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CADE SIMU AS A SIMULATION AND LEARNING TOOL FOR PROGRAMMABLE LOGIC CONTROLLERS

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ABSTRACT:

This document presents the CADE SIMU software as a tool for testing control and power schemes of electric motors manipulated from programmable logic controllers (PLC), it should be noted that the use of software simulators type in higher education help the future engineer to stage the real behavior of a system, In this case it is used in the subject of fundamentals of control and automation of the Mechanical Engineering program at the Universidad Francisco de Paula Santander Ocaña as part of the methodology is the use of simulation software as support for learning and solving cases in the area of Industrial automation, this software allows to explore, analyze, understand, correlate and experiment in the virtual world solutions that can later be applied to solve a real problem.

Keywords: SIMU CADE Simulator, programmable logic controllers, simulation.

INTRODUCTION

Today there is a need to improve pedagogical approaches in higher education with the use of new technologies in teaching that gradually replaces the traditional lecture-based teaching style with a more active teaching style in which students play a more active role in the learning process (Potkonjak et al. 2016). Active learning provides a powerful mechanism to enhance the depth of learning, increase retention of material, and engage students with the material rather than passively listening to a lecture.(Hamada 2007).

One of the challenges that Higher Education is pursuing, is to train autonomous students who innovate in the face of changing the changing needs of society.(López-Collazo and Pérez-Martínez 2020).

Simulation-based software is an "illustrative tool" widely used in student-centered learning methodologies(Feng and Rong 2005). It is an active learning technique, which stimulates a learner's diverse cognitive skills and understanding of a system by instantaneously staging the dynamic behavior of a real system(Bauer, Heitzmann, and Fischer 2022).

Simulators: These are devices, usually computerized, that allow the reproduction of a system. Many of them recreate sensations and/or experiences that may occur in reality (Aguayo et al. 2013). Applied to education, they are one of the most avant-garde tools and academic updating according to the advance of technology.(Carcaño Bringas 2021).

Simulations play a vital role in training learners to gain expertise in their profession and make challenging topics easy to understand. In both cases of simulation-based learning, learners are exposed to existing simulation models that are operated by the learner with small creative efforts to enhance domain-specific knowledge. While we recognize the educational value of such simulations, we argue that simulations are equally critical tools for providing learners with creative thinking skills in addition to exposing them to science, technology, engineering, and mathematics concepts.(Kavak et al. 2020).

Simulation software reduces the costs associated with conventional hands-on laboratories due to the equipment, space and maintenance personnel required. They also provide additional benefits, such as supporting distance learning, improving lab accessibility for the disabled, and increasing safety for hazardous experimentation (Heradio et al. 2016).

Simulation is a technique and a tool to investigate the behavior of different types of systems by analyzing their models. For example, when designing an industrial system using a programmable logic controller (PLC), we can examine what type of automation should be implemented to suit different factory and laboratory environments. This is where simulation software comes in and is an essential tool in the process of designing automation systems. In this article we used the CADE SIMU software which is a program used as a pedagogical tool, which allows to draw electrical, electronic and electrical schematics, to check the programming done in the PLC easily and quickly.

METHODOLOGY

The methodology used was that of the Experiential Learning Procedure for Simulation Projects proposed by (Müller, Menn, and Seliger 2017). It uses The procedure consisting of Kühn's simulation cycle in the center (Kühn 2006), surrounded by Kolb's experiential learning cycle,(Kolb, Rubin, and Mcintyre 1971).

Figure 1 shows the experiential learning procedure for carrying out industrial automation simulation projects.

During the modeling phase, the student has the concrete experience of building a simulation model. This includes the specification of the problem and the research objective, data collection and the creation of the initial digital model. After achieving a satisfactory simulation result, the results must be interpreted and evaluated with respect to a real-world application. Since the results are based on the simulation model, which is nothing more than an abstract representation of the real problem, the abstract conceptualization is trained by mentally transferring the results achieved with the simulation to reality. Once the improvement is specified, it can be applied in reality. Active experimentation refers to both implementing the improvement and operating with the implemented improvement.

The main benefit is to allow students to experience a simulation project. They have to collect data from a problem, build a digital simulation model, perform simulation experiments, evaluate the results, and finally reapply their improvements to the problem they are working on. Students experiment, for example, their assumptions during modeling, the degree of abstraction and validation have been appropriate.

