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CHAPTER 48

Simulation as a tool of active flipped classroom methodology: A didactic form of application for the discipline of control in the teaching of Electrical and Electronic Engineering at UEA

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ABSTRACT

The improvement of practical activities in engineering courses has become currently an objective of higher education centers. In the present work, the authors present the results obtained from the application of simulation as a tool of active teaching methodology in the discipline of Control Systems in the courses of Electrical and Electronic Engineering of the School of Technology of the University of the State of Amazonas. It is a matter of introducing in the practical components of the discipline the latest guidelines of the National Curriculum Guidelines, DNC, which support the improvement of the didactic ways of teaching the contents, linking them to ensure a greater number of practical experiences and individual work, to encourage more expressive results in the acquisition of knowledge with the use of new technologies. In the case of the active flipped classroom methodology, applied in the work, it allowed us to advance in multidisciplinary integration processes and new laboratory practices in the context of the discipline.

Keywords: Active methodologies, Didactic form, Apprenticeship, Simulation.

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INTRODUCTION

With the rapid improvement of computational resources and the arrival of industry 4.0, the investment in the knowledge and design of control systems for a wide variety of industrial operations has increased significantly, allowing new algorithms and more elaborate strategies to be implemented, but due to the great diversity of processes and industrial policy issues, These improvements were not widespread in all plants.

In the northern part of Brazil is Manaus, **"the capital of the state of Amazonas**, [...] **The city is one of the most populous in the country** and the main one in its region. It plays an important role as the economic center of that area, since it concentrates large industries from various productive sectors in the Manaus Free Trade Zone (ZFM)" (GUITARRARA, 2021, *emphasis added*). In this context, nowadays for the technological updating of industries, there is a need for prepared professionals capable of following the new challenges of the implementation of new technologies, being fundamentally those in the control area because the values of the production indicators depend on the degree of control of their processes. The absence of effective, safe methods and automated control systems leads to a decrease in production and low efficiency. All this has been an opportunity to work on raising the quality of professionals in the training process through the use of active teaching methodologies (MAMEDE, 2001) to raise the levels of knowledge through the disciplines in engineering courses, such as the disciplines of Control Systems in Electrical and Electronic Engineering courses, existing today at the School of Technology of the University of the State of Amazonas.

Active methodologies are among the didactic forms that today allow the increase of students' practical and theoretical knowledge in the disciplines of different forms of study, including engineering. Resolution No. 1, of March 26, 2021 of the Ministry of Education, which updated the National Curriculum Guidelines for the Undergraduate Engineering Course in its article § 5, section II, highlights as new tools for the acquisition of knowledge the following: "[...] experimentation in laboratories, elaboration of models, use of computers, consultation of libraries and databases", (SEMESP, 2021). In this aspect, according to Thuinie and Fragelli (2020), they argue that: "[...] Active methodologies constitute a pedagogical alternative capable of developing competencies and skills desired in a society in intense transformation".

Thus, the objective of the present work has been to use simulation as a component tool of the active flipped classroom methodology, which as a didactic form is applied in a task of the control discipline in the teaching of Electrical and Electronic Engineering at the University of the State of Amazonas, UEA.

METHODOLOGICAL ANALYSIS FOR THE APPLICATION

The disciplines of Control Systems 1 and 2 belong to the curriculum of the Electrical Engineering course, being equivalent to the first part with the discipline of Control and Servomechanism of the Electronic Engineering course. In general, its objective is to allow students to know the main characteristics of the systems, their modeling and simulation for the design through projects of control strategies that allow optimizing the behavior of the output variables of the systems.

The active methodology used in this work was the flipped classroom, using as a tool the development of virtual laboratories in the selected discipline, according to the methodology proposed in the work of Guzmán et al (2021), individually using computer technologies, from the proposal of a modeling, simulation and control question to be solved and then sharing their experiences with the whole class, This allows the integration of knowledge received in different disciplines and their socialization, now using it to solve an objective of a specific content of the discipline, which are linked to the learning objectives and the main ones of the year.

To apply active learning methods in the course, it is necessary to select the theme and content to be worked on. This makes it possible to implement a methodology that presents each of the activities to be performed in a hierarchical sequence, which is reflected in the items shown in Figure 1.

Figure 1. Organizational chart of activities for the implementation of the active methodology in the discipline of Control Systems.

Source: Authors.

The **learning objective of** the proposed problem would be: To design from modeling and simulation the position and speed control of a conveyor belt of electronic boards in an industry of the industrial pole of Manaus, Figure 2, using computational technologies; The **learning goals:** From the selection and design of the control strategy that involves the choice of the object, In this case, the treadmill selects and analyzes the variables in order to design and implement them in a simulator

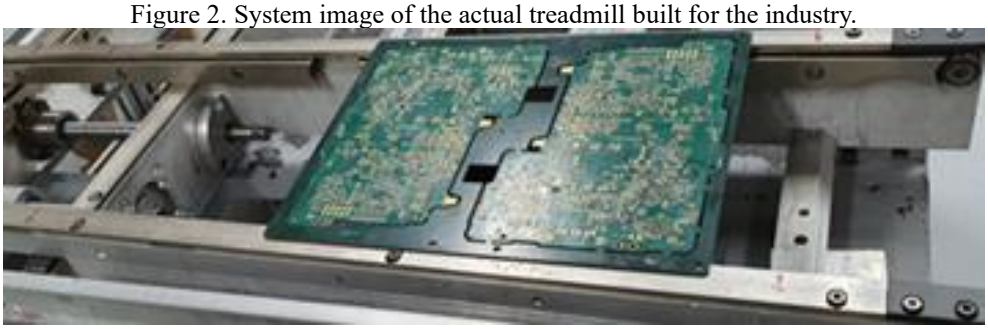
program and describe the elements that make up the control loop, analyzing their performance and characteristics. The **skills** would be to select, analyze, choose variables to manipulate, model, simulate, **and competencies** would be marked in reflecting, interpreting, doing and reasoning.

