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Experiential Learning Model And Problem-Based Learning Based On Laboratory Practices Applied To The Subject Of Fundamentals Of Control And Automation At The Universidad Francisco De Paula Santander Ocaña

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Abstract

With the rapid growth of the technology era, the conventional teaching approach is not sufficient for students of the millennial generation. With this in mind, this article presents the justification for incorporating Kolb's experiential learning, based on laboratory practices with an environment supported by simulation software, combined with problem-based learning, into the Fundamentals of Control and Automation course of the Mechanical Engineering program of the Universidad Francisco de Paula Santander Ocaña. The central objective of the proposal is to work on the generation of competencies and performance skills in the mechanical engineering student from his academic training. This approach takes advantage of the strength of learning based on laboratory practices and problem-based learning using modern teaching technologies and a combination of face-to-face laboratory practices and simulation software, which are associated with Kolb's cycle to facilitate constructivist learning.

Keywords: Kolb's experiential learning; PBL; programmable logic controllers.

1. Introduction

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The teaching-learning process has changed over time and it is a fact that the "traditional" education in which a teacher transmitted knowledge and the student was only a receiver of it, has changed drastically, today the new way of seeing the world, the influence of information and communication technologies have led us to the student to be the builder of their own knowledge and not only be satisfied in receiving information, where the role of the teacher is modified to become a guide that leads the student to the completion of their studies and the achievement of objectives, where learning methodologies, styles and the way of transmitting knowledge must be at the forefront of the new requirements of the student (Franco, Vega Lugo, and Hurtado Vega 2019). One of these methodologies is experiential learning based on laboratory practices plays an important role in education because it allows pedagogical objectives to be achieved through the direct application of theory to practice and, as such, allows students to manipulate the physical environment and understand its limitations and real-world problems.(Zhang et al. 2020),(Konak, Clark, and Nasereddin 2014).

Laboratories are complex teaching and learning environments, as they can be broadly defined as places that provide opportunities for experimentation, observation and practice in a field of study. Lab-based learning is also seen as a way to accompany the digital shift in engineering education (Mehrtash, Yuen, and Balan 2019),(Bakoush 2022). digital change in engineering education. It allows students to directly manipulate materials, electronic components, sensors, energy and information and provides adequate opportunities to apply their knowledge and efforts to find creative solutions to real problems with the laboratory equipment provided (Ángel et al. 2020).

Another active teaching methodology that has been gaining ground in the teaching of Control and Automation is Problem Based Learning (PBL).(Maya Palacios, González Hernández, and Ocampo Casados 2017). One of the advantages of using PBL in the classroom is the promotion of collaboration, since students naturally have different skills and competencies, but through group work they practice the constant exchange of knowledge and complement each other to solve the problem.

Within the subject of Fundamentals of Control and Automation, which is in the eighth semester of the Mechanical Engineering program at the Universidad Francisco de Paula Santander Ocaña, we see cutting-edge topics such as Pneumatic Technologies, Electropneumatic Technologies and Programmable Logic Controllers, which are aimed at Industry 4.0 and the fourth industrial revolution.

The fourth industrial revolution has affected education, which is defined by an increased use of digital technology (electronic systems) in the learning process. This technology allows the learning process to continue indefinitely in terms of location and time, i.e., it is not limited to classroom and study hours. Changes in learning, thinking and acting of students to produce creative ideas must be combined with teaching-learning methodologies (Samiha et al. 2021).

This research proposes a hybrid methodology where Kolb's experiential learning and problem-based learning complemented with laboratory practices are mixed for the fundamentals of control and automation, with the objective of guaranteeing students of the mechanical engineering program a learning that allows them to collaborate, communicate, solve problems, and experiment in a critical, creative and innovative way. This ensures that competencies and skills can only be achieved through blended learning.

2. Learning Theories

2.1. Experience-based learning (EBL)

Experience-based learning Is an approach that can be used especially for the acquisition of competencies in engineering programs, it focuses on designing, building and operating a laboratory practice infrastructure with the objective of supporting theory-practice transfer.(Uğur, Akkoyunlu, and Kurbanoğlu 2011),(Mehrtash, Ghalkhani, and Singh 2021).

