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Contexts And Strategies For The Implementation Of Learning Outcomes In The Industrial Automation Specialization Program At Ufps Ocaña

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ABSTRACT: In the framework of quality assurance in higher education, it is essential that the specialization programs have a continuous improvement in the teaching-learning process. In this order of ideas, the Universidad Francisco de Paula Santander Ocaña sectional approved through Agreement No. 022 of May 27, 2021 the Institutional Policy of Learning Outcomes, which has a plan for the identification, definition, implementation, monitoring and evaluation of Learning Outcomes. The main objective of this research is to show a model that contemplates some development phases for the realization and implementation of the learning outcomes of the specialization program in Industrial Automation of the University. The methodology used is descriptive. In the particular case of the program, the curricular committee of the Specialization collects and applies the guidelines proposed in the institutional educational project and identifies the social demands and makes the recognition of the University's Mission to define its Training Objectives, which in turn constitute the starting point to build the Professional and Occupational Profiles of the Specialists in Industrial Automation.

Keywords: learning achievements, Teaching Methodologies, Training Objectives, Professional Profile.

INTRODUCTION

We are living in the fourth industrial revolution or Industry 4.0, which is defined as the combination of the Internet and emerging technologies and is driving a new fundamental paradigm shift in industrial production.(Gürdür Broo, Kaynak, and Sait 2022). This advance in technology has caused the different actors in the educational field to rethink the way in which students and teachers should construct knowledge(Aziz, Yusof, and Yatim 2012).

This improvement involves a redesign of subject matter programs where the learning outcomes, graduate profile and Institutional Educational Model play an important role in this student-centered teaching and learning process.(Rué 2007),(Arribas 2017).

In Colombia, according to Decree 1330 of July 25, 2019 (Gonzales 2021), all higher education institutions, within the framework of the qualified registration and in compliance with the regulations, must integrate learning outcomes as a factor to be taken into account within the culture of self-evaluation. These will be conceived as the express statements of what a student is expected to know and demonstrate at the moment of completing the training process in an academic program.

In order to implement these, graduate programs offered in the university system must have professional profiles and occupational profiles so that applicants and the general public are aware of the university's commitment to this future professional.(Moller and Gómez 2018).

"The professional profile, insofar as this is understood as the description that characterizes and makes it possible to identify a professional who is in the practice of the profession."(León rubio 2014). "The professional profile should address all key areas of importance to the profession, as well as identify observable actions to communicate practitioner expectation."(McCormack et al. 2011)

This paper presents the results and associated methodology, related to the design and application of instruments to evaluate the terminal educational achievements in students of specialization in Industrial Automation.

METHODOLOGY

The methodology used is a descriptive methodology(Guevara, Verdesoto, and Castro 2020), that is implemented through four stages that were adopted from the institutional policy of the Francisco de Paula Santander University 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.

The industrial automation specialization program worked in each of the stages oriented by the academic sub-direction of the university as shown in Figure 1.