The format of the activities: Once the virtual laboratory is completed, following the methodology of Guzmán et al (2021), individually present the report that includes the models of the control loop, the design of the scheme in the simulator program and all the graphs of temporal responses to changes in the manipulated variables and the possible disturbances, which can be developed in the Matlab®/Simulink® program, (MATHWORKS, 2024), explaining and demonstrating through the results that the design made is robust to be implemented. The construction of the activity is autonomous.

RESULTS AND DISCUSSION

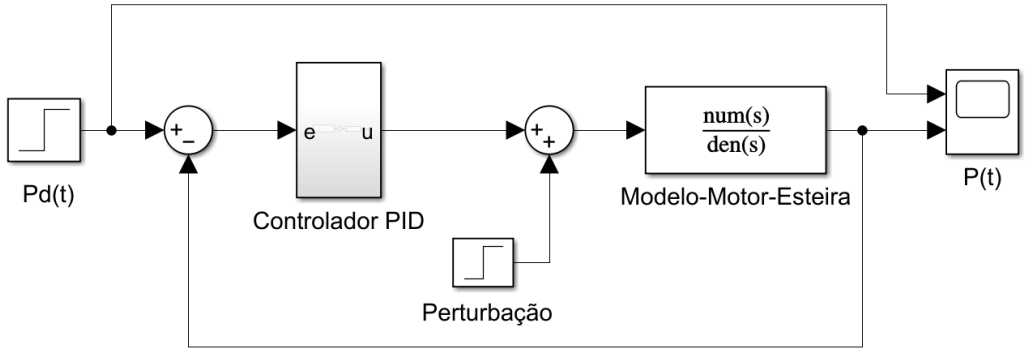
The **evaluation activity** starts from the presentation of the results, which happens individually with the use of the computational resources available in the presence of the whole group, the student has to explain and justify: How was the object chosen?; How was the modeling of the conveyor system (including drive elements and the AC motor) obtained?; What are the main components of the control loop?, Figure 2; How was the design and choice of the controller?; How was the choice and positioning of the sensor to ensure the stop of the belt at the P(t) position, having as reference the desired position of the stop point of the P(t) belt, Figure 4, so that the electronic component is inserted exactly by the robotic manipulator mechanism?.

Figure 2. System image of the actual treadmill built for the industry.



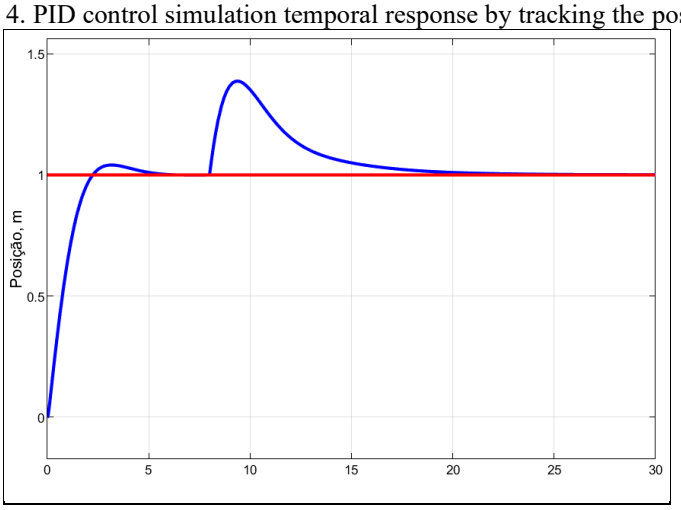
Source: Authors, 2024.

Figure 3. Simulation scheme of the conveyor system with PID control.



Source: Authors, 2024. Matlab®/Simulink®, 2024a.

Figure 4. PID control simulation temporal response by tracking the position.



Fonte: Autores, 2024. Matlab®/Simulink®, 2024a.

In the last part of the presentation and evaluation stage, a chart can be drawn to reflect the individual evaluation, starting from the concepts that the teacher considers important that complement the learning objectives outlined at the beginning of the task.

Table 1. Evaluative summary of the task on the position control of an industrial conveyor belt of electronic boards with AC motor.

	Evaluation of the Report				**Presentation**	**AF**
Items	**Simulation Schematic Design**	**Execution of the virtual lab walkthrough**	**Presentation of the results obtained**	**Interpretation of results**	**Presentation and answers to teacher or group questions**	**S 10,0**
Name/P.	**x 0.2**	**x 0.3**	**x 0.2**	**x 0.2**	**x 0.1**	**-**

Source: Authors.

CONCLUSION

The results obtained using the simulation tools demonstrate the possibility of using it in practical activities of the control disciplines as part of active methodologies, as was the case of the flipped class, through the realization of virtual laboratories previously designed and programmed

with a step-by-step guide of realization in the disciplines of Control Systems, which provides practical knowledge to the students, thus allowing to increase the technical and professional development individual, at first, sharing after their experiences in their team or group. This has made it possible to integrate knowledge from other disciplines such as Calculus, Programming, Physics, Portuguese Language and Drawing into a single task.

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