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PROPOSAL FOR THE IMPLEMENTATION OF LEARNING OUTCOMES IN THE MODULE OF STUDY AND MODELING OF MECHANICAL SYSTEMS OF THE SPECIALIZATION IN INDUSTRIAL AUTOMATION

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ABSTRACT

This document focuses on the evaluation of the competencies and learning outcomes applied in the module of Study and modeling of mechanical systems of the specialization in industrial automation of the Universidad Francisco de Paula Santander Ocaña based on pedagogies such as group work and simulation software. The purpose is that the specialists in industrial automation acquire the competencies assigned to each module when designing the learning outcomes of the program.

For the evaluation of the competencies and learning outcomes, guides, evaluation rubrics, the course planner and the micro-curriculum of the subject designed for each module were used in order to establish a plan for the diagnosis and fulfillment of the criteria of the learning outcomes process, in order to guarantee the academic quality according to the Colombian legislation models.

Keywords: evaluation of learning results, rubrics, laboratory guides, programmable logic controllers.

INTRODUCTION

Within the framework of quality assurance in higher education, it is essential to continuously improve the teaching-learning process in the subjects of the study programs (Dasso Vassallo and Evaristo Chiyong 2020). This improvement involves a redesign of the programs of the subjects where the learning outcomes, graduation profile and Institutional Educational Model play an important role in this process of student-centered teaching and learning(Avagliano and Vega 2013).

In this regard, one of the important challenges that teachers must meet is the incorporation of active methodologies and more participatory evaluation that adequately favor the achievement of the learning outcomes of their students as the main protagonists of their own training in the field of higher education(Boud 2020),(Abella García et al. 2020).

Learning outcomes are a standard specification of knowledge, skills and abilities that a student is expected to acquire by attending a course or degree program (Fontalvo, Delahoz-Dominguez, and De la Hoz 2022),(Nieto Ortiz and Cacheiro González 2021).

If aligned the learning outcomes guide instruction to adjust teaching strategies, learning activities (practice) and assessments as shown in Figure 1.

In the field of education in the specialization in Industrial Automation, the learning outcomes of the students are related to the professional competencies towards which the program is oriented. Competence is the result of the formative process received, which integrates knowledge, abilities, skills, dispositions, aptitudes, values and attitudes that make it possible to understand and analyze problems or situations, and to act coherently and effectively.

Evaluation is important to improve the quality of the content taught during the modules and to obtain feedback that the teacher can use as input for future changes and improvements to the course material. The quality of teaching can be measured in several ways by applying many different criteria. Some criteria, such as course structure, teaching materials, practical relevance and connections between lectures and tutorials.(Rothe, Winzker, and Salega 2019).

the evaluation and monitoring of learning outcomes are a continuous process that seeks to assess the achievement of the competencies established through levels of difficulty; in this perspective, evaluation criteria are required that include the achievement of competencies according to levels of difficulty, in order to be able to plan and improve their development in the learning that the student carries out throughout the training project at the university.(Paz 2022)

