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Online Tools for Electrical and Electronics Education

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Abstract

The efficiency of the education is variable, which is very difficult to measure, influenced by a variety of input components-students, teachers, school curricula, the school's internal and external factors. Generally, it is necessary to assess the degree of efficiency of the functioning of the training to carry out a comparison of the rate variables describing the inputs with the same intensity of quantities characterizing the outputs. This article deals with the intermediate results of the research evaluating the scope of the efficiency of the functioning of the educational process in the field of education and training in the context of electrical engineering by on-line education. The research investigated the extent to which online electrical engineering kits have an impact on learning and whether their use has a corresponding impact on learning outcomes. The object of the research was the students and the subject of the research was their knowledge and understanding.

Keywords: education, efficiency, electrical construction kits, project training, subject didactics, on-line education

Introduction

Electrical engineering, or electronics – these are the traditional fields whose products we encounter at every turn. Apart from the fact that our homes are lit up and warm and it is nice to have a television, it is also great to have the whole world at our fingertips thanks to the computer. We wouldn't have any of this without professionals – electrical engineers, electronics engineers, technicians. Their preparation is a matter of education in the system of vocational education, where the teaching of electrical subjects is aimed at acquiring basic theoretical and practical knowledge, where pupils, students try out the acquired theoretical knowledge on concrete practical examples (Dostál, 2015).

Teaching electrical or electronic engineering is in many ways different from teaching in other disciplines, even those in engineering or science. Its peculiarity stems mainly from the physical elusiveness of the laws and phenomena that accompany this (these) field(s). The didactics of electrical engineering can be characterised as the theory and practice of teaching and learning electrical engineering subjects in relation to the education and formation of knowledge, skills, competences, attitudes and other dispositions; it is the sum of the didactics of individual electrical engineering subjects, but it is not the sum of these didactics. Similarly, we could characterise the didactics of electronics. If we characterize the didactics of electrical (or electronic) subjects as a science, then we understand the didactics of electrical (electronic) engineering as an interdisciplinary, independent boundary discipline that didactically processes the knowledge of electrical (electronic) engineering and integrates it with the knowledge of the social sciences into a didactic system of electrical (electronic) subjects. Characteristic for this system is the combination of the theoretical-expert component with the practical-expert component, where these two components cannot be absolutely separated from each other, as they are both necessary for understanding the laws, phenomena and connections of electrical or electronic engineering.

It is clear and also understandable that today's students are not only self--confessed computer users, but often at a fairly high level of programming knowledge. However, it is also up to the teacher whether they become mere "users" of electrical software and applications in his classes, where they will get and analyse the results very quickly, but will not understand much about what they are doing, or whether they start using these tools to solve practical problems. Although the first case is important for practical knowledge, in the second case they are going to a foundation in which they cannot do without knowledge of the theory as well as the principles of analysis methods implemented in software circuit simulators (Biolek, 1999).

Modelling and simulation

Today, simulation programs open a huge field of possibilities for the analysis and simulation of processes in complex electronic circuits. Thanks to the power of contemporary computers and as a result of the historical development that began in the 1950s, programs designed for analog and digital circuit simulation are now the standard virtual laboratory tools. SPICE is the standard for analog simulation, while several software tools exist for digital simulation, with simulators with the "Mixed-Mode" attribute having the ability to simulate circuits at both the analog and logic levels.

The analysis of electrical circuits can be characterized as a concrete procedure from the circuit model to obtaining the result. Currently existing analysis methods can be divided into non-algorithmic, or heuristic, and algorithmic methods (Biolek, 1994). The former can be classified as procedures that the solver chooses based on his or her and previous experience, thus it is a constructivist approach. The algorithmic method, on the other hand, defines a precise procedure – an algorithm, i.e., for example, solving a circuit by the nodal stress method. Each of these methods performs a function in the solution: the non-algorithmic method forces the solver to think creatively in a technical way, while the algorithmic method provides a tool for the solution.

Modelling can be defined as the process of describing reality by limited means, where the result is a model of the original object. Analysis is then a one-time activity where by examining the model we try to find out a certain property of the original and last but not least simulation is an activity where by analysing the model we try to obtain the most true picture of the behaviour of the original under well-defined conditions. Thus, when solving with a computer program, we build a model of the circuit using a schematic editor, where the computer effectively assists in this build by being a source of complex internal models of the components (transistors, operational amplifiers, integrated circuits...). The actual setting up of the equations, their solution and the visualisation of the results is then entirely in the hands of the program.

Model analysis has its own objectives, inputs and outputs, method, form and means of implementation. The form of the analysis is then determined primarily by the means of its implementation, i.e. a computer with the appropriate software, while the form of the internal analysis procedures is hidden from the user and depends on the numerical algorithms used and their programming by the software developers. In addition to computational goals, the analysis may have other goals, for example, the teacher may assign pedagogical goals (practicing a particular analysis method, understanding a particular process in a circuit, etc.). The basic pedagogical goals in teaching analysis include (Biolek, 1994):

1. To promote the creative way of thinking of pupils and students. The analysis should contribute to a better understanding of circuit function.