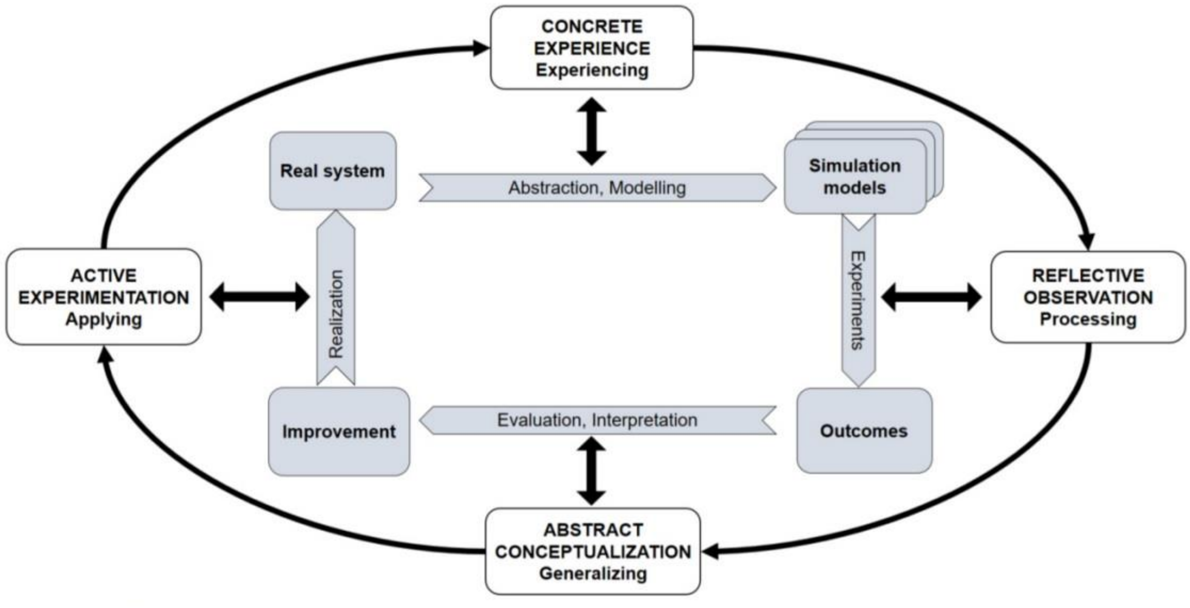

Figure 1. the experiential learning procedure for carrying out industrial automation simulation projects. (Müller et al. 2017)

RESULTS AND DISCUSSIONS

- **Software:**

CADE SIMU: is a free electrotechnical software that helps to create diagrams of electrical commands, through which it is possible to realize any type of electrical circuit (focused on electrical commands and also PLC and pneumatics), from direct motor starting with the help of soft starters and variable frequency drives. No installation is required, you just start with the executable file, which allows you to insert symbols found in libraries, draw a diagram and then perform the simulation of a given project. With an excellent proposal, CADE SIMU offers very useful resources through a simple, intuitive and free interface, besides being a very light software (about 5Mb) capable of simulating electrical control circuits: 1) Draw electrical command diagrams from scratch; 2) Perform simulations and understand an entire operation; and 3) Save, print and collect multiple electrical diagrams(Lima Filho et al. 2017) Figure 2 shows the main screen of the CADE SIMU software.

LOGO!Soft Comfort program:

In the automation era, industries need to be prepared with the best devices and equipment, with international quality standards. One of the most used solutions in this type of industries is the Programmable Logic Controller or PLC. It is, as its name suggests, a device capable of being programmed to perform various automation tasks customized as required.

Nowadays, there are several manufacturers of Programmable Logic Controllers dedicated to the improvement in the design of this high demand equipment. One of the leading developers in the market is SIEMENS, a specialist in the development of technological solutions and infrastructure. For Siemens, the PLC has been one of its main works, and today, it offers one of the most innovative solutions: LOGO!.

LOGO! Siemens is one of the most versatile solutions created by this company. It is a Programmable Logic Controller of very small size but great capacity. It stands out for its ability to integrate with industrial standard buses. Its small size does not limit it and it is capable of absorbing various automation tasks.

Figure 3 shows the main screen of the software.

