FRI-2G.302-1-CCT2-03

IMPROVING ELECTRONICS EDUCATION THROUGH PROJECT-BASED LEARNING[15]

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Abstract: *The world faces many challenges today and the key to their long term solutions lies in the education systems which are one of the main supporting pillars of all countries. A study on good educational practices was done. The best way to improve engineering education is through a well-organized and well-interconnected educational process that includes practical real-world problem-based and project-based learning approaches and outcome-based exam assessments. Some major problems with the Bulgarian education system are presented from the electronics engineering point of view. An analysis of the possible problem-solving is done. Some relevant practical solutions and approaches are presented which improve the learning process despite all limitations.*

Keywords: *Education, Quality, Project, Electronics, Problem.*

INTRODUCTION

The world faces many challenges today, as rising world tensions, rising energy prices, lack of fuels, stagnation and rising inflation. The key to the long term solutions of all problems lies in the education systems. A study concludes that an education including environmental benefits in curriculum could reduce CO2 emissions by 0.11%, (Mehmood, U., 2021). This could be achieved through simple environmental awareness imparted to students.

The high quality education of the population is very important for every country economic development and for the prosperity of its people. It is a global responsibility for all individuals and governments, (Neamtu, D., 2015). The good education is actually one of the main supporting pillars of all countries. It is the right solution to all problems. A paper reviews the role of education in promoting economic well-being, with a particular focus on the role of educational quality and concludes that there is strong evidence that the cognitive skills of the population – rather than mere school attainment – are powerfully related to individual earnings, to the distribution of income, and to economic growth, (Hanushek, E., & Wößmann, L., 2007). The high quality education must develop students' minds and make them more intelligent, because the variety of problems is endless and the best solutions are endless too. The education system is the one that must provide all the prerequisites for the successful development of each separate person.

The best way people learn is through games, as they do in their childhood years, or through practical problem solving when they grow up. For better learning outcomes, the high quality education must engage all their senses which is possible only through well-chosen real-life practical exercises. In this regard the outcome-based education, which includes knowledge, skills and behaviour, shows good results and that is why it is being adopted at a fast pace at Technical institutions all over the world, (Rathy, G., Sivasankar, P., & Gnanasambandhan T., 2020). A study investigating the gamification effects on engineering education concludes that students who actively played the game showed a substantial greater passing rate compared to non-active players, and high engagement in problem-solving activities, even of a higher level than the class, (Díaz-Ramírez, J. 2020).

In order the education process to be effective, students must work with desire. People work with desire when they work on real and important issues and when they are allowed to express their

[15] Докладът е представен на сесия на секция 3.2 на 28 октомври 2022 с оригинално заглавие: IMPROVING ELECTRONICS EDUCATION THROUGH PROJECT-BASED LEARNING

creativity practically. Practical electronics activities enhance the appropriate understanding of difficult concepts in electricity, it further improves the students' problem-solving skills, stimulates permanence of knowledge and also ensures positive attitude towards physics in general, (Amusa, J., 2022). A study concludes that most of the students are not aiming for high grades, but instead want to learn about the practical skills that they know would be useful after graduation, (Mohd-Yasin, F., 2021). Our experience is the same, but often students are not aware what skills they will need in future. Citizens of this century need more and more skills to solve problems in the today's technology-rich environments. Problem-solving skills are needed not only for their professional (work) life but also for their nonprofessional (everyday) life, (Hämäläinen, R., De Wever B., Nissinen, K., & Cincinnato, S., 2019).

The practical education could be problem-based or project-based. They are similar, but the way of processing knowledge is the key difference, (Guo, P., Saab, N., Post, & L., Admiraal, W., 2020). The focus of problem-based learning lies in knowledge application while project-based learning emphasizes knowledge construction (Krajcik, J., & Shin, N., 2014). Both have advantages and disadvantages, but which type is more appropriate depends on the taught subject. For the practical engineering education, in most cases, the project-based is the more appropriate one.

The conclusion is that the best way to improve engineering education is through a well-organized and well-interconnected educational process that includes practical real-world problem and project-based learning approaches and outcome-based exam assessments. These proper ways of work are already applied by the world lading educational institutes and universities.

The aim of this work is to analyse and present major flaws in the electronics education subjects led by the author and to present certain good solutions that we have found.

