinctive feature of CDIPS is formulating the tasks of the heuristic (third) level. For this in the structure of CDIPS the block of computer modeling the studied processes (phenomena) is provided. The interactive educational dialogue is based on the correlation of student's solution, obtained by any means (also by means of UMPS), with the solution obtained from the block of computer modeling. Therewith the student may choose any solving method suitable for him, CDIPS does not limit his freedom in choosing - thereby the skills of orientating in non-standard situations in solving nonstandard problems are formed. The control in this case is organized in a more flexible form. The program does not expect the indications of the facts of making certain mistakes of that or this kind. The student is given a possibility to draw conclusions about the correctness of the solution method himself. This possibility is provided by means of visualizing on the screen the discrepancy between the results input by the student and the values of standard obtained by the block of computer modeling. The visualization can be realized with the help of figures, schemes, graphs, video files and so on. We were the first to represent the given feedback type in the present work. This study for the first time offered creating the block of computer modeling in combination with the visual-suggestive feedback for solving the problem of the control over heuristic educational-cognitive activity.

In realizing the tasks of the third heuristic level the contradiction between the necessity of providing the freedom in choosing the solution method by the students and the difficulty of realizing the control over the educational-cognitive activity gains momentum. For solving the given problem in CDIPS it is offered to widen somewhat the volume of the controlled fragment of the student's educational activity (in comparison with the tasks, corresponding to the reproductive level of the educational -cognitive activity). In formulating the tasks of the heuristic level we offer the organization of such an interactive educational dialogue, where the controlled training step corresponds to the execution of one logically completed stage of work under the program. Each stage is the totality of elementary operations, providing the obtaining of the intermediate result. In other words, it is necessary to realize stage-by-stage control over the student's educational-cognitive activity. In this case the student has freedom in choosing the suitable solution method of nonstandard tasks.

Conclusion

«Combined didactic interactive program system» (CDIPS), a training program system of the complex purpose, providing the organization of the reproductive (recognition and reproduction) and productive heuristic student's educational-cognitive activity in conditions of gradualness and maturity of the education under the closed directed auto control is designed.

The designed CDIPS possesses scientific novelty, namely: it provides the closed directed automatic stage-by-stage control over the productive heuristic student's educational-cognitive activity by means of the block of visual-suggestive feedback in combination with the block of computer modeling.

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