Kolb's experiential learning cycle theory holds that learning is the process by which knowledge is created through the transformation of experience(Li and Armstrong 2015), The cycle diagram is shown in Figure 1,consisting of four stages of adaptive learning:

- The Concrete Experience: is a new experience for students to fully participate in, learning from existing experience through the senses, pertaining to the senses.
- Reflective Observation: refers to the fact that learners look for the meaning of things from different aspects by observing, listening and thinking about the experience they have lived, which belongs to the observation side.
- Abstract concept, in which students abstract their experience through thinking and learning, which belongs to the thinking side;
- Active experiment, students learn through practical operations, verify these concepts and apply them to develop strategies and solve problems, which belongs to the behavioral side; and

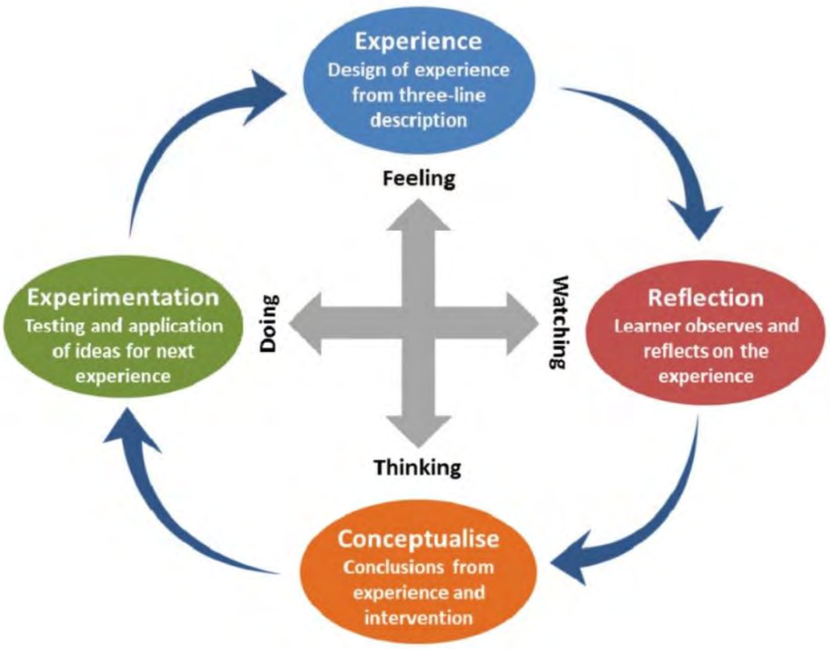

Figure 1. Four stages of Kolb's experiential learning cycle.
Source: (Espinosa et al. 2020)

The theory of the experiential learning cycle is cyclical and continuous: through the contact of specific experience, people use the process of reflection and observation to produce new principles and concepts, and then apply new concepts to new specific experiences (Li and Armstrong 2015).(Masse et al. 2019).

2.2. Problem-based learning (PBL)

Problem-Based Learning (PBL) is a teaching and learning methodology that uses situations or scenarios in a context close to reality (problems). This methodology is based on a constructivist approach where the student starts from an experience, abstracts the knowledge and can apply it to another similar situation. The implicit purpose of PBL is to use a situation (problem) that is capable of activating previous knowledge, while favoring the construction of knowledge. This real-life situation would serve as a trigger for students to meet learning goals(Shih 2008).

The typical cycle of Problem Based Learning (PBL), as shown in Figure 2, basically consists of:

Phase 1: problem restatement and identification,

Phase 2: peer teaching, synthesis of information, and formulation of solutions.

Phase 3: generalization, closure and reflection.

