

## RESULTS FROM THE PILOT EXPERIMENT WITHIN THE PROJECT “NEW TRENDS IN ELECTRICAL ENGINEERING TRAINING IN A PANDEMIC”

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### Abstract

The main challenge for engineering training is to create a strong connection between theory and practice. Only in this way the new generations of engineers will be able to adapt to a fast –changing work environment. That was the reason Plovdiv University "Paisii Hilendarski" to start a project "New trends in Electrical engineering training in a pandemic" in 2021. The project aims at developing educational technology to support the laboratory exercises in electrical engineering during the distance or blended learning and to make them more effective and flexible in a pandemic. Project-based learning, remote access to laboratory equipment, computer simulations via Multisim Live and QR codes were used to support the practical classes in electrical engineering. Multimedia instructional resources were developed within the project, including: multimedia resources related to the theory, instructional videos demonstrating how to conduct the laboratory exercises or how to work with the measuring instruments in the laboratory. Students were able to access these videos during the face-to-face classes by scanning QR codes located on the laboratory equipment or printed on students' laboratory handouts.

In this paper we present the results from a questionnaire exploring students' satisfaction with the training in electrical engineering. The survey was conducted at the end of the pilot experiment during the first semester of the academic year 2021/2022. It involved second-year students from the speciality "Information and computer engineering". The training was blended - 5 weeks face-to-face and 10 weeks online. All practical classes were held in the modern electrical engineering laboratory equipped under the project. The results are very positive. Over 80% of the surveyed students indicate that the developed instructional materials in electrical engineering have helped them to complete the laboratory tasks with minimal help from the educator. The results show that the use of QR codes during the face-to-face laboratory classes has helped the students to work more confident with the laboratory equipment. Most of the students are satisfied with the quality of the system for remote control of laboratory equipment. Almost 85% of them are of the opinion that the practical exercises with Multisim Live have helped them develop practical skills in simulating circuits and analysing the simulated results. Almost 75% of respondents believe that the course is consistent with their prior expectations, which is indicative of the quality of the training provided.

**Keywords:** blended learning, distance learning, electrical engineering, pandemic, QR code.

## **1 INTRODUCTION**

The main challenge for engineering training is to create a strong connection between theory and practice. Only in this way the new generations of engineers will be able to adapt to a fast –changing work environment.

In a pandemic for the training of such specialists, satisfying the needs of the industry, it is necessary to implement innovative methods and forms for conducting distance and / or blended learning. This is possible due to technological advances in the fields of artificial intelligence, information and communication technology, software methods for analysis and simulation, virtual reality etc. Through online education using modern technologies, things become more straightforward and more available (Doneva, Gaftandzhieva, Islam, Almasri and Lalchhanhima, 2020, pp. 3500-3506).

The use of these technologies establishes new ways of sharing information and laboratory resources between different educational institutions. This allows remote access to expensive equipment, which is not usually available in all universities.

Simulation techniques provide students with the opportunity to observe the application of complex engineering principles in a controlled virtual environment (Raydovska, 2020, pp. 2687–2697). The implementation of simulation software products such as Multisim Live in engineering education can help students easily design, calculate and analyse electrical circuits. In this way, teachers can improve the quality of education and prepare students for their future work in real working conditions (Paunkov, Lyubomirov, Popov and Shehova, 2021, pp. 9801-9809).

In this article we present the results of the pilot experiment conducted within the project “New Trends in “Electrical Engineering” Training in a Pandemic”, funded by the Research Fund at Plovdiv University. The project aims at developing educational technology to support the laboratory exercises in electrical engineering during the distance or blended learning and to make them more effective and flexible in a pandemic.

The project aims at meeting the needs of the two target groups (students and teachers):

- Using innovative teaching methods, the students gain knowledge and experience regarding the design of electrical circuits and work with modern measuring equipment, which is a necessary prerequisite for their future career.
- The developed educational technology for distance and/or blended learning in "Electrical Engineering" can be used by both teachers of electrical engineering and teachers of other engineering disciplines.

Two questionnaires were used to identify the needs of the two target groups:

- Teachers' and students' questionnaires regarding their opinion about distance and/or blended learning in “Electrical engineering” – Part I and Part II;
- A questionnaire determining students' prior knowledge and expectations from the course "Electrical Engineering”.

The results from the first survey show that most students highly appreciate the quality of the online lectures but are not satisfied with the online laboratory classes (Stoyanova, et.al., 2021, pp. 5024-5028). Both students and teachers think that the number of face-to-face labs was not enough to develop solid practical skills in electrical engineering which will inevitably affect students' future professional career.