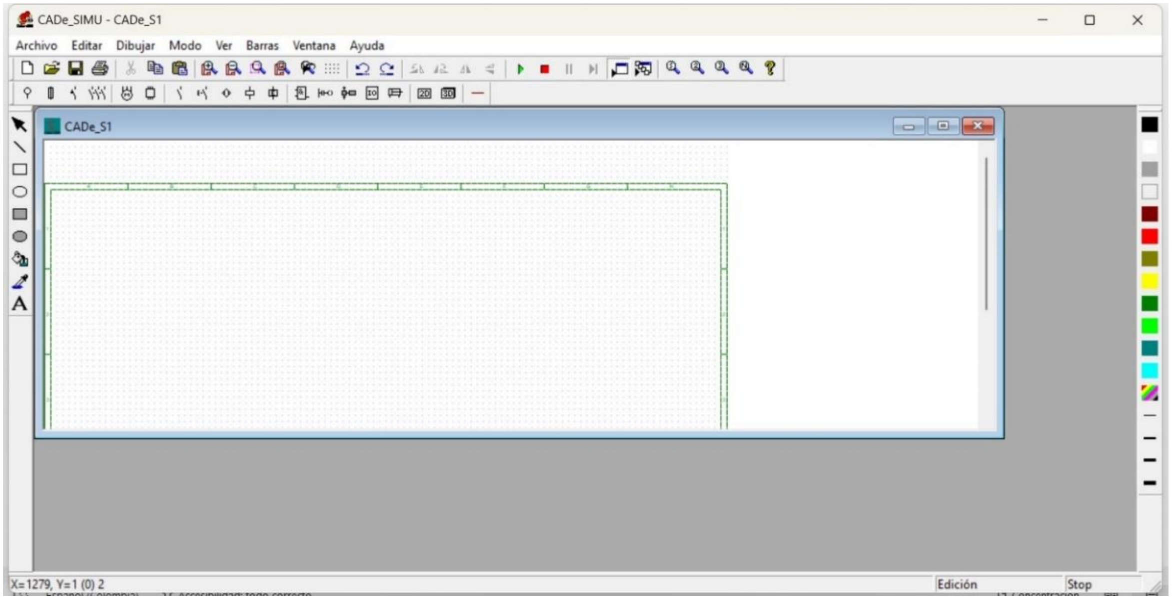

Figure 2. CaDe_SIMU software main screen

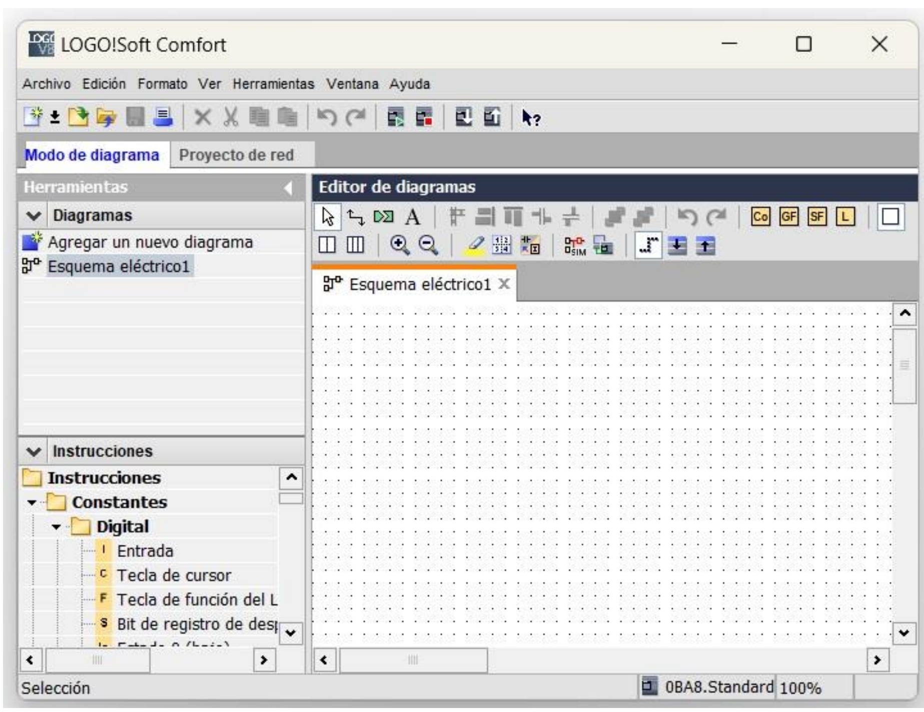

Figure 3. software LOGO! Soft Comfort

- **The teaching task and its articulation with the CADE SIMU simulator for learning programmable automatons**

The proposed methodology was used in a course of Fundamentals of Control and Automation for 22 students of Mechanical Engineering at the

University Francisco de Paula Santander Ocaña to teach the topic of programmable logic controllers using the simulation software CADE SIMU.