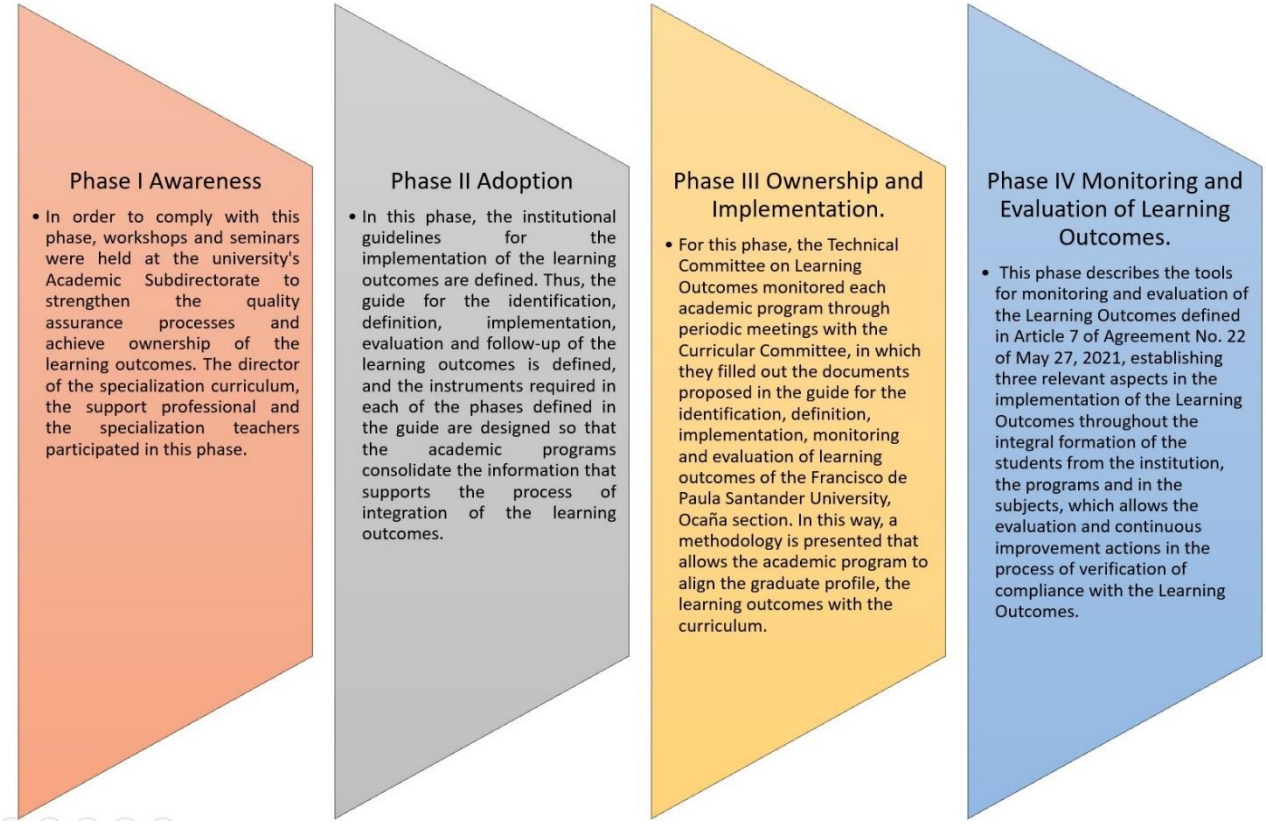

Figure 1. Institutional policy steps for learning outcomes

RESULTS AND DISCUSSIONS

The curriculum of specialization in Industrial Automation is composed of four areas of knowledge: Automation, Instrumentation, control and interdisciplinary of deepening, these areas are composed of 14 modules distributed as follows: the automation area comprises 3 subjects with a total of 6 credits and a percentage within the curricular mesh of 23%, the Instrumentation area comprises two subjects with a total of 4 credits and a percentage of 15% in the mesh, the control area comprises 4 subjects with a total of 8 credits and a percentage of 31%, finally the deepening area comprises 5 subjects with a total of 8 credits with a percentage of 31% in the curricular mesh.

The Industrial Automation Specialization Program carried out the process of the stages of relevance, drafting and evaluation of learning outcomes of the program, after the awareness and adoption phase, in compliance with the provisions of the Institutional Policy on Learning Outcomes. For this, the task begins with a situational analysis of the program to update the graduate profile, based on a review of national and international references that are adapted to the program and the taxonomy by which the competencies and learning outcomes corresponding to each one are defined, this process is presented in the following sections:

Determination of national and international benchmarks

For the creation of the program's competencies, the national and international references listed in Table 1 were used as references.

Table 1. National and International References

Referrer	Name
International	Isa Certified Automation Professional
International	National Commission for Evaluation and Accreditation CONEAU Argentina
National	Unique Classification of Occupations In Colombia (Mintrabajo) Occupation 21522
National	University Francisco De Paula Santander Ocaña
National	National Qualifications Framework

When identifying the competencies of each referent, it was decided that the international referent (Isa Certified Automation Professional) and the national referents (CUOC, UFPSO) were the ones that best focused on the purpose of the career, since they are similar to the characteristics of the program, Specialization in Industrial Automation, based on affinity, purpose and objectives of the program. This allowed the formulation of the program's own competencies.

Restructuring of program competencies

Once the referents were selected, the competencies of each of them were analyzed and related to those of the Industrial Automation Specialization Program, taking as a criterion that they should have affinity with those proposed for the specialist to be trained. The competences were also written taking into account the verbs of Bloom's taxonomy revised by Anderson and Krathwohl in 2001, which is classified into six levels of increasing complexity, where each level of knowledge depends on the student's ability to perform at the level or levels of learning, so that the student has a scientific, technological and management training to activities for the development of solutions in the area of industrial automation to problems present in the regional industry and the country.