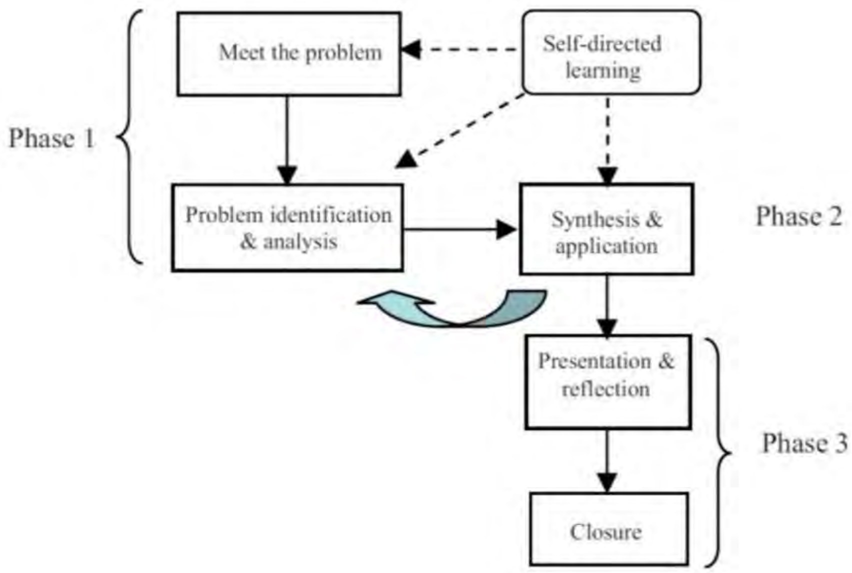

Figure 2. Typical Problem Based Learning cycle.
Source: (Mohd-yusof et al. 2011)

3. Methodology

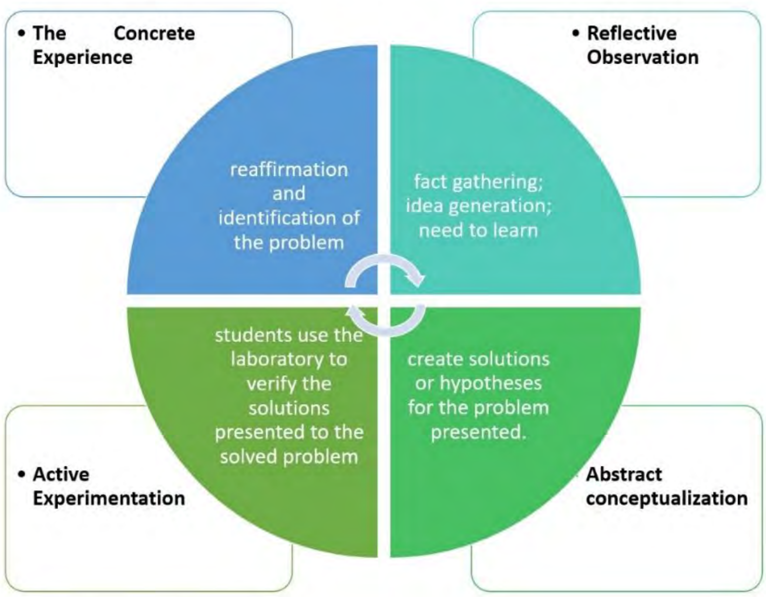

Figure 3. Integration of the problem-based methodology approach and Kolb's cyclical experiential model.

Several features of the problem-based learning approach and Kolb's cyclical experiential learning model have been integrated to create a new experiential model based on a hybrid system. Kolb's cyclical experiential learning model was reoriented, Figure 3 shows the model reoriented to fit the Problem Based Learning approach. With the reorientation of Kolb's cyclical experiential learning model, the four steps were aligned, reaffirmation and identification of the problem with concrete experience (step 1), reflective observation (step 2) with data collection; idea generation; need to learn, abstract conceptualization (step 3) with creating solutions or hypotheses for the presented problem, and finally active experimentation (step 4) with verification of the solution by the students through the laboratory bench and implementation of the proposed solution.

4. Results

4.1. Curriculum Context

The activities described in Figure 3 are applied in a required eighth semester Fundamentals of Control and Automation course of the Mechanical Engineering curriculum of the Universidad Francisco de Paula Santander Ocaña, the subject is a higher level design-based course dealing with modern technologies such as automation, programmable logic controllers (PLC), pneumatics and electro-pneumatics. The micro-curricular model of the course includes practical experiences that help to meet the following learning outcomes of the course:

RA1: Design logical-sequential automations through the use and programming of automatons.