2. To master an effective tool – the algorithmic method of analysis to “manually” solve circuits.

3. Understand the principles of circuit analysis methods implemented in commonly used simulation programs.

Problems of simulation programs from the perspective of students

A simulation of an electrical circuit may differ more or less from a real circuit – the basis for this is the inclusion or exclusion of all conditions and circumstances in the model that affect the measurements. Thus, it is not only a matter of building a model of the circuit, but also of including other conditions – setting the parameters of the simulation, which of course the respective program should eventually offer. On the other hand, if the user leaves the settings implicit, then he has to take into account that in some situations the simulation result may be different than it would be in a real circuit. To set the parameters, one then needs:

a) The program to allow this setting or offer the user the possibility to influence some parameters of the circuit model or the measurement instrument models.

b) The programs usually set up the circuit equations based on the nodal voltage method. The unknown quantities, therefore, are the voltages between the nodes and the so-called reference node (marked with a ground mark). This means that the program always solves the entire system of equations and therefore all the unknowns.

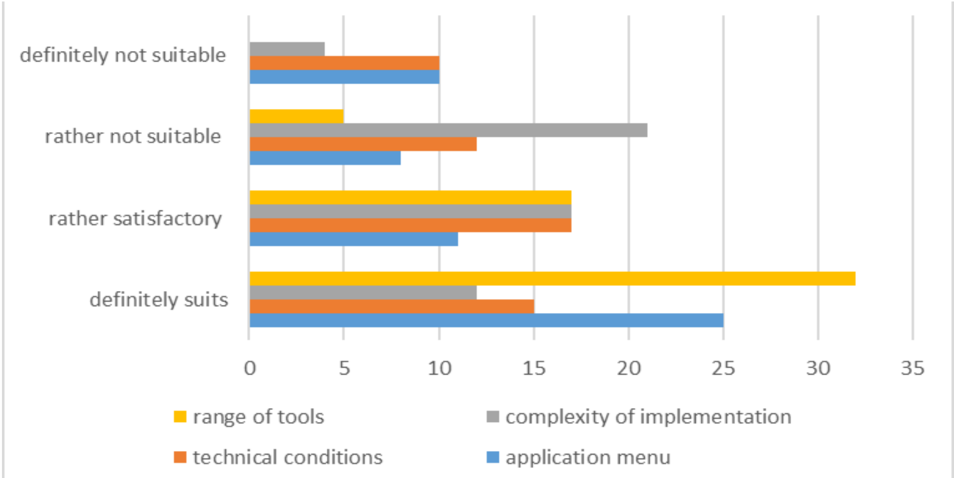
c) The response of the circuit model to a given excitation signal depends not only on this signal, but also on the so-called initial conditions in which the circuit was at the time of connection of the excitation signal.

Methods of analysis of electrical circuits should not only serve as a tool for solving, but can also be used by the teacher for explanatory purposes. However, the correct use of computer programs for circuit simulation requires at least a minimum theoretical training on the part of the user, consisting of an understanding of concepts such as initial conditions, nonlinear and linear circuits, transient processes, steady state, etc. Thus, the approach to teaching in this concept has much different features from classical laboratory teaching and combines different methods and procedures. Levert and Pierre (2000) offer a methodology – a general concept about modelling a virtual laboratory and using simulation models that should work in different configurations and on different platforms (Michael, 2001; Musil, Dobrovolny, 1997).

On-line applications and students teaching technical subjects

In a survey conducted in 2020 and early 2021, students teaching technical subjects at the undergraduate level were contacted during the teaching of practical courses focused on laboratory teaching of electrical and electronic engineering and their views on virtual online laboratories – electrical circuit simulators were obtained. 54 students in full-time and combined studies participated in the survey, and the questions were directed to their view of the applications as users and also which online applications they used for the implementation of laboratory tasks in electrical and electronics engineering.

The questions were directed to whether the offer of application tools is suitable for the implementation of the given tasks, whether the complexity of the implementation of the circuit simulation is large or small, whether the technical conditions, i.e. the demand on the computer, the Internet connection, possibly the pricing policy but also the language of the application are suitable for them as users and last but not least, the question was directed to the offer of applications on the Internet, whether it was possible to choose or the choice was limited. The answers are summarized and presented in Graph 1.



Graph 1. Students' view on the use of apps

The graph shows that the offer of tools and applications is suitable for the purpose and fulfils the conditions for the realization of the tasks they had to create – simulate in the field of electrical and electronic engineering. It is already ambiguous in terms of the complexity of implementation and technical conditions. Here the respondents expressed themselves more hesitantly – between "rather satisfactory" and "rather unsatisfactory". Responses indicated that respondents had problems both on the language level and on licensing issues (having to register or pay a registration fee). They also struggled with creating their own circuit and setting parameters in the respective simulation, including finding appropriate tools, measuring instruments.

Conclusion

Simulation programs are an invaluable tool in the analysis of electrical or electronic circuits, due to the fact that they bring many possibilities in their testing, both amateurishly by simulating circuits before their physical implementation, and educationally – didactically by practicing the correct implementation of circuits, or by solving problem problems or approaching research. The basis is, however, sufficient digital literacy in working with them, not only in terms of the simulation itself, but also in terms of understanding the phenomena and contexts we simulate. The main advantage of these programs or applications is that they can avoid cases that in a real environment can lead to considerable material losses in the form of destroyed components or even the measuring instruments themselves. Other advantages of simulation programs, especially online ones, include their accessibility from anywhere with minimal material costs and often simplicity and intuitiveness in design and operation. On the other hand, the main disadvantage is the model itself, its quality in including influences and circumstances that we often take for granted in a real circuit, but in a simulated one we have to add them to the circuit if possible to make the results comparable to the real ones.

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