OUR EXPERIENCE FROM THE USE OF INNOVATIVE TECHNOLOGIES IN TEACHING "ELECTRICAL ENGINEERING" DURING THE COVID-19 PANDEMIC

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Abstract

The emergency transition from face-to-face to online learning during the COVID-19 pandemic proved to be a challenge for academics all over the world. They urgently needed to change their curricula, teaching methods and assessment to adapt to the new situation, namely: the limited face-to-face contact and access to laboratories.

In this paper we present our experience in teaching "Electrical engineering" at the Faculty of Physics and Technology of Plovdiv University during the lockdown. The described educational technology was developed within the framework of the project "New trends in Electrical engineering" training in a pandemic", which started in 2021. The main goal of the project is implementation of innovative methods and tools which will help engineering students develop practical skills during distance or blended learning, namely:

• Use of the project-based approach aimed at pre-training students before attending laboratory classes;

• Inclusion of simulation labs (using Multisim Live) in the curriculum via which students gain knowledge in building circuits using simulation software;

• Use of a system for remote access to the laboratory equipment, developed by a team of Plovdiv University;

• Use of QR codes during the face-to-face laboratory exercises. Every measuring instrument in the Electrical engineering laboratory has an attached QR code. After scanning the QR codes students get access to instructional videos demonstrating the work with the instruments.

The pilot experiment was conducted during the first semester of the 2021/2022 academic year with second-year students majoring in "Information and computer engineering". The results from the performed observations, questionnaires, the grades received from individual assignments on Multisim Live and from the students' laboratory worksheets, give us reason to believe that the developed educational technology is effective in the conditions of distance or blended learning.

Keywords: Blended learning, distance learning, electrical engineering, pandemic, QR code.

1 INTRODUCTIOIN

Electrical Engineering is one of the basic disciplines in engineering education which is considered by students to be one of the most difficult subjects in the field. The main reason is that studied concepts and procedures are complicated and not directly observable (Chen, Wei and Li, 2016, pp. 148-165). That is why laboratory experiments are extremely important for engineering students to make theory more accessible, to stimulate their interest in studying (Zlatanski and Gospodinov, 2019, pp.1 - 5).

The emergency transition from face-to-face to online learning during the COVID-19 pandemic proved to be a challenge for engineering educators. They urgently needed to change their curricula, teaching methods and assessment to overcome the limited face-to-face contact and access to laboratories.

This was the reason Plovdiv University “Paisii Hilendarski” to start a project "New Trends in "Electrical Engineering” Training in a Pandemic" in 2021. The main goal of the project is implementation of innovative methods and tools which will help engineering students develop practical skills during distance or blended learning. The main objectives of the project are:

a. Development of educational technology for distance and/or blended learning in "Electrical Engineering".

b. Equipment of a modern laboratory in electrical engineering with new measuring instruments that allow remote control.

2 EDUCATIONAL TECHNOLOGY FOR DISTANCE AND/OR BLENDED LEARNING IN ELECTRICAL ENGINEERING

The main idea of the developed educational technology is provide students with an effective practical, hands-on education regardless of the pandemic situation and the restrictions associated with it. Computer simulations, remote laboratory and smartphones were integrated in learning process for complementing laboratory exercises during the lockdown.

Another idea behind the proposed educational technology is to promote students’ problem solving skills. The project team thinks that project-based learning is the most effective method which contributes to the development of these skills (Lucas, Hanson and Claxton, 2014, p.3). That is why all lectures were uploaded in DIPSEIL (https://v4.dipseil.net) – an Internet-based learning environment in which students study by performing different learning tasks (projects) which are aimed at solving real problems (Tokmakov, 2013, pp.186-191). All laboratory exercises were also uploaded in DIPSEIL- thus we aim for prior training of students ahead of the laboratory class so that class-time can be used mainly for practical work.

The pilot experiment was conducted during the first semester of the 2021/2022 academic year with 50 second-year students majoring in “Information and computer engineering”.