RA2: Select the appropriate components in the physical interaction with the process to be automated.

RA3: Plan control strategies for industrial automation problems with different levels of complexity.

RA4: Develop diagrams that represent the characteristics and operation of the elements that make up the process to be automated.

In this study, we concentrate on experience with Programmable Logic Controllers. The laboratory exercises are developed for students to learn and improve their problem solving skills using known design situations.

4.2. programmable logic controller (PLC) laboratory

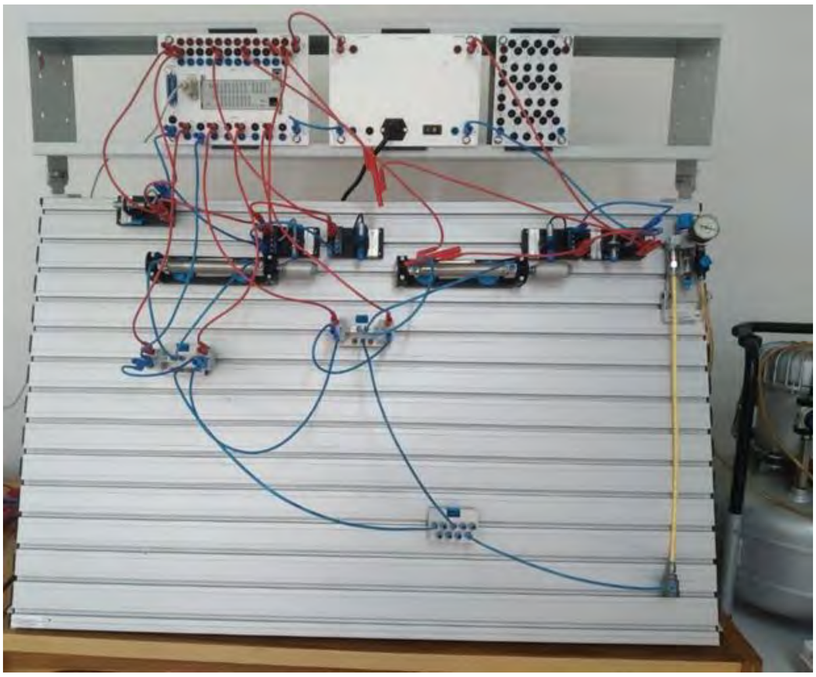

Figure 4. PLC Laboratory Experiment Bench

The Programmable Logic Controller (PLC) Laboratory is part of the Control and Automation Fundamentals course. Figure 4 shows the experiment bench of the PLC laboratory. The laboratory aims to introduce students to the principles of programming programmable logic controllers and to learn about and apply the technology (devices and software tools) used in industrial automation and control systems.

Although relatively simple in concept, the design applications can be quite complicated and complex. There are five lab practicals. One lab practical is used for students to effectively use the PLC graphical user interface and the PLC programming environment. The remaining four lab practicals are presented to learn how to design and assemble pneumatic and electro-pneumatic circuits.

4.3. PLC laboratory practice

In order for the student to learn the basic principles of programming programmable logic controllers, a laboratory guide called Practice 5 Programmable Logic Controllers (PLC) was used. The main objectives of the laboratory practice are described below:

- To know the structure and operation of PLCs.
- To identify the PLC programming languages.
- To connect the PLC to the computer.

In the procedure of the guide the student is asked to implement by means of the programmable logic controller (PLC), and by means of electro-pneumatic circuits the following sequence of Automation :

sequence A + B + A - B –

Figures 5 and 6 show the results of the practical implementation of the sequence on the Automation laboratory bench.

Figure 5. ladder language sequence

Figure 5 describes the sequence in Ladder language, for this the FESTO FC34 PLC module is used with the Festo electro-pneumatic bench, where it is programmed in FST and Figure 6 shows the operation of the sequence. With these practices it is intended that the student is strengthened in the knowledge of design and operation of automatic circuits.