In articulation with the taxonomy adopted by the program and the competencies that signify the graduate profile of the specialist in Industrial Automation of the Universidad Francisco de Paula Santander Ocaña, the scope of knowledge in hierarchical order and the related activity according to the taxonomy to achieve the purpose are listed below in Table 2.

Table 2. Scope of knowledge of the selected taxonomy

LEVEL	DESCRIPTION	VERBS
Analyze	Break down, decompose the information into its parts by identifying its causes.	Differentiate – Distinguish – Discriminate – Contrast – Analyze – Infer
Evaluate	Present and defend opinions making judgments about information	Measure-Evaluate - Compare - Deduce - Discuss - Decide - Test

Create	Propose solutions or alternatives when gathering information or situation presented.	Adapt - Experiment - Plan - Build - Create - Design - Produce

Fuente: (CUENCA et al. 2021)

According to the pedagogical model, the graduate academic program of the Specialization in Industrial Automation adopts Bloom's taxonomy 2001 revised by Anderson and Krathwhol described in table 2, since the level of knowledge in which it is structured has great affinity with the area of knowledge in which the program is classified from automation, instrumentation and control of industrial processes; this taxonomy fits in the same way with the objectives and learning domain that predominates in the program: cognitive, this domain will be reinforced through the six objectives comprising: analysis, synthesis and evaluation organized in the superior. In this way, they allow to reach the achievement of the graduate profile defined for the specialist in Industrial Automation of the Francisco de Paula Santander Ocaña University. Subsequently, the updated profile matrix was developed, which consisted in relating the competences of the program with the capacities of the occupational profile, the competences of the occupational profile were written based on the occupations that apply to the Specialist in Industrial Automation in Colombia. In this matrix the working group related each of the occupational competencies with those of the professional profile.
Table 3 shows the competencies of the professional and occupational profile updated for the program.

Table 3. List of competencies of the updated profile

Professional Profile	**Occupational Profile**
Generates solutions to failures presented in processes related to the operation of the components of an electromechanical system, technically meeting the needs of customers of a company or industry with objective, analytical and adaptive capacity to change to be timely generator of the development required by our region and the country.	Engineering support coordinator in electronic assemblies of production and manufacturing automation systems to automate manufacturing lines of products, equipment or machinery.
Formulates technological development projects related to automation and control of industrial processes with the ability to participate in interdisciplinary work groups, valuing the importance of interaction with respect, open-mindedness and attitude of change within the parameters of coexistence to effectively solve the problems of the regional, national and international community.	Advisor and consultant for automated systems

Demonstrates the technological advantages of autonomous equipment through simulations and the use of electronic means of communication that facilitate the transfer, consultation, exchange and comparison with new technologies.	Analyst of production process systems to incorporate new technologies in industrial automation to solve problems.

Taking into account the competencies of the industrial automation specialization program, the program's curriculum committee drafted the learning outcomes, which were aligned to each of the modules offered in the specialization program, organized in the curriculum in a logical way to guarantee the formation of the competencies required in the teaching-learning process of the specialist, Table 4 relates the competencies of the program's graduate profile with the program's learning outcomes.

Table 4. Academic program competencies and learning outcomes

COMPETENCIES	PROGRAM LEARNING OUTCOMES
Generates solutions to failures presented in processes related to the operation of the components of an electromechanical system, technically meeting the needs of customers of a company or industry with objective, analytical and adaptive capacity to change to be timely generator of the development required by our region and the country.	Select and integrate measuring, control and automation equipment, machines and components for different applications, according to the needs presented.
	Design control and protection schemes of mechatronic systems for process monitoring and automation considering economic, environmental and social aspects.
Formulates technological development projects related to automation and control of industrial processes with the ability to participate in interdisciplinary work groups, valuing the importance of interaction with respect, open-mindedness and attitude of change within the parameters of coexistence to effectively solve the problems of the regional, national and international community.	Create solutions to problems related to automation and process control in the region, acting ethically, responsibly and respecting the ideas of colleagues in the work group.
Demonstrates the technological advantages of autonomous equipment through simulations and the use of electronic means of communication that facilitate the transfer, consultation, exchange and comparison with new technologies.	Establish automatic installations and systems based on the need to automate through a preliminary study of the processes in the industry and the characteristics of the automatic regulation and control systems.

