

Computer-aided education in Electrical Engineering in the light of Didactic Principles

D. Biolek & V. Biolkova

Brno University of Technology
Brno, Czech Republic

ABSTRACT: The paper deals with the general questions relating to the utilization of computers in teaching electrical engineering, electronics, circuit and signal theory. The generally applicable methods of computer program compilation and utilization are evaluated on the basis of general didactic principles and authors' experience.

INTRODUCTION

Nowadays, computer programs are utilized practically at all schools in numerous forms and various intensity. As regards the faculties of Electrical Engineering in Czech Republic, both professional and "self-compiled" programs are used in the teaching process.

Existing dissension how to use computers optimally in various teaching forms indicates the difficulty of given problem. An extensive and permanent discussion is recommended. In this contribution, some personal opinions will be presented as a result of practical teaching experience in two Universities in the Czech Republic.

BASIC QUESTIONS

In the course of time, teachers engaged in updating their subject have to reply to the following and many similar questions:

- When is it /or not advantageous to use computer in the teaching process?
- How to proceed to gain maximal didactic effect from the utilization of computer? What to avoid not to weaken this effect unnecessarily?
- Which type of program to use in a given phase and form of the teaching process? What about its properties and the way of its utilization?
- Which properties of the operational system would be optimal for the teaching purposes? Which of the operational systems established in our universities approximates closely this ideal?

ANSWERS

It is very difficult to find such answers that teachers solving similar didactic problems would agree with without exceptions. From our experience, opinions can even exist among colleagues from the same department that differ in principle. As a result, not only different universities but also several departments of the same faculty and sometimes the readers in related subjects choose their own way.

The state described above indicates the complexity of the problem. There is no universal reply to the aforementioned questions or to any system of questions whose solution would reduce all specific pedagogical problems of all schools. On the contrary, the solution should be optimized to meet the specific conditions of the given school, teaching subject, student level, and also take into account other aspects, for instance the relation to other teaching subjects of the school curriculum.

We will agree, however, that the fundamental didactic principles should not be violated by any pedagogical activities. Computer utilization is no exception. Since the period of J.A. Comenius, these principles have been revised only insignificantly [1]. Because of the increased possibilities of our pedagogical influence due to computers, we will try to concretize these "sempiternal" principles with a view to the present-day condition which even Comenius could not anticipate. Although Comenius could not foresee the invention of personal computer as a powerful didactic tool, his didactic principles can help us, for example, to select a suitable computer operational system for education.

The realist is aware of the discrepancy at schools between the ideal model of the education to fulfil all didactic principles and the material and financial possibilities of the schools and the students [2].

FUNDAMENTAL DIDACTIC PRINCIPLES [1] AND THEIR APPLICATION TO COMPUTER-AIDED EDUCATION

Principle of goal-seeking
Principle of systematicness and succession
Principle of adequacy
Principle of object teaching
Principle of activity and creativity
Principle of emotionality

The principle of goal-seeking

advises to build a detailed plan of updating the teaching subject, including the explicit aim of computerization. Respecting this principle, we can avoid the typical blunder as "computerization at any price".

The principle of systematicness and succession

declares the requirement to compile such a well-ordered and substantiated system of the subject matter that enables its acquirement in a logical order, and also the requirement for teacher's systematic influence and student's systematic work. Comenius summarizes this idea as follows: „If you teach something, let everything that follows be the aim, and everything that precedes, the resource the means to an end“ [1].

This principle can be easily violated during the application of analyzing and simulation programs to subjects like “Basics of EE” and “Circuit Theory”. According to our experience, using such programs has the required effect only when the students have some basic knowledge of the function of analyzed circuit and elements. Without physical understanding of simulated phenomena, the teaching unit in the computer laboratory is a waste of time. In addition, this negative phenomenon is enhanced if the student unconditionally accepts the simulation results without the possibility/ability (and later without the willingness) to check the result by own reasoning. It stands to reason that the student's physical understanding can also be developed using the computer but by means of special programs.

The principle of systematicness and succession has also to do with the frequent question which CAD/CAE programs are the best for the successive and gradual work during the study. The answer could be found, taking into account

the principle of adequacy:

It is not reasonable to train beginners to the exacting professional software. Instead, we begin using programs that are simple for students with minimum knowledge of simulation rules, mathematical models of semiconductors, etc. At this stage, we can use “self-compiled” programs that include – in contrast to the professional ones- the necessary didactic elements. The principle of adequacy recommends observing the basic pedagogical rule: from easy to difficult, from known to unknown, from concrete to abstract. Teachers agree on the requirement of simple control of the developed programs [2]. However, I think that the meaning of the term “simple control” changes with time – today's generation has fewer problems with the same program than the previous one. This is true on the assumption of user-friendly, logical and intuitive control. Illogical and unforeseeable program responses have to be excluded.

As a consequence of the principles of goal-seeking, systematicness and succession and the adequacy, the following recommendation can be given:

During the first semesters the student gains the basic theoretical knowledge of electrical engineering and his/her physical understanding is developed in experimental and the computer labs. Starting with the second year, he/she meets professional programs that he/she utilizes for the work in the related technical subjects until the final diploma project.