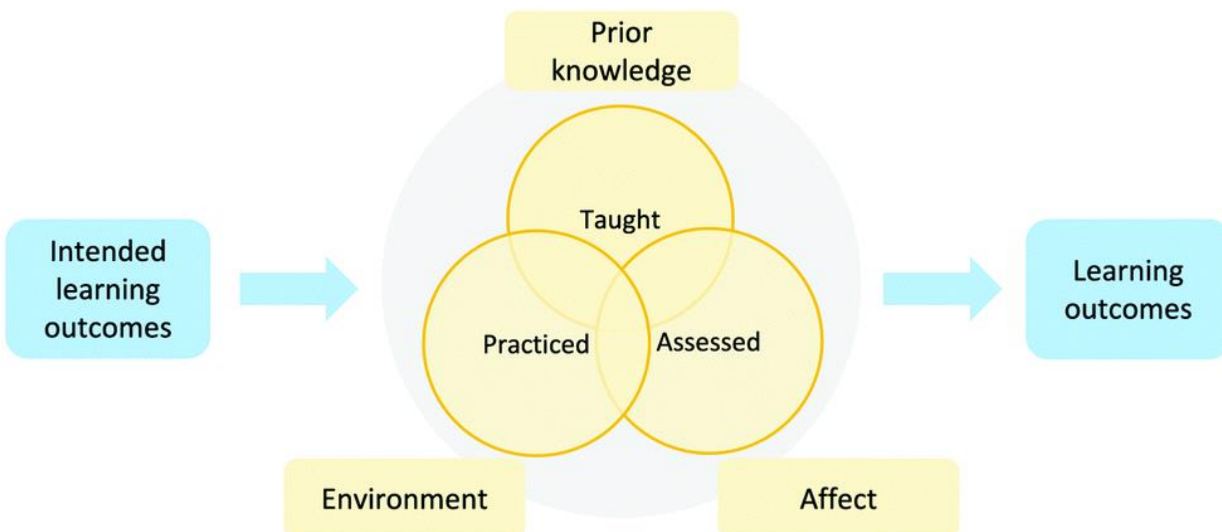

Figure 1. alignment of learning outcomes(Carle and Flynn 2020).

METHODOLOGY

The methodology used to propose the learning outcomes of the industrial automation specialization program was adapted from the institutional policy of the Universidad Francisco de Paula Santander that was approved by agreement No. 22 of May 27, 2021, on learning outcomes, which has an Institutional Plan for the Identification, Definition, Implementation, Monitoring and Evaluation of Learning Outcomes. Described in (Andrea et al. 2022).

After proposing the learning outcomes of the program from the curriculum committee of the specialization in industrial automation, it is analyzed in which modules each learning outcome can be met in order to contribute to the graduate profile for this from the University Francisco de Paula Santander Ocaña an implementation, monitoring and evaluation policy is proposed.

For the implementation stage, each teacher focused on the micro curricular redesign, in developing guides and evaluation rubrics depending on the methodologies in the module to achieve the learning outcome assigned to the subject.

For the monitoring and evaluation stage of the learning outcomes of the industrial automation specialization program, a space was created in the Univirtual platform of the Universidad Francisco de Paula Santander Ocaña with the purpose that the team of the academic sub-direction of the university and the curricular committee of the specialization could evidence the compliance and implementation of the learning outcomes in each module of the specialization as shown in figure 2. On this page you will find the regulations and forms established by the university for compliance as shown in figure 3. The university proposed a template for the micro-curricular model format, a guide for the subject planner, and a template for the evaluation guide and rubric; the other formats were used to create the program's graduate profile and learning outcomes.

Figure 2. Page for the learning outcomes of the specialization in industrial automation

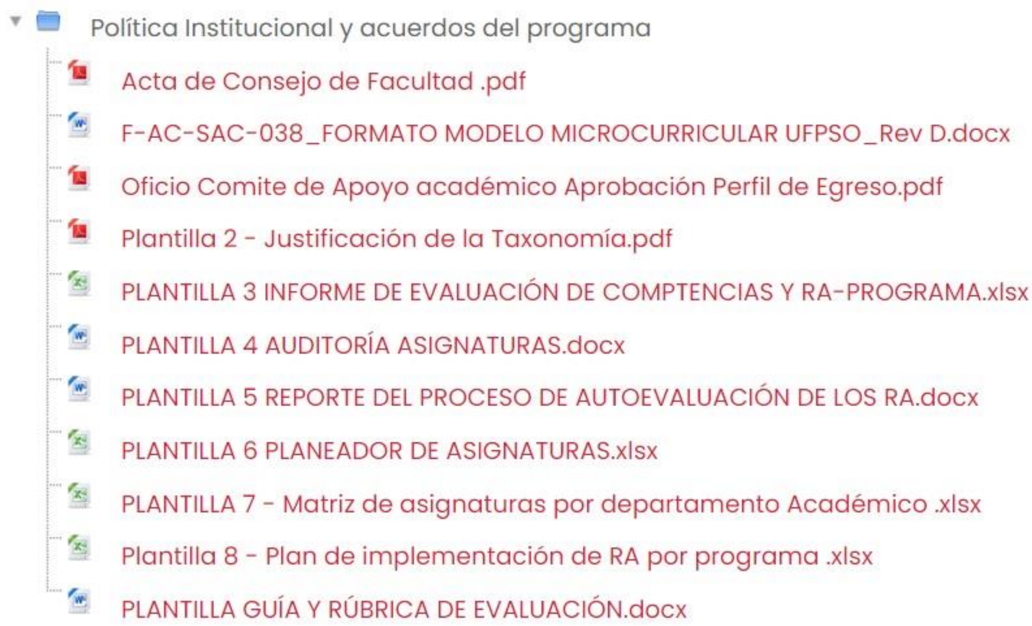

Figure 3. regulations and formats established by the university.