The results from the second survey show that students expect more practical oriented teaching process. All of them prefer hands-on learning than theory based one.

On the basis of the surveyed students' and teachers' responses, the project team developed the educational technology for distance and/or blended education in "Electrical Engineering" to make the training more effective, efficient and flexible in a pandemic context.

New measuring instruments were purchased and a system for remote access to laboratory equipment was created within the frame of the project. The course "Electrical Engineering" was developed and uploaded on the system for project-based learning DIPSEIL (<https://v4.dipseil.net>). Multimedia training resources for the electrical engineering course were developed, including:

- Multimedia resources related to the theory of each of the assignments in the course.
- Multimedia resources related to the methodology for simulations of electrical circuits in Multisim Live.

- Video files demonstrating how to conduct the laboratory exercises.
- Instructional videos how to work with the measuring equipment.

These video files will be accessible via QR codes during the face-to-face classes.

## **2 PILOT EXPERIMENT AND RESULTS**

### **2.1 Pilot experiment**

The pilot experiment involved 50 second-year students majoring in Information and Computer Engineering, Faculty of Physics and Technology, bachelor's degree. The students studied the subject "Electrical Engineering". The pilot experiment was conducted during the first semester of the 2021/2022 academic year. All students were in the age range of 20-30 years. The training was blended- the first 5 weeks were face-to-face, the remaining 10 weeks were online. The face-to-face laboratory training was conducted in the modern electrical engineering laboratory equipped under the project. Students were divided into groups of 10 students. Some of the laboratory exercises were performed remotely by using software system developed by a team of Plovdiv University.

### **2.2 Results**

At the end of the pilot experiment, a survey was conducted to explore students' satisfaction with the training in "Electrical Engineering" in a pandemic condition. The survey included questions on a four-point Likert scale ("No"; "Rather no"; "Rather yes"; "Yes"). The last question was open-ended. The survey included questions in the following five categories: satisfaction with the uploaded in DIPSEIL teaching materials for the laboratory exercises in electrical engineering; satisfaction with the use of QR codes during the face-to-face laboratory exercises; satisfaction with the quality of the developed multimedia resources; satisfaction with the use of the remote access laboratory; overall satisfaction with the course. The survey results are shown in Table 1.

Almost all of the surveyed students (10% - "Rather Yes" and 84% - "Yes") believe that there is no difference between the uploaded in DIPSEIL teaching materials for laboratory exercises and the laboratory handouts used during the face-to-face classes.

Over 80% of the surveyed students indicate that the developed instructional materials for the laboratory exercises in electrical engineering have helped them to complete the experiments more quickly and with minimal help from the educator.

Unsurprisingly (given the age range of respondents), almost all surveyed students (14% - "Rather Yes" and 80% - "Yes") did not experience any difficulties in using QR codes.

The results show that the use of QR codes during the face-to-face laboratory classes has helped the students to work more confident with the laboratory equipment (24%- "Rather Yes" and 58%- "Yes").

In general, students are satisfied with the quality of the developed multimedia resources. Most of the respondents think that the multimedia resources are of good quality (28% - "Rather Yes" and 52% - "Yes") and are in accordance with the set didactic goals (38% - "Rather Yes" and 48% - "Yes").

Most of the students are satisfied with the quality of the developed system for remote control of laboratory equipment (26%- "Rather Yes" and 58%- "Yes"). More than 85% of the surveyed students are of the opinion that the developed system for remote access to laboratory equipment can be used in other engineering disciplines.

Overall, students are satisfied with the quality of lectures (8% - "Rather Yes" and 68% - "Yes") and laboratory exercises on "Electrical Engineering" (14%- "Rather Yes" and 64%- "Yes").

Almost 85% of them are of the opinion that the practical exercises with Multisim Live have helped them develop practical skills in simulating circuits and analysing the simulated results.

Almost 75% of respondents believe that the course is consistent with their prior expectations, which is indicative of the quality of the training provided.

Almost 60% of students believe that there is no difference in effectiveness between lectures and laboratory exercises in "Electrical Engineering", conducted in distance mode and those conducted in a face-to-face mode (22% - "Rather Yes" and 36% - "Yes").