EXPOSITION

Problems with the Electronics Engineering Subjects

The Bulgarian education system is poorly financed which leads to many problems. The electronics subjects are considered to be ones of the most difficult for understanding from students. The author leads semiconductor devices, power supplies and power conversion technique. The main education problems come from the lack of enough practice hours for work with students. The problem with lack of enough lecturing hours is not so bad, but the exercises are constant rush which is detrimental for the quality of the education process. As the creativity expert Sir Ken Robinson fairly states, teaching is a creative profession, not a delivery system. Great teachers do "pass on information", but what great teachers also do is mentor, stimulate, provoke, engage. The rush could be overcome by presenting less learning material but certain minimum must be presented, otherwise the education process becomes useless. Video lectures have been created to improve the learning process. Another option is more homework to be given, but this will overload the teacher, who has to check students' reports separately and to explain their mistakes, to each of them, separately. The organized education process at the campus is more fluent and less burdensome for the busy teaching staff and more useful for students.

Of the exercises, the students usually work with pre-created learning setups for all subjects and they have certain tasks to complete. For most exercises they have to connect the investigated circuits themselves, which is an important practice for them. The circuit testing is based on the problem-solving approach. For each exercise the students must find the answers of many questions concerning the working of the investigated circuit. Recently a new Power Supply exercise manual have been created and there the questions are integrated in the different tasks for each exercise. The students are required to answer each question explicitly in their final reports. This way of work stimulates their thinking, develops their research skills and focuses their attention on the important things that might be missed otherwise.

The problem is that they are taught design methods but they don't actually create or design anything and the education process is not outcome oriented. A person who does not practically test what he has learned does not know what he actually has understood. All misunderstandings could only be resolved by enough practice. In order the education process to be improved more working

hours with students are needed, because the design process even of a simple circuit takes them a lot of time. If the time is not enough, the teachers have to do everything on their behalf and in this case they are practicing, but the students are not. The education process is for the students and they have to do their work on their own, because whoever works he learns. If the education process isn't design oriented and if there isn't enough time for work with students, then the exams cannot be outcome oriented.

Solutions

In order the education process for the led electronics subjects to be improved, a design and creation component, based on real-world problems, should be added to it. This will make the subjects a lot more attractive, desired, understandable and above all useful, but also will require more exercise working hours. Creativity and entrepreneurship are two interconnected competencies, as entrepreneurship promotes and results from creative practice. Making activities that involve real-world problems can help students develop these competencies, (Weng, H., Chiu, T., & Tsang, Ch., 2022). The well-developed creativity is a guarantee of future success for students and society.

Not all exercise setups could be redesigned and recreated at class, but there are many that can be. Only after enough working hours with students the evaluation process could become outcome-based. Such evaluation requires from students to solve a practical problem or to design something based on customer requirements. In order the students to complete the task, they must apply what they have learned during the semester. The outcome-based evaluation better distinguishes those who can and understand from those who cannot and do not understand. The able man can do the work because he understands. The outcome-based evaluation is better and easier for the skilful intelligent people who are able to solve problems. The paper-exams are better for rote learners, who remember facts, but often don't understand them and cannot do any work because of that. They are also good for copyists. In an outcome-based exam, students cannot just copy the information because on such exam they can use all available information, but they have to solve the problem with it. Said in another words they must show intelligence and skills.

Recently, the circumstances allowed more exercise working hours for the semiconductor devices, but for the rest of the subjects it seems that the time limitations can only be solved through education reform, which happens slowly.

In our case, the best option for design oriented exercises is universal breadboards to be used. The breadboards allow for healthy schematic creation without soldering. We have done a research and the result is that nowadays there are many different models of breadboards that can suite every project. The model we have chosen is presented in fig. 1.

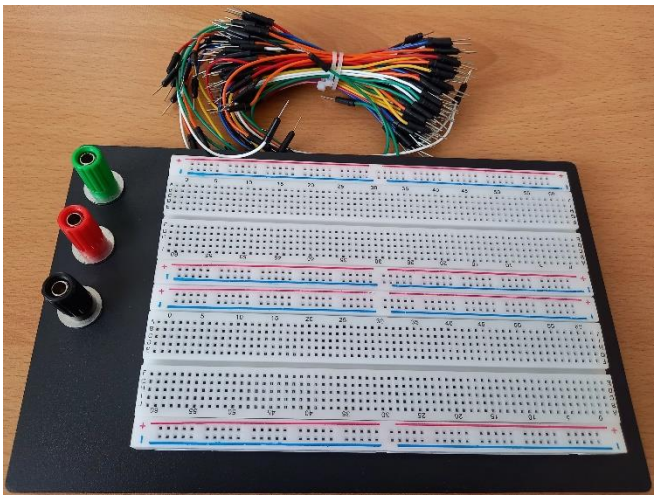

Fig. 1. Breadboard and connectors for electronic schematic design exercises

The laboratory is equipped with all necessary equipment for each working place. There are some electronic components, accumulated over the years. Some additional electronic components