RESULTS AND DISCUSSIONS

- **Case Study: MECHANICAL SYSTEMS MODELING AND STUDY MODULE**

Module Justification:

The module of Study and Modeling of Mechanical Systems deals with the construction of mathematical models for computer simulation useful in the field of process control. The models are formulated by applying the basic principles of physics. The modeling of electrical, mechanical, thermal, hydraulic, chemical and thermodynamic systems is discussed, highlighting the analogies existing between the physical laws in the different domains. The models are described by means of differential equations, algebraic equations and discrete events.

The module of study and modeling of mechanical systems contributes to the graduate's profile by enabling him/her to:

(a) Apply the concepts and methodology of networks to obtain mathematical models of mechanical systems and at the same time develop an abstraction capacity regarding the analysis of these systems.

b) Analyze the importance of the systems through the use of the fundamental concepts of the physical and mathematical disciplines.

Training Objective(s)

The purpose of this module is to provide the Industrial Automation specialist with the ability to analyze the behavior of continuous and discrete linear dynamic systems in time. Especially in the modeling of physical mechanical, thermal, hydraulic and electrical systems that allow him/her to optimize the systems.

Module learning outcomes

For the construction of the learning outcomes it is necessary to start from the professional profile. For this purpose, we start from the professional profile of the Specialization Program in Industrial Automation of the Universidad Francisco de Paula Santander Ocaña, described in(Andrea et al. 2022).

The Universidad Francisco de Paula Santander Ocaña through the academic subdirection creates a micro curricular template model where a description of the subject is made, which for the case study is described in the justification section of the module.

Table 1 shows the learning outcome to be developed in the STUDY AND MODELING OF MECHANICAL SYSTEMS module associated with each content.

The learning outcomes of the module are as follows:

RA1: Study the concepts and tools of mathematical modeling and computational simulation of different mechanical systems.

RA2: Develop mathematical models involving complex situations, based on the analysis of systems and processes.

RA3: Analyze dynamic system models using computational tools to simulate their behavior and technical characteristics.

Learning strategies for face-to-face classes:

● LECTURE LESSON: Exposure of contents through presentation or explanation by the professor.

● LECTURE-WRITING STRATEGIES: Activities such as: workshop, literature review, preparation of laboratory reports, basic reading.

● VISUAL OR PRACTICAL STRATEGIES: Laboratory practices, videos on the subject, presentations and presentation of work.

● PROBLEM-BASED LEARNING: Problems and solutions: Develop mathematical engineering problems that may arise, derived from the master class.

● GROUP WORK: Supervised session where students work in groups and receive assistance and guidance when needed.

Table 1. Learning outcomes with associated content

Thematic unit	**Themes, concepts or problems addressed by the course**	**RA 1**	**RA 2**	**RA 3**
Dynamic and static systems	1.1. Introduction to dynamic and static systems 1.2. Elements of dynamic systems 1.3. Types of dynamic systems	x		
Mathematical modeling of dynamic systems	2.1. Linear and nonlinear systems 2.2. Transfer function 2.3. Electrical and electronic systems 2.4. State space modeling	x	x	
Identification of dynamic systems	3.1. Models used in the identification of dynamical systems 3.2. Non-parametric models (impulsional and frequency response) 3.3. Parametric models (transfer function model, ARX, ARMAX) 3.4. Estimation of time and frequency response			x
Systems analysis	4.1. Translational and rotational mechanical systems 4.2. 4.2. Electrical systems			x

	4.3. Hydraulic systems 4.4. Thermal systems			

Assessment of learning outcomes through rubrics and MOODLE-type tools.