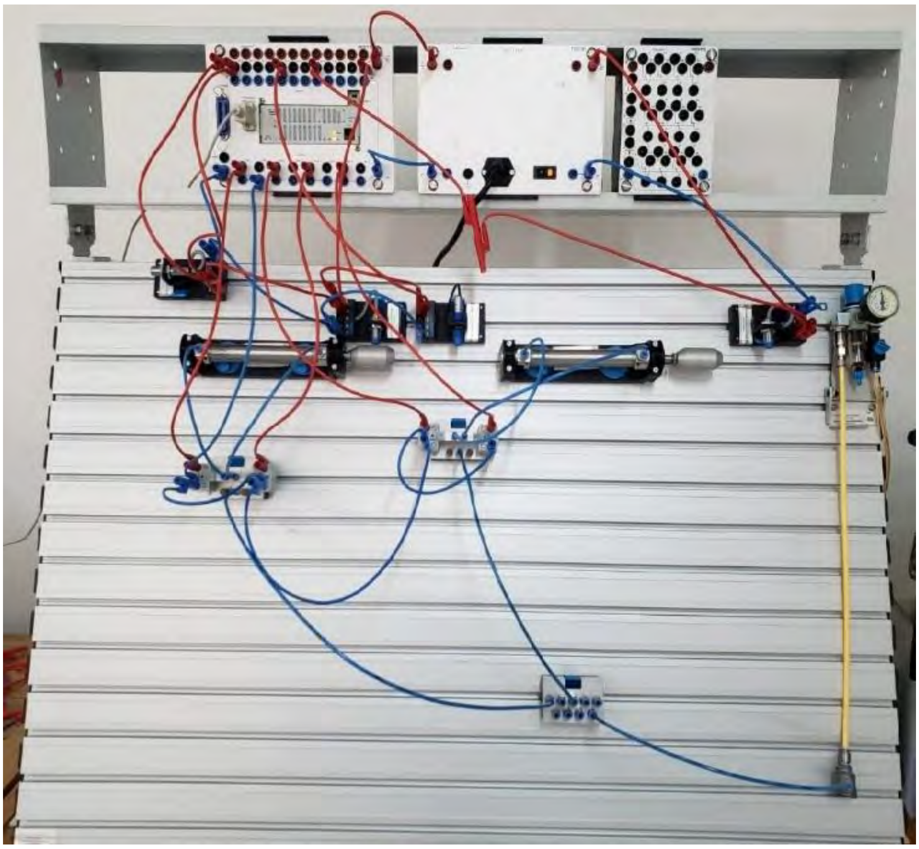

Figure 6. Assembly of the sequence on the test bench

4.4. Mixed methodology case study

4.4.1 Step 1

During the first classes, the importance of being able to automate an industrial process was highlighted. Theoretical and practical aspects of PLCs are then explained. In this way a "global vision" of the subject is obtained.

And as a case study, an industrial problem described below is presented in an exercise:

Electrolysis Process:

Process Description: The process consists of the treatment of surfaces, in order to make them resistant to oxidation. The system will consist of three baths:

- ✓ One for degreasing the parts.
- ✓ Another one for rinsing the parts.
- ✓ A third one where the electrolytic bath will be applied.

The crane will introduce the cage carrying the parts to be treated in each of the baths, starting with the degreasing bath, then the rinsing bath and finally it will give them the electrolytic bath; in the latter, the crane must remain for a certain time to achieve uniformity on the surface of the treated parts.

System components:

- A crane.

- A two-way motor for the horizontal movement of the crane.
- A two-way motor for the vertical movement of the crane.
- Six limit switches F2, F3, F4, F5, F6 and F7.
- One cycle start contact.

4.4.2 Step 2

In step 2 the students form groups of 3 people to solve the problem posed and as a complement to provide a solution, the elements of ladder logic are discussed, and the inputs and outputs of the circuit (switches, outputs and relays) are defined. Through other examples the student is helped to understand how a solution to the given problem could be proposed.

4.4.3 Step 3

In this step the students propose a solution to the problem posed in step 1 and develop it in this case in logo soft comfort V8 software, which has been previously explained in class, and use block diagram programming logic, as shown in Figure 7.