Objective: is that the students of the subject of fundamentals of automation and control can become familiar with the automation of industrial processes through the use of simulation software and thus can integrate several systems in the same automated system (fundamental objective of the career), in addition it is important that the student works with the most updated software on the market to international standards.

case study:

Electrolysis Process, 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.

Course of the exercise with students:

The 22 students were divided into groups of three, and to reinforce the subject, they were taught for two weeks the theoretical contents of programmable logic controllers, they were also taught how to use the logosoft and CADE SIMU software in the simulation parts based on practical cases. In this way, the students knew how to apply the software and the available functionalities.

Development of the case study exercise:

They proceeded to design the solution of the case study in the LOGO! Soft program, obtaining as a result the block diagram shown in Figure 4.

Simulation sequence:

START-F2-F3-F4-F2-F2-F3-F5-F2-F3-F6-F2(sustained)-F3-F7 START CYCLE WITH F2.

- Pressing the start button (i1) starts the sequence with the motor turning down (Q1).
- On reaching the F2 sensor (i2) the downward rotation is restarted and the upward rotation (Q2) is activated.
- When it detects F3(i3), it restarts the turn to go up (Q2) and activates the turn to go right (Q3) until it finds sensor F4(i4) to start the turn to go down (Q1), performs the degreasing immersion and goes up again, thus repeating the rinsing process with sensor F5(i5).
- When reaching the sensor F6(i6) the piece goes down to the sensor F2(i2) to start the counter and perform the electrolytic process for the example was used 4 seconds, finish the timer starts to rotate to go up, and when reaching F3(i3) the left turn is activated (Q4) to find the sensor F7(i7) to start the cycle.
- Finally, the Cycle Start counter is activated, when the sensor F7(i7) is activated, and the sequence starts again.

After designing the solution in the logo soft program, the next step was to evaluate its performance using the CADE SIMU software, as shown in Figure 5.