Evidently, it is insufficient to propose and structure the learning outcomes (with the respective scenarios, indicators and evidence) for the competencies of each academic area, if there is no evaluation that demonstrates scenarios, indicators and evidences) for the competencies of each academic space, if there is no evaluation that demonstrates the fulfillment of the results.

In this case study to assess learning outcome RA1 y RA2 we used an assessment guide and rubric which contains the following:

General Observations:

- For the realization of this activity the student is asked to have an adequate attitude, availability and order with respect to the exercise.
- The student is asked to be available in order to perform the exercise correctly and that there are no problems with respect to cancellation.
- For the report the student is asked to perform the activities in order during the exercise.
- Initially, it is recommended that the student read and analyze the exercises to be evaluated and start with the one that is easiest to interpret.
- In this activity, an exercise is proposed to evaluate the course theme oriented in class.
- The activity must be delivered through the Moodle platform in the activity area in "Final Activity".
- The activity is developed individually and its delivery is on May 13 until 23:59 pm.
- Evidence of the use of the computational tool must be attached.

A detailed description of each of the proposed activities is presented below:

a. To describe the differential equations of the mathematical model of the system, we must start from a balance of all the forces acting on each of the bodies, keeping in mind that it is a dynamic system, the free body diagram of each of the masses (1 and 2) helps to have the perception of the relationship that exists between them. Each of the forces is directly related to a first or second order derivative which leads us to express a differential equation for each body, which is the objective of this first section of the activity.

b. Being a system that has one input and two outputs, it must be taken into account that the result of this activity are two transfer functions for each of the positions x1 and x2 (outputs). To solve this part, the starting point are the dynamic equations of the behavior of the system obtained previously; correctly applying the Laplace transform we arrive at a system of equations 2x2 that is solved by applying a basic mathematical method of substitution and then the correct factorization and simplification is performed.

c. Making use of the transfer functions we can obtain the block diagram. Using the common input for both functions this system is schematized showing the respective outputs of the system.

d. The state space equation is a matrix form that represents the complete system. It begins by transforming the differential equations found in the development of the activity, taking these to show the four states they represent, in an orderly manner we express a 4x4 system of equations that will give us the coefficients that have each of the variables involved to subsequently form the matrix system that is the representation of the system in state space. Thus, we arrive to the solution of this subsection.

e. In this case we start by defining in the command window of the Matlab computational tool each of the conditions given for the system As shown in figure 4.

After this, the Matlab Toolbox to be used to verify the correspondence of the system is opened: Simulink. Using the respective libraries, the system must be schematized in block diagram taking into account the transfer functions found.