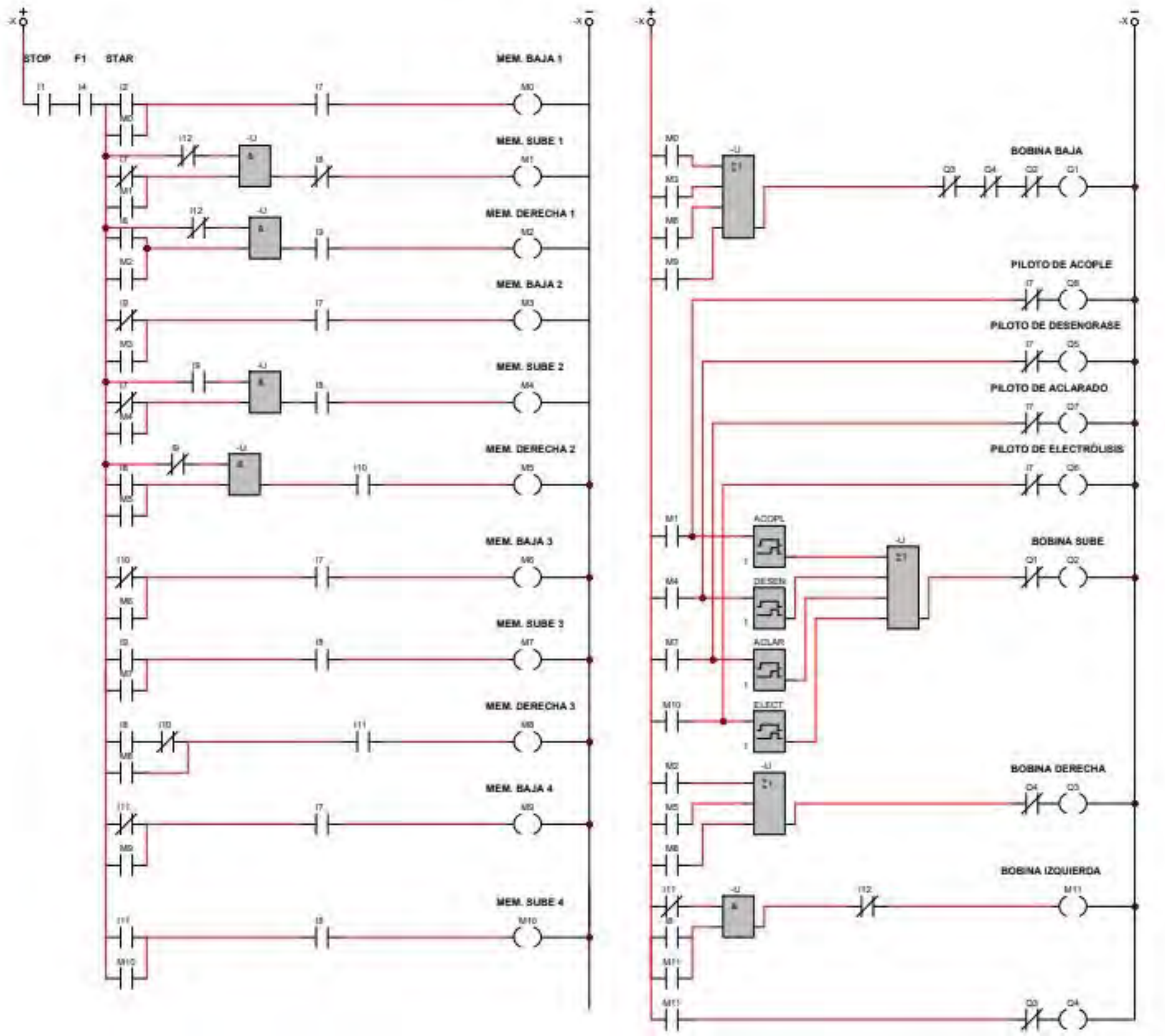

Figure 7. Ladder programming of the solution.

4.4.4 Step 4

In step 4, the solution is verified by the students through the implementation of the proposed solution. Figure 8 shows the siemens logo PLC already programmed and linked to the cade simu software to simulate the operation of the motors in the electrolysis process exercise.