2.1 Teaching Lectures in Electrical Engineering

All lectures in electrical engineering were conducted online, using both synchronous (Goggle Meet) and asynchronous (DIPSEIL) learning platforms. Students had to read the lecture material in advance so that the online sessions could be used mainly for questions, discussions and assistance in performing the learning tasks. Our experience showed that most of the students are satisfied with this form of delivery of the learning content as it provides them the flexibility to study on their own time while getting an opportunity to communicate with peers and teachers during the online meetings. According to teachers this model for online instruction is an effective approach and gives the best learning results.

2.2 Teaching Laboratory Exercises in Electrical Engineering

2.2.1 Using a System for Remote Access to the Laboratory Equipment

During the pandemic all laboratory exercises at the Faculty of Physics and Technology of Plovdiv University remained face-to-face but were moved during the first half of the winter semester or the second half of the summer semester respectively before or after the lectures. This caused the following problems:

• Teachers had to spend more time to explain theory concerning the laboratory exercise which reduced students' working time;

• The requirement for social distancing limited laboratory capacities.

In order to overcome the limited laboratory capacities some of the laboratory exercises were performed remotely using the new equipment in a laboratory, purchased under the project (Fig. 1). The remote

laboratory includes:

- A digital oscilloscope model GWINSTEK GDS2072A;
- Keithley 2015 THD multimeter;
- Two-channel waveform generator based on the AD9833 IC.

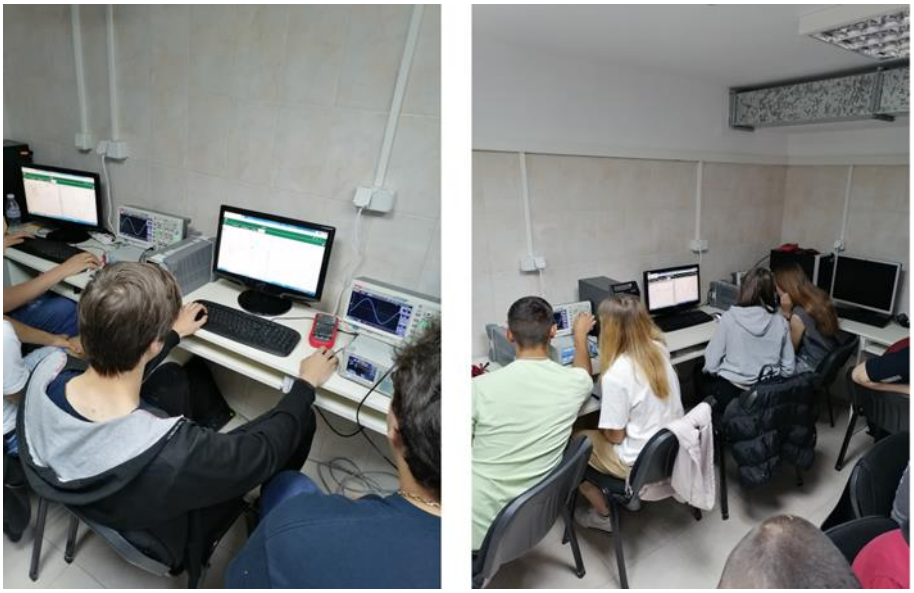

Fig.1.The new electrical engineering laboratory

All these devices can be completely controlled through authoring software developed by a team of Plovdiv University. The connection between the users and the remote laboratory is made through a web-based software system, which has been successfully tested in “Fundamentals of telecommunications” training during the pandemic (Mengov et.al., 2021, pp. 5370-5373).

The following exercises were conducted remotely:

- Study of alternating current (AC) circuits- students analyse the shape and the parameters of the signal: amplitude, phase and frequency.
- Study of low pass, high pass and band pass filters- students determine the basic characteristics of filters - filter slope, passband and stopband.
- Study of RLC resonance circuits- determination of the bandwidth and the quality factor.