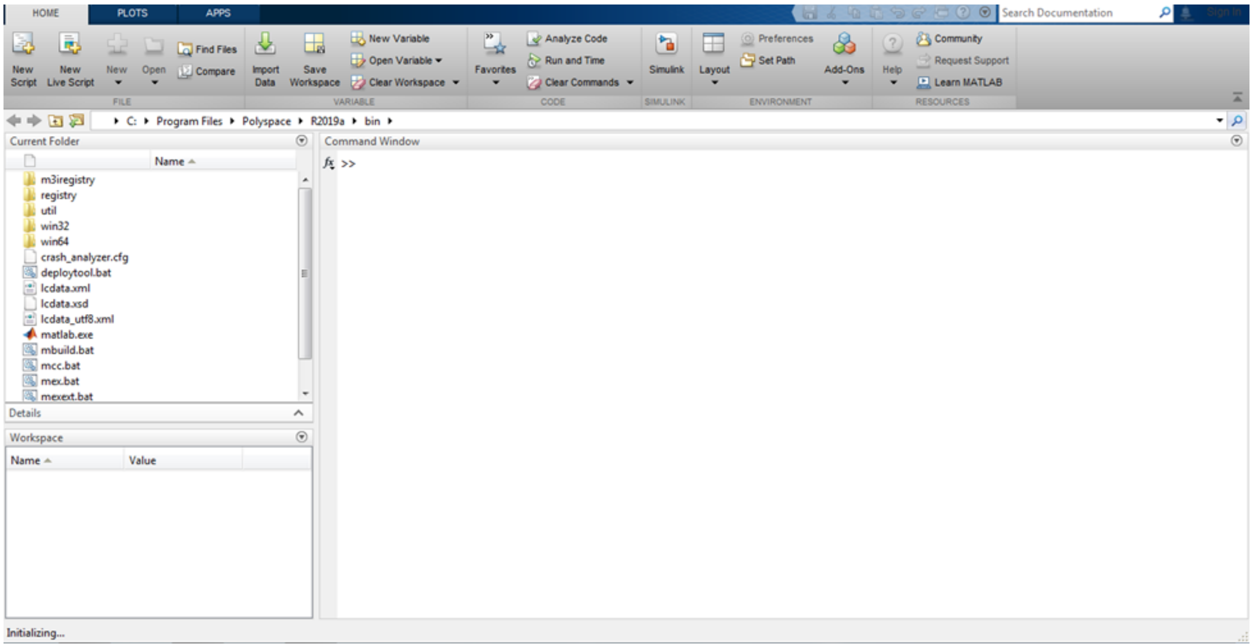

Figure 4. Matlab command screen

Evaluation Content

From the mechanical system of the following figure 5.

a. (1.0) Obtain the differential equations describing its mathematical model.

b. (1.0) Obtain the transfer function of the positions x1 and x2 with respect to the input of this system (2 FT).

c. (1.0) Obtain the block diagram representation of the total system.

d. (1.0) Obtain its state space representation.

e. (1.0) Verify the correspondence of the previous representations (block diagram, transfer function and state space) according to the results with the help of Matlab Simulink by means of its (equal) behavior in front of a unit pulse train signal (m1=1, m2=2, k1=k2= k3=1, b1= b2 =0.5, f=u=1).

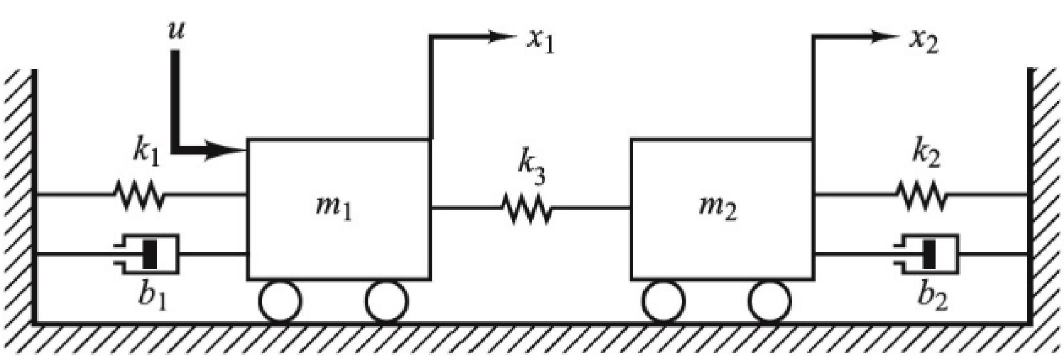

Figure 5. case study exercise

Table 2 shows the evaluation rubric applied to the student, the grade is applied according to how each point proposed in the exercise is fulfilled.

Table 2. evaluation rubric

	Performance Indicators				
Evaluation criteria	**Lower Level** **0-<60%**	**Low Level** **60%-<70%**	**Medium Level** **70%-<80%**	**High Level** **80%-<90%**	**Higher Level** **90%-≤100%**
RA1: Study the concepts and tools of mathematical modeling and computational simulation of different mechanical systems. RA2: Develop mathematical models involving complex situations, based on the analysis of systems and processes.	The student does not present the solution to any or the first point raised in the work.	There is no evidence of interest in the search and organization of the activity to be developed, reflected in the little participation and inquiry on the topic. The student does not present the results proposed in the development of the activities.	The student uses basic information for the development of the activity, showing a slight interest. There is little evidence of mastery in the use of materials and elements for the development of the activities. The student presents brief results that give a moderate answer to the explanation of the phenomenon under study.	The student shows interest, investigates and approaches the phenomenon under study, using accurate and adequate information for the solution of the case. Students present results, analysis, conclusions or models that allow the explanation of the phenomenon under study.	The student analyzes, studies and learns all the subject matter projecting a high knowledge in the subject, and also great capacity in the handling of the equipment. Within the delivery of the work, it is evident that the student presents greater requirements than those requested, standing out in the effective fulfillment.