	Choose proposed models supported by design and simulation tools of the systems and elements involved in automation and control to define their technical characteristics.

In order to comply with, follow up and evaluate the Learning Outcomes, strategies and a set of tools were designed to verify the achievement of the Learning Outcomes by the students. For this purpose, an evaluation plan of the academic program is established, which describes the alignment of the competencies and Learning Outcomes of the program with the subjects established in the curriculum; thus, through work tables, the formative activities and evaluation strategies that are applied through the subjects, oriented to the significant learning of the students, are socialized, considering the moments in which the evaluation is performed (diagnostic, formative or summative). In this way, teachers know the instruments to be considered in each subject, which are listed below:

- Guides
- Evaluation Rubrics
- Course Planner
- Course Micro-curriculum of the subject.

Regarding the evaluation mechanisms of the Learning Outcomes of the program are oriented from Curricular Committee considering the following instruments:

- Competency Assessment Report and Program Learning Outcomes.
- Audit of subjects.
- Report of the self-evaluation process of the Learning Outcomes.
- Monitoring of student academic performance indicators.
- Characterization of first semester students.
- Evaluation of Learning Outcomes of graduates.

Case study: Subject: Programmable Logic Controllers

For the construction of the learning outcomes it is necessary to start from the professional profile. For this purpose, the professional profile of the Specialization Program in Industrial Automation of the Universidad Francisco de Paula Santander Ocaña, described in Table 3, is taken as a reference.

The Universidad Fráncico de Paula Santander Ocaña by the academic subdirection creates a model of microcurricular template where a description of the subject is made, which for the case of study is the following:

The technological development in the areas of engineering and the need to store and process large volumes of information from the elements involved in industrial processes, generate the need to implement programmable controllers, which together with the interconnection of

devices control various systems such as industrial processes, pneumatic systems and manufacturing cells around the world. In addition, automation systems together with programmable logic controllers and computer tools, allow to monitor and control process variables in order to increase productivity in less time and better product quality.

Table 5 shows the associated competency of the program with the learning outcome that will be developed in the subject of programmable logic controllers with the learning outcomes of the subject.

Table 5. Learning Results of the subject

COMPETENCIES	PROGRAM LEARNING OUTCOMES	SUBJECT LEARNING OUTCOMES
Generates solutions to failures presented in processes related to the operation of the components of an electromechanical system, technically meeting the needs of customers of a company or industry with objective, analytical and adaptive capacity to change to be timely generator of the development required by our region and the country.	Select and integrate measuring, control and automation equipment, machines and components for different applications, according to the needs presented.	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.
Demonstrates the technological advantages of autonomous equipment through simulations and the use of electronic means of communication that facilitate the transfer, consultation, exchange and comparison with new technologies.	Choose proposed models supported by design and simulation tools of the systems and elements involved in automation and control to define their technical characteristics.	RA3: Plan control strategies with respect to industrial automation problems with various levels of complexity.
		RA4: Construct diagrams that represent the characteristics and operation of the elements that make up the process to be automated.

- The following learning strategies were defined for the subject of programmable logic controllers in the industrial automation specialization program:
- Case studies based on the review of the state of the art on the problematic issues discussed in class, in correspondence with their future professional performance.
- Permanent discussions: round tables, debates, group work, panels, discussion groups, workshops.

- Writing texts on the topics covered in class, reading and defense of the thesis of the writings in class.
- Problem-based teaching (EBP). This method of teaching and learning is oriented to the student's acquisition of knowledge, skills or competencies through the analysis of situations in which elements of the context and real life are integrated. In essence, the aim is for students to build their knowledge from more practical situations in which they generally have to integrate knowledge from different areas. The purpose of the EBP lies in the search for solutions and this in turn translates into new learning and skills that need to be developed at the individual and group level.

To evaluate the course, three types of evaluations were defined: diagnostic evaluation, formative evaluation and summative evaluation, as described below:

- ✓ Diagnostic evaluation

Review of pre-knowledge on basic concepts by means of a questionnaire filled out in the Moodle platform.

- ✓ Formative evaluation (3 Note 23.3 % over 70% of the course).

- Development of laboratory practices.

- Development of a literature review document.

- Workshops and class work.

- ✓ Summative evaluation

Development of previous 1, previous 2 (each one with a value of 23.3 % on the 70% of the course).