**Table 1. The distribution of students' answers to the survey questions**

Question	No	Rather No	Rather Yes	Yes
<b>Satisfaction with the uploaded in DIPSEIL teaching materials for the laboratory exercises in electrical engineering</b>				
1. There is no difference between the uploaded in DIPSEIL teaching materials for laboratory exercises and the laboratory handouts used during the face-to-face classes	2%	4%	10%	84%
2. The uploaded in DIPSEIL instructional materials for the laboratory exercises in electrical engineering helped me to complete the experiments more quickly during the face-to-face classes.	4%	14%	10%	72%
3. The uploaded in DIPSEIL instructional materials for the laboratory exercises in electrical engineering helped me to complete the experiments with minimal help from the educator during the face-to-face classes.	8%	10%	24%	58%
<b>Satisfaction with the use of QR codes during the face-to-face laboratory exercises</b>				
4. I did not experience any difficulties in using QR codes.	2%	4%	14%	80%
5. The use of QR codes during the face-to-face laboratory classes helped me to conduct more quickly the laboratory exercise.	8%	14%	22%	56%
6. The use of QR codes during the face-to-face laboratory classes helped me to work more confident with the laboratory equipment.	8%	10%	24%	58%
<b>Satisfaction with the quality of the developed multimedia resources</b>				
7. The developed multimedia resources have an optimal duration.	4%	8%	24%	64%
8. The developed multimedia resources are of good quality.	4%	16%	28%	52%
9. The developed multimedia resources are in accordance with the set didactic goals.	4%	10%	38%	48%
<b>Satisfaction with the use of the remote access laboratory</b>				
10. Overall, I am satisfied with the system for remote access to laboratory equipment.	4%	12%	26%	58%
11. I would recommend using the system for remote access to laboratory equipment in other engineering disciplines.	2%	12%	12%	74%
<b>Overall satisfaction with the course quality</b>				
12. Overall, I am satisfied with the quality of the lectures on electrical engineering.	4%	20%	8%	68%
13. Overall, I am satisfied with the quality of the laboratory exercises on electrical engineering.	8%	14%	14%	64%

14. The practical exercises with Multisim Live helped me to develop practical skills for simulating circuits and analyzing the simulated results.	4%	12%	10%	74%
15. The course content in electrical engineering is consistent with my prior expectations.	4%	22%	14%	60%
16. I think that conducting the lectures and laboratory exercises on electrical engineering in distance mode is as effective as conducting them in face-to-face mode.	12%	30%	22%	36%
Do you have any recommendations for the way of conducting lectures and laboratory exercises in "Electrical engineering"? .....				
.....				

Most of the students answered the question "Do you have any recommendations for the way of conducting lectures and laboratory exercises in "Electrical engineering?". In general, students appreciate the use of modern technologies in engineering education but also they noted some problems, gave us some suggestions that we should take into account in our future work. Their opinions and recommendations can be summarized as follows:

- Students are of the opinion that the first and second year of their training must include real laboratory work, although working in a remote laboratory is an useful experience. The students consider that working only in a remote laboratory in the first years of their education would deprive them of acquiring some basic but essential practical skills. The students express their satisfaction with the blended mode of training in "Electrical Engineering" conducted during the semester - a combination of distance and face-to-face classes. This statement clearly shows that students want to continue to benefit from the new technologies in education, but at the same time insist on real laboratory training.
- According to the students, another advantage of the face-to-face laboratory exercises is that they support the teamwork. In the remote access laboratory the work is rather individual.
- Some of the students noted that during their work with the remote access system they needed additional help and instructions, while when working in a real laboratory, the laboratory handouts and multimedia resources were completely sufficient.
- Students prefer lectures to be entirely in distance mode.

### 3 CONCLUSIONS

The results of the survey conducted at the end of the pilot experiment show the students' satisfaction with the training in "Electrical Engineering". They are convinced that the combination of distance and face-to-face training is a very good option for conducting training in engineering subjects during a pandemic. Almost 75% of respondents believe that the course is consistent with their prior expectations, which is indicative of the quality of the training provided.

The students' answers show their positive attitude towards the technologies used to support their practical training in "Electrical Engineering": project-based e-learning system, remote access to the laboratory equipment, computer simulation via Multisim Live and QR codes. The results show that the use of QR codes during the face-to-face laboratory classes has helped the students to work more confident with the laboratory equipment. Almost 85% of them are of the opinion that the practical exercises with Multisim Live have helped them develop practical skills in simulating circuits and analysing the simulated results.

Students are confident that the remote access laboratories can be successfully used in addition to the traditional face-to-face laboratory training. In this way they will be prepared for the industry requirements and globalization in the workplace.

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