CONCLUSIONS

Current trends in competency assessment and Learning Outcomes in higher education require the balanced integration of a number of perspectives, factors and actors involved in this phase of the training process.

Through this study, we proposed three essential learning outcomes for the subject of STUDY AND MODELING OF MECHANICAL SYSTEMS, designed based on key concepts related to the mathematical modeling of dynamic systems and to the computational analysis of these systems. The identification of learning outcomes can help align curricular and instructional practices, including assessment.

through this study an evaluation guide and rubric was proposed as a case study to evaluate the learning outcome RA1 and RA2 of the module, the performance indicators for obtaining the evaluation result are also described.

REFERENCES

[1] Abella García, Víctor, Vanesa Ausín Villaverde, Vanesa Delgado Benito, and Raquel Casado Muñoz. 2020. "Aprendizaje Basado En Proyectos y Estrategias de Evaluación Formativas: Percepción de Los Estudiantes Universitarios." *Revista Iberoamericana de Evaluación Educativa* 13(1):93. doi: 10.15366/riee2020.13.1.004.

[2] Andrea, July, Gómez Camperos, Haidee Yulady Jaramillo, and Sir Alexci. 2022. "Contexts And Strategies For The Implementation Of Learning Outcomes In The Industrial Automation Specialization Program At Ufps Ocaña." *Webology* 19(5):570–80.

[3] Avagliano, Alessandro R., and Sylvana A. Vega. 2013. "Mejora Del Proceso de Enseñanza y Aprendizaje En La Carrera de Ingeniería de Ejecución Mecánica. Diseño Micro-Curricular Basado En Resultados de Aprendizaje." *Formacion Universitaria* 6(4):3–12. doi: 10.4067/S0718-50062013000400002.

[4] Boud, David. 2020. "Retos En La Reforma de La Evaluación En Educación Superior: Una Mirada Desde La Lejanía." *RELIEVE - Revista Electrónica de Investigación y Evaluación Educativa* 26(1). doi: 10.7203/relieve.26.1.17088.

[5] Carle, Myriam S., and Alison B. Flynn. 2020. "Essential Learning Outcomes for Delocalization (Resonance) Concepts: How Are They Taught, Practiced, and Assessed in Organic Chemistry?" *Chemistry Education Research and Practice* 21(2):622–37. doi: 10.1039/c9rp00203k.

[6] Dasso Vassallo, Ana, and Inés Evaristo Chiyong. 2020. "Análisis de Resultados Del Aprendizaje Presencial y Aprendizaje Semipresencial En Dos Cursos Universitarios TT - Comparative Study: Face-to-Face Learning and Blended Learning TT - Analises Dos Resultados Da Aprendizagem Na Modalidade Presencial y Misto ." *Educación* 29(57):27–42.

[7] Fontalvo, Tomás J., Enrique J. Delahoz-Dominguez, and Gustavo De la Hoz. 2022. "Resultados de Aprendizaje y Mecanismos de Evaluación En Los Programas Académicos de Educación Superior En Colombia." *Formación Universitaria* 15(1):105–14. doi: 10.4067/s0718-50062022000100105.

[8] Nieto Ortiz, Jorge, and María Luz Cacheiro González. 2021. "La Evaluación de Las Competencias En La Formación Profesional Desde Un Enfoque Basado En Los Resultados de Aprendizaje." *Revista Internacional de Organizaciones* (27):173–96. doi: 10.17345/rio27.173-196.

[9] Paz, Hernán. 2022. "Análisis Comparativo de Las Metodologías Educativas Para La Evaluación y El Seguimiento de Los Resultados de Aprendizaje En Programas de Ingeniería." 1–12. doi: 10.26507/paper.2461.

[10] Rothe, Irene, Marco Winzker, and Cathleen Salega. 2019. "An Approach to Assessing Learning Outcomes over Consecutive Courses." *Proceedings - Frontiers in Education Conference, FIE* 2018-Octob. doi: 10.1109/FIE.2018.8658562.