might be needed, but they are cheap. We could give second live to the old electronic equipment by using some of its components, especially the bulky more expensive ones, as radiators, coils and electronic switches. Certain standard tasks are in process of creation and they will require certain number and types of components that could be provided in advance. The idea is the already present ones to be used while stocks last. The main drawback is that the constant need of education process development requires a lot of time to be spent by the teacher, who is overcharged with many different engagements.

The main problem with the electronics subjects is that students cannot exercise circuit design, creation and research at home because they need to possess expensive equipment. In this regard, the accelerating pace of technological progress requires new approaches to the organization of education with appropriately trained educators who know how to use a variety of digital learning tools, (Meirbekov, A., Maslova, I., & Gallyamova, Z., 2022). A study concluded that the computer simulation method as pre-lab task, in general, is capable in helping the students to understand better and more effectively than the written-based method, (Yusof , Y., Sanusi, H., & Mat, K., 2012).

The aforementioned problem could be solved with the help of simulation software, but a research led to the conclusion that nowadays the analog circuit simulation is realistic for comparatively simple circuits only. Despite this drawback, such software is widely used nowadays during circuit design processes. 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 or approaching research, (Serafin, C., 2021). In order such software to become useful, the complicated task should be divided into small enough subtasks and each of them should be solved separately. When all of the subtasks are solved well, then the whole difficult task is solved.

We teach students to divide all complicated problems to simple enough sub-problems, which they can solve one by one easier and faster. This structured approach allows the use of initial simulation for faster design process, but in order the students to be able to do that at home a free of charge simulation software should be provided to them. A research and testing of different freewares led to the conclusion that there are two good possibilities. One of them is Micro-Cap, created by Spectrum Software, and the other is LTspice, product of Analog Devices.

We have used Micro-Cap since the beginning of the Covid pandemic and for simple circuits it could present realistic results. One of its main drawbacks is that it couldn’t draw precise oscillograms with more points, or at least we didn’t figure out how to make it to do so. Its main advantage is its simple interface.

A recent research led to the conclusion that LTspice is mostly used by professionals when they don’t have access to paid professional software. We have tested it and it seems to be working great. Its main drawback is the more complicated interface. It possess many advanced features but you should know how to use them. Currently we learn how to use it and evaluate the possibility LTspice to be used in an education process.

CONCLUSION

The complete design process in the electronics field requires calculations, initial simulation and improvement of the design, practical creation, testing and final improvements. Each of these steps requires a lot of time for diligent and trouble-free work on the part of students, as well as on the part of teachers. The lack of enough time for education process development and work with students is the main limitation that worsens the quality of education in Bulgaria. Introducing new technologies and paradigms in established engineering courses is always challenging. In addition to the core subject matter, students had to learn new tools and development workflows, but in a whole, it has been a rewarding experience for both students and teachers, (Vasileva, T., & Tchoumatchenko, V., 2014).

Despite that the modern analog simulation softwares are far from perfect, they could be of a big help when the difficult task is subdivided into smaller and easier for solving subtasks. Nowadays there are free quality simulation programs that can help students develop their skills at home without

the need of expensive equipment. Even if the students are loaded with a lot of homework, this overloads the teacher, who has to check their work separately and to explain their mistakes to each of them separately. The organised education process at the campus is more fluent and less burdensome for the teaching staff, and more useful for students.

ACKNOWLEDGMENTS

The work in this document was supported by the following projects:

EC Project 2020-1-PL01-KA226-HE-096196, project title: "Holistic approach towards problem-based ICT education based on international cooperation in pandemic conditions".

Project 2022-FEEA-03 "Development of a robotic autonomous platform for obtaining and analyzing spectral images of the ground surface", financed by the Scientific Research Fund of the University of Ruse "Angel Kanchev".

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