# Modelling of laboratory work in the science "Fundamentals of power supply" using an educational simulator based on a programmed logic controller

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**Abstract.** Today, the use of programmable logic controller devices in the educational process brings great results. This study demonstrated the effectiveness of using a programmable logic controller (PLC)-based training simulator in modeling laboratory work on the subject of "Power Supply Fundamentals". The results show that the training simulator was considered effective in providing students with a flexible and safe way to learn PLC and power supply systems. Also, this article presents the working principle and algorithm of a model virtual simulator based on PLC that meets the requirements of modern education in the field of "Basics of Power Supply" developed during our research. At the same time, the methodologies used for the research are also widely covered.

## 1 Introduction

The field of industrial automation and control relies heavily on the use of programmed logic controllers (PLCs) to control and monitor processes in various industries. One of the key components of training and educating engineers, technicians, and operators in the use of PLCs is laboratory work. Laboratory work allows students to gain hands-on experience with PLCs in a controlled environment, but it also has its limitations, such as a lack of flexibility and the risk of equipment damage [1, 2, 10].

To address these limitations, this study aims to investigate the use of an educational simulator based on a programmed logic controller (PLC) to model laboratory work in the science "Fundamentals of power supply". The simulator will be used to provide students with a flexible and safe way to learn about PLCs and power supply systems. The objective of this study is to design and implement an educational simulator for laboratory work in the science "Fundamentals of power supply" that accurately replicates the behavior of real PLC-controlled systems.

The study will begin by reviewing the literature on educational simulators and PLCs in industrial automation and control. The methodology will then involve the collection of data from an existing PLC-controlled power supply system, the creation of a simulation model, and the integration of the simulation model with a user interface to create the educational simulator [3, 12, 6]. The effectiveness of the educational simulator will be evaluated through its use in laboratory work and through a comparison of the performance of students who have used the simulator with those who have not.

The study's goal is to provide an educational tool that will enable laboratory work in the science "Fundamentals of power supply" to be performed more efficiently, with more flexibility and safety. The results of this study will provide insight into the potential of educational simulators based on PLCs as a valuable tool for training and education in the field of industrial automation and control [4, 11-15, 5, 8].

## 2 The current state of the investigated problem

The methodology used in this study to model laboratory work in the science "Fundamentals of power supply" using an educational simulator based on a programmed logic controller (PLC) is divided into 6 stages [7, 16-20, 9, 12, 14]:

1. Literature review: To begin, a literature review was conducted to gather information on educational simulators and PLCs in industrial automation and control. This helped to identify the current state of the field and the challenges associated with using PLCs in laboratory work [4, 21-24, 13, 17].
2. Data collection: Data was collected from an existing PLC-controlled power supply system. This data

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included the PLC program, electrical schematics, and process parameters.

3. Simulation model development: Using the data collected, a simulation model was developed that accurately replicates the behavior of the PLC-controlled power supply system. The simulation model was built using a PLC simulation software.

4. User interface design and development: The simulation model was integrated with a user interface to create the educational simulator. The user interface was designed to be user-friendly, intuitive, and interactive. It was developed using a software development tool.

5. Evaluation: The effectiveness of the educational simulator was evaluated through its use in laboratory work. The performance of students who have used the simulator was compared to the performance of students who have not. The evaluation was conducted by monitoring the students' understanding and their ability to work with the PLC-controlled power supply system.

6. Analysis and interpretation: The results of the evaluation were analyzed and interpreted to determine the effectiveness of the educational simulator in modeling laboratory work in the science "Fundamentals of power supply" and to identify areas for improvement.

The results of this study on modeling laboratory work in the science "Fundamentals of power supply" using an educational simulator based on a programmed logic controller (PLC) showed that the educational simulator was effective in providing students with a flexible and safe way to learn about PLCs and power supply systems [16, 25, 19].