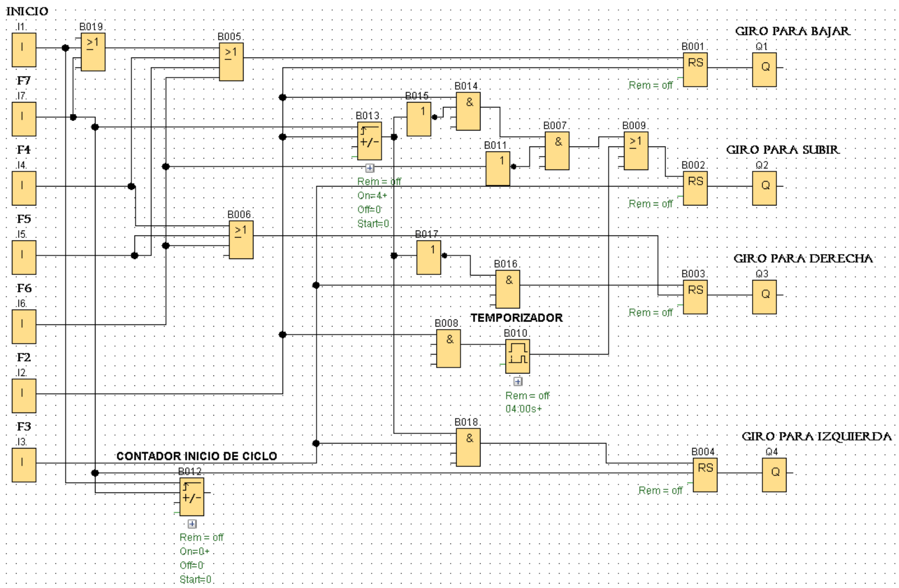

Figure 4. block diagram of the case study solution

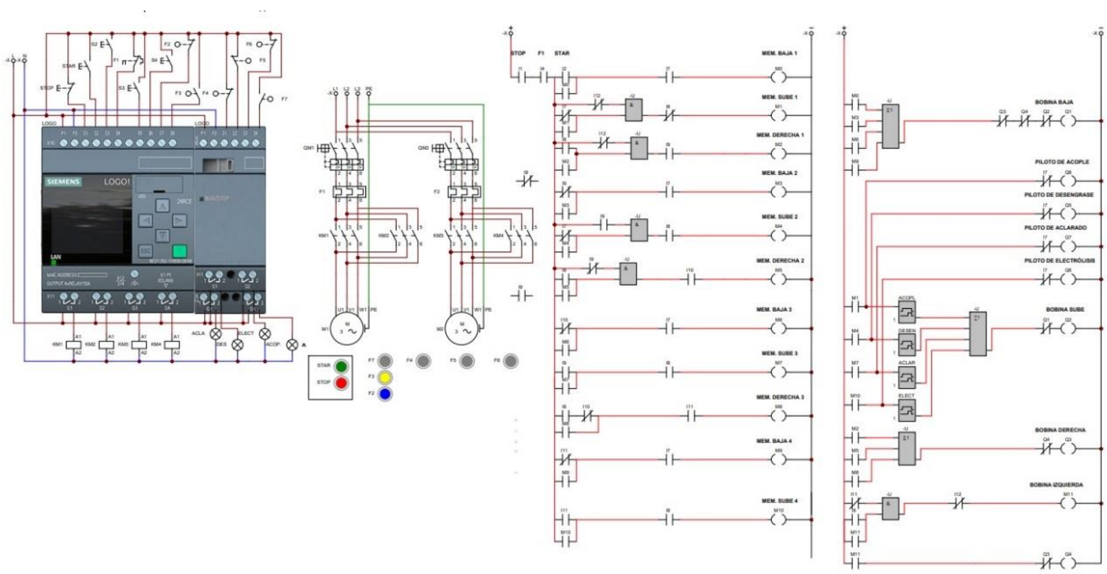

Figure 5. testing with the cade Simu software

Evaluation of subject results

The outcome of the subject has been evaluated using two approaches. In the first approach, the evaluation is based on the students' academic performance approach and the application of knowledge is evaluated after completing the project in its respective assignment and the performance indicators described in Table 1 are used.

In a second approach, the results of the university evaluation of teaching at the end of the course indicate the following assessment: This activity has created a simulation where it replicates the solution to a real problem in an industrial environment as can be seen in Figure 5

Table 1. performance indicators of the subject

	Performance Indicators				
Evaluation criteria	**Lower Level** **0-<60%**	**Low Level** **60%-<70%**	**Medium Level70%-<80%**	**High Level** **80%-<90%**	**Higher Level** **90%-≤100%**
RA3: Analyze dynamic system models using computational tools to simulate their behavior and technical characteristics.	Student: - Does not perform the modeling of the proposed system. - Does not perform the simulations of the models of the proposed system in different specialized software - Does not perform an analysis of the models of the proposed system.	The student: - Performs modeling of the proposed system. - Does not perform the simulations of the models of the proposed system in different specialized software - Does not perform an analysis of the models of the proposed system.	The student: - Performs modeling of the proposed system. - Performs the simulations of the models of the proposed system in different specialized software - Does not perform an analysis of the models of the proposed system.	The student: - Performs modeling of the proposed system. - Performs the simulations of the models of the proposed system in the different specialized softwares -Performs an analysis of the models of the proposed system.	The student: - Performs modeling of the proposed system. - Performs the simulations of the models of the proposed system in different specialized softwares -Performs an analysis of the models of the proposed system Identifying its technical characteristics.

CONCLUSIONS

The purpose of this article is to share the experience and approach in teaching simulation software-based learning. In the classes, the basic concepts of PLC hardware, PLC programming and PLC interfacing with models were covered. Then, students were expected to gain the competency to develop an industrial problem using simulation software such as CADE SIMU based on the topics covered in the course.

Simulation helps the user to understand the system behavior and develop alternatives in a safe digital environment. To help increase learning productivity, an experiential learning procedure has been developed. The simulation cycle has been harmonized with the experiential learning cycle. The procedure has been applied to the subject of fundamentals of control and automation. The simulation cycle describes the workflow of a simulation project. The experiential learning cycle shows how people learn, based on their experiences.

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