For the evaluation of previous 1 (23.3%) and previous 2 (23.3%), each student presents a written work: Creation of documents with developed activity to deliver or expose in the theoretical classes.

Final Exam (30% of the course evaluation).

The 30% of the course evaluation considers the presentation of Reports: Creation of documents with detailed description of the events related to the activity developed to deliver or expose in the theoretical classes and in the practical classes.

CONCLUSIONS

Table 3 mentioned the professional profile and occupational profile of the Industrial Automation specialization program of the Universidad Francisco de Paula Santander Ocaña and from there the five competencies associated with the program were assigned, Table 5 showed the competencies and learning outcomes assigned from the program to the subject of Programmable Logic Controllers of the specialization, it can be analyzed that from the subject the scientific knowledge that contribute to the professional profile and occupational profile of the specialist is built.

Similarly, emphasis is placed on Selecting the appropriate components in the physical interaction with the process to be automated, and in Building diagrams representing the characteristics and operation of the elements that make up the process to be automated with these two learning outcomes of the subject contributes to meet in part with the learning outcomes of the program specialization in Industrial Automation at the Universidad Francisco de Paula Santander Ocaña.

The construction of the learning outcomes proposed in this work goes hand in hand with the competencies. By proposing as input for the elaboration of the competencies the professional profile and occupational profile of the Industrial Automation specialization program and understanding that the learning outcomes are derived from the competency, it is guaranteed that the proposal of the latter contributes to the professional and occupational profile as such.

REFERENCES

Arribas, José M. 2017. "La Evaluación de Los Aprendizajes. Problemas y Soluciones." Profesorado 21(4):381–404.

Aziz, Azmahani A., Khairiyah M. Yusof, and Jamaludin M. Yatim. 2012. "Evaluation on the Effectiveness of Learning Outcomes from Students' Perspectives." Procedia - Social and Behavioral Sciences 56(Ictlhe):22–30. doi: 10.1016/j.sbspro.2012.09.628.

CUENCA, Alex A., Mauricio ALVAREZ, Luis J. ONTANEDA, and Elvis A. ONTANEDA. 2021. "La Taxonomía de Bloom Para La Era Digital: Actividades Digitales Docentes En Octavo, Noveno y Décimo Grado de Educación General Básica (EGB) En La Habilidad de «Comprender»." Espacios 42(11):11–25. doi: 10.48082/espacios-a21v42n11p02.

Gonzales, Maria Victoria angulo. 2021. "Por El Cual Se Sustituye El Capítulo 2 y Se Suprime El Capítulo 7 Del Título 3 de La Parte 5 Del Libro 2 Del Decreto 1075 de 2015 -Único Reglamentario Del Sector Educación" EL.

Guevara, Gladys, Alexis Verdesoto, and Nelly Castro. 2020. "Educational Research Methodologies (Descriptive, Experimental, Participatory, and Action Research)." Revista Científica Mundo de La Investigación y El Conocimiento 0(3):163–73. doi: 10.26820/recimundo/4.(3).julio.2020.163-173.

Gürdür Broo, Didem, Okyay Kaynak, and Sadiq M. Sait. 2022. "Rethinking Engineering Education at the Age of Industry 5.0." Journal of Industrial Information Integration 25(May 2021):100311. doi: 10.1016/j.jii.2021.100311.

León rubio, Atilio. 2014. "Características de La Autopercepción Estudiantil Sobre Su Perfil de Egreso , 2010 20-2013 20 , de La Escuela de Ciencias de La Comunicación de La Universidad Privada Antenor Orrego - Campus Trujillo Characteristics of Student Self-Perception about Their P." 25:305–13.

McCormack, Jay, Steve Beyerlein, Patricia Brackin, Denny Davis, Michael Trevisan, Howard Davis, Jennifer Lebeau, Robert Gerlick, Phillip Thompson, M. Javed Khan, Paul Leiffer, and Susannah Howe. 2011. "Assessing Professional Skill Development in Capstone Design Courses." International Journal of Engineering Education 27(6):1308–23.

Moller, Isabel, and Héctor Gómez. 2018. "Coherencia Entre Perfiles de Egreso e Instrumentos de Evaluación En Carreras de Educación Básica En Chile." Calidad En La Educación

(41):17. doi: 10.31619/caledu.n41.58.
Rué, Joan. 2007. Enseñar En La Universidad :El EEEs Como Reto Para La Educación Superior.