After completing the exercise, the students had to send the laboratory worksheets to the teacher for evaluation. Results from the laboratory worksheets confirmed the reliability and accuracy of the data measurements through the remote laboratory. The main disadvantage is that at a certain time interval only one student can perform a given remote experiment. This is very time consuming for educators because they had to spend much more time observing students' work. Nevertheless, all teachers are confident that the system can be successfully used in addition to the traditional face-to-face laboratory training.

2.2.2 Using Simulation Labs

The main idea behind the integration of computer simulations in the electrical engineering curriculum was to enhance students’ simulation skills and to stimulate their active learning (Vakrilov, 2018, pp. 1-4). The inclusion of computer simulations in electrical engineering training went through the following main steps:

1. Selection of efficient online simulation software.
2. Selection of a set of laboratory exercises that will be conducted using computer simulations.
3. Conduction of an introductory training on the selected software.
4. Preparation of a set of lab manuals that will help students to perform the laboratory tasks.
5. Preparation an individual assignment which students must complete outside of class time.

6. Assessing the individual assignments at the end of the course.

Our preliminary studies have shown that Multisim and Proteus are the most often used electronics circuit simulation tools in engineering education (Shehova et.al., 2020, pp.1637-1643; Valiente et.al., 2019, pages 121-128). The software that our team chose is Multisim Live (https://www.multisim.com/). Multisim Live is a free, online circuit simulator, which allows users to create, interactively simulate, learn and share circuits online. It has an intuitive interface and can be used on any device (cell, phone, tablet, computer, etc.) without installing any software.

Five laboratory tasks were conducted with Miltisim Live:

• Study of alternating current (AC) circuits.

• Measurement of inductance and capacitance by using a bridge.

• Study of the characteristics of four terminal networks.

• Study of the characteristics of RC filters.

• Study of the characteristics of LC filters.

For each laboratory task the students prepared laboratory worksheets, which include: title of the laboratory work, goals and objectives, tables with recorded data, diagrams and conclusions. The completed worksheet was evaluated by the teacher. During the semester students were given individual projects in Multisim Live through which they must demonstrate their skills to design and analyze more complicated circuits. Students worked on the projects independently. They defended the projects at the end of the semester. The evaluation of students' projects was performed on two indicators: acquired skills for using the software and skills for interpreting the results, which indicates their understanding of the theory. The obtained mean score was 4.25 which is a good result.

2.2.3 Using QR Codes in Electrical Engineering Labs

The project team has an almost 5 year experience in using QR codes (Quick Response codes) in education. Our previous researches showed that QR codes can increase efficiency in the face-to-face laboratory exercises by providing quick access to:

• User manuals on how to operate measuring instruments;

• Step-by-step instructions how to conduct the laboratory exercise to reduce the need for support from the teachers.

For every measuring instrument in the electrical engineering laboratory we prepared a short video how to handle it and generated a QR code for it. All videos are less than 2 minutes and can be quickly downloaded. Then this QR code was attached to the relevant instrument. By scanning the QR codes with their smartphones, students could directly access these videos. Educators who observed students' work during the face-to-face laboratory exercises reported that QR codes helped students to work more confidently with the laboratory equipment. In case of need, most students chose to use QR codes instead of asking for support from the teacher. Results from the laboratory worksheets showed a reduction in measurement errors. It was also reported that the students did not encounter any difficulty with scanning the QR codes and downloading the videos.

3 CONCLUSION

The developed educational technology is consistent with the modern technological advancements and industry requirements for engineering education. Its main goal is to support laboratory exercises during distance or blended learning. It includes:

• Use of the project-based approach aimed at pre-training students before attending laboratory classes;

• Inclusion of simulation labs (using Multisim Live) in the curriculum via which students gain knowledge in building circuits using simulation software;

• Use of a system for remote access to the laboratory equipment, developed by a team of Plovdiv University;

• Use of QR codes during the face-to-face laboratory exercises to access instructional videos demonstrating the work with the instruments.

The results from the performed observations, the grades received from individual assignments on Multisim

Live and from the students' laboratory worksheets, give us reason to believe that the developed educational technology is effective in the conditions of distance or blended learning.

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