During the research, the algorithm of the laboratory on "Basics of power supply" was developed as a sample. This algorithm consists of two parts (Figure 1):

1. Performing the laboratory
2. Evaluation

In the laboratory for studying the circuits of main step-down substations of industrial enterprises, the student's skills are formed in relation to this laboratory on the basis of three tasks, and his knowledge is assessed step by step. From the point of view of complexity, questions are divided into easy (green), medium difficulty (blue) and complex (red) questions. The first assignment is the question of placing the devices in series in the circuit of the main step-down substations, in which it is initially taken that c=0, the reason for the errors is to take into account the fact that the student performed the experiment without a scholarship, in this question, the device is asked in series from 1 to 6 in the range where the student will need to correctly enter the names of the devices. Entered device names are accepted and checked to see if the device name is entered correctly. If the device name is entered incorrectly, an error message will be displayed and the count will be 1 because the operation was performed incorrectly. Actions are repeated six times, because here six devices are requested, and in the next step, the command to start the step-down substations of industrial enterprises is given. In this case, the student will have to start the substation in the correct sequence. Of course, the correct sequence starts with the top source and then the consumer is connected. In the next case, it checks whether the initialization of industrial enterprises is done correctly, if it is done incorrectly, 1 error is recorded and this cycle is repeated from 1 to 10 for starting ten devices.

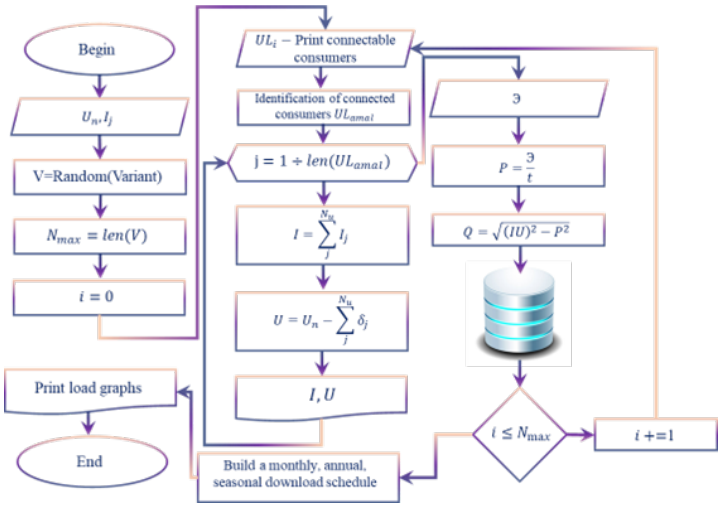


**Fig. 1.** Algorithm for evaluating the performance of the students who completed the training and the laboratory of the study of the schemes of the step-down substations of the industrial enterprises [21]

The next task is the commissioning of the step-down substation of industrial enterprises, in which the correct commissioning of ten devices in a row is carried out and the device is checked after disconnection, and an error is recorded if it is incorrectly started. If executed correctly, it will be repeated ten times and at the end of this assignment, the student evaluation algorithm will be activated, the maximum score and the number of repetitions will be accepted. Based on the formula $b = \frac{N_{max}-c}{N_{max}} b_{max}$ the grade of the student is derived.

Based on the above processes, one of the main tasks of the laboratory work created on the basis of virtual simulations is to provide students with theoretical and practical knowledge of the basics of electricity supply, to create skills and qualifications for applying the knowledge they have acquired in practice. Including the algorithms of the virtual simulation laboratory work, the developed software is perfectly created in all aspects. These virtual simulators serve to represent the future activity of students as specialists [25-28, 22, 24, 3].

As a result, the web page included the use of the virtual laboratory created in the framework of the research dissertation on the science of the basics of power supply, lectures, practical exercises, tests, useful tips, literature and other handouts related to the science in general.

## 3 Conclusion

The students who used the simulator had a better understanding of the PLC-controlled power supply system and were able to work with the system more efficiently [7]. The educational simulator was also found to be a valuable tool for training and education in the

field of industrial automation and control, as it allowed students to repeat the laboratory tasks as many times as they needed to, allowing them to master the material at their own pace.

The results of this study demonstrate the potential of educational simulators based on PLCs as a valuable tool for training and education in the field of industrial automation and control [8]. However, it is important to note that the use of the educational simulator should be supplemented with practical, hands-on experience in order to provide students with a complete understanding of PLCs and power supply systems.

In summary, the use of an educational simulator based on PLC in laboratory work has been shown to be an effective method of teaching the fundamentals of power supply, providing students with a flexible and safe way to learn about PLCs and power supply systems. This approach can be effectively used in the field of industrial automation and control, providing valuable training and education.

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