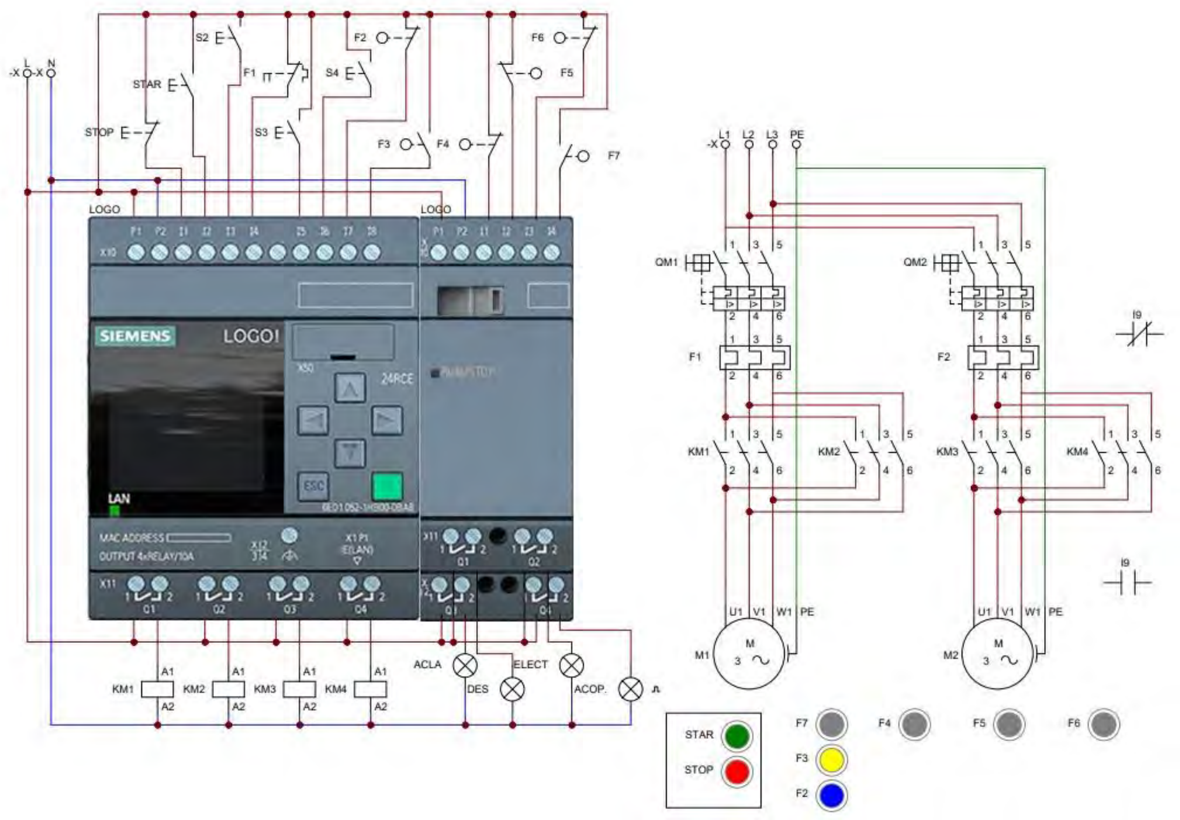

Figure 8. solution implementation

5. Conclusions

From the integration of the mixed methodology proposed in section 3 and the practices carried out in the Automation laboratory, the integration of experiential learning with problem-based learning was achieved.

In particular, the introduction of the simulation software in the preparation session prior to the hands-on laboratory practice has led to a considerable improvement in the students' conceptual understanding during the hands-on laboratory session. It also helped to reduce the cognitive load of the students.

With the proposed activities the students of the Fundamentals of Control and Automation course were able to consolidate knowledge and design techniques through the solution of problems and test the solutions both in simulation software and in the laboratory bench to solve problems within the social context, it is necessary the integration between methodologies and teaching-learning processes with specialized tools, which promote collaborative work that grant innovation through technological practices, and the generation of cognitive processes such as meaningful learning within the classroom, finally what is sought is to improve the educational practices enshrined within the educational micro curriculum based and through integrative problem solving.

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