The principle of object teaching

offers some advice on what properties the developed computer programs should have and how to use them during the teaching. Comenius regarded this principle as the “golden rule” of didactics. The given principle combines two rules [1]: 1. To

start from the student's sensory activity and permanently occupy it (i.e. direct opinion) and to utilize his/her hitherto notions and experience (i.e. indirect opinion), 2. To improve his/her perception and imagination abilities simultaneously (his/her receptivity, observation and the fantasy). The “golden rule” can then be utilized on the highest possible level.

It is well-known that a nucleus of knowledge arises by repeated irritation of the cortex through the receptors. According to Comenius, the memory effect is more effective if several receptors are activated simultaneously. The efficacy of the memory effect depends on the given receptors: hearing 10%-20%, sight 30%-40%, and their combination 50%-70% (these values are highly individual). A computer offers much image information. During the teaching unit, where the computer simulator is used for the study of electrical phenomena inside the circuits, the teacher's influence is important (explanation role, hearing influence). In the signal laboratory, the use of the soundblaster PC card could be rewarding. Using the ingenious script of the laboratory exercise, the teaching of spectral analysis and related themes can end in unprecedented pedagogical success.

From the point of view of object teaching, therefore we prefer computer utilization in the experimental (not classical computer) laboratory as part of the working place.

On the other hand, our effort to improve object teaching can meet some psycho-physiological and didactic limitations due to the great feasibility of present-day multimedia. Flooding the receptors with excessive amounts of information reduces the efficiency of teaching. In addition, it has been shown that excessive object teaching often suppresses independent thinking and creativity. That is way the compilation of good didactic programs can be a serious problem even for experienced schoolmasters.

The memory and learning process supported by the computer is raised considerably if the student finds that: 1. he/she has mastered the computer in the sense that the computer serves him/her and he/she does not serve the computer, 2. he/she is able to use the computer to solve a technical problem independently, 3. the computer/program gives him/her replies to questions that appear during the problem solution (and thus teaches him/her) 4. he/she wants to learn because it is exciting. In other words, the student behaves as an active subject.

The principle of activity and creativity.

Activity, creativity and independence belong to the internal forces of students that enable them to learn the required subject matter profoundly with the utilization of creativity. However, it is necessary to motivate or, to put it in a better way, to make students to adopt this style of work. Computer utilization can be an efficient tool of such “compulsion”. The teacher's role is here the principal thing. If the teacher directs the student towards memorization, then his/her activity is concentrated on the noncreative area. However, if the teacher requires explanation and problem analysis, then the reasoning activity dominates and creativity is expressed as independent searching and solution. Then the computer can be used as an excellent tool for the student's needs.

It is known that from a certain average value of IQ, there is no correlation between intelligence and creativity. The ability to

solve problems in a creative way – one of student's most valuable possessions – can be increased by special didactic methods. In the area of computer supported teaching of electrical subjects, the most efficient methods are as follows: Formulation of questions and motivation to produce ideas [3]. The computer can help to practice these activities.

Problem solution starts from a question. The success depends considerably on the formulation of the question. Via questions, the student is attracted to the solution. Indeed, putting a question is a great art. Students often do not understand what the teacher asks about. Ideally, students should be able to put questions as a means to understanding the essence of the problem that is being solved.

It should be noted that the ability to put correct questions is useful for the individual work with computer simulation software. The simulation of electric circuit is a chain of simulator replies (results of the given analysis) to a set of questions (analysis requirements) with the aim to study circuit behavior under various conditions.

Putting questions is partially dependent on the motivation to produce ideas. Common teaching procedures discourage students from putting questions and producing their own ideas. The computer can motivate thoughtful students to use their new procedures, which are not prescribed but which the student will try to use any way. These didactic rules prove to be especially effective during the teaching in experimental labs where students work continuously on individual projects.

The principle of emotionality.

According to Comenius, „Without bright mood, disgust or ugliness appears, the true bane of teaching“ [1]. Occasionally, I remember this sentence when walking past a typical computer room of some “electrical department”. Through the open door, I catch sight of a frowning and stooping student who starkly examines something on the screen. The stillness inside the

room is sometimes broken by the student's response to some unexpected program action. We must hope that this is not a looming image of the nightfall of electronics in our universities.

Let us leave classical computer rooms to the training of word processors and spreadsheets. Do not tear our students away from the world of real phenomena. Let us prefer interesting work in modern experimental laboratories, where the personal computer performs its own function as one of the many systems in the chain of data collection, processing, and evaluation, with the possibility of coexistence of real experiments and computer simulation.

Computer programs and the operational system applied must not evoke the „disgust or ugliness“, as Comenius warns. Operational systems of the type of Windows, often reproached in some schools, offer outstanding didactic possibilities. Windows 95/98 is not easy to service due to its vulnerability: the student's incompetent action may cause computer malfunction. OS Linux and Windows NT have better stability. The last mentioned operational system seems to be the perspective for supporting the teaching process in future. However, only on the assumption of adequate financial grants to the educational system.

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