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Continuous improvement process in the Electronic Engineering program: application of rubric in the course "Formulation and Management of Electronic Projects"

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Abstract*–This research is part of the search for continuous improvement as part of the accreditation of the Electronic Engineering program and establishes the different paths that have led to determining its own measurement and evaluation plan which, in particular, is specified in the application of a rubric for measuring criteria aligned with two attributes required by the accreditor and internalized by the members of the university to guarantee the academic quality and professional success of our students. These attributes are "Ethics" and "Project Management", which are described in this document from the conception of the idea of the measurement plan, through its processes, and the choice of the course where the application will be made. In this case, it was "Formulation and Management of Electronic Projects", the assignment of criteria and the results that propose an auspicious scope of goals, but that also leaves us with important optimization reflections about the search for academic excellence, contextualization of technological careers, and the continuous review and improvement of pedagogical, social, cultural, and ethical parameters and indicators; to guarantee the training of professionals committed to social development.

Keywords*-- continuous improvement, rubric, attributes, measuring system.

I. Introduction

In a promptly evolving and competitive landscape, it's crucial to possess efficient tools for evaluating our students' performance and competency. Being a university institution dedicated to social and cultural progress, with a longstanding emphasis on educational excellence and holistic student development, we recognize the necessity of implementing a continuous measurement and improvement plan as part of the accreditation process for our Electronic Engineering program. This initiative aims to thoroughly assess learning outcomes to guarantee outstanding training that aligns with academic standards for future engineering professionals [1].

Accreditation has generated a great challenge since it consists of extrapolating the elements of the mission and vision of the university itself, which are reviewed in the various licensing processes to which the university has been subjected in the legal frameworks that government entities requested, and applying them in the development of careers or programs independently [2], without losing the integral meaning of the educational model and that, in turn, can be aligned with the social, research, technological and citizen participation needs, which are seeking an engineering professional as a graduation profile [3]. It is in this context that the issue of accreditation not only constitutes a process that is aligned with the comprehensive objective pursued by the university, but also particularizes the obtaining of measurable results, and for this, it is necessary to consider the specific objective of providing a complete vision of the results obtained through a system of measurement, evaluation, and improvement [4].

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With this premise identified, and based on the frameworks of current university law and the accreditation criteria for undergraduate engineering programs, both nationally and internationally, we choose to develop and apply the evaluation instruments necessary to measure the performance of students about the attributes of the graduate based on the measurement system, carrying out the systematic collection of data and evidence from the evaluations carried out in certain key courses such as "Formulation and Management of Electronic Projects", analyzing the data collected to evaluate the level of development of students' attributes, identifying areas in which students show weaknesses about the desired attributes and using these results to foster a culture of continuous improvement in the Electronic Engineering program [5].

II. Methodology

The process of the measurement and continuous improvement plan is a continuous cycle that ranges from the planning and identification of courses that encompass the results expected by the measurement standards and that lead to developing instruments and policies for feedback and constant improvement:

A. Process of establishing learning outcomes or attributes in the Electronic Engineering program

The first step of the process involves the precise definition of the skills and competencies that students are expected to acquire in each academic engineering program. These competencies must be by the determined academic and professional standards. The process of establishing the graduate's attributes begins with the recommendation of an accrediting agency, in charge of supervising and evaluating the quality of the program, which is provided by the coordinator of the study program. These attributes can encompass key skills, knowledge, and competencies. Next, the program's curricular design and educational objectives are examined to ensure their alignment with the proposed graduate attributes and the standards of the accrediting agency [6]. Table I defines the attributes of the Electronic Engineering program based on the accreditor [7].

TABLE I
ATTRIBUTES FOR THE ELECTRONIC ENGINEERING PROGRAM

Attrib. number	Attrib. name	Description
1	The professional and the world	The student examines and assesses how solutions to complex engineering challenges influence the sustainable progress of society, the economy, the preservation of the environment, health, and safety, as well as established legal frameworks.
2	Ethics	It uses ethical and professional principles, as well as engineering regulations, conforms to the applicable legal framework, and shows respect for the diversity of human groups.
3	Individual work and on team	Performs effectively as an individual and as part of a team, in a multidisciplinary, collaborative, and inclusive environment, using in-person and/or remote interaction mechanisms, establishing goals and strategies to meet their objectives.
4	Communica-tion	Communicates effectively in complex engineering activities with the engineering community and society in general, through the preparation and understanding of reports and design documentation.
5	Project management	Applies the principles of engineering management and economic decision making, considering possible risks, as a member and leader of a team, to manage projects in multidisciplinary environments.
6	Learning throughout life	Recognizes the need and is prepared to: learn independently and continuously, adapt to new and emerging technologies, and apply critical thinking in the broader context of technological changes.
7	Engineering knowledge	Applies knowledge of mathematics, natural sciences, computing, and fundamental and specialized engineering knowledge to develop solutions to complex engineering problems.
8	Problem analysis	Identifies and collects relevant information to characterize and analyze complex engineering problems along with their context.
9	Design and development of solutions	Design creative solutions to complex engineering problems and design systems, components, or processes to meet identified needs within realistic constraints.
10	Inquiry	Carries out investigations on complex engineering issues utilizing research methods that encompass research-based knowledge, experimental design, and execution.
11	Use of modern tools	Creates, selects, and recognizes the limitations of appropriate modern engineering and information technology techniques, resources, and tools.

Student attributes are recorded in a document that details the students' expected achievements upon completion of the program. The program review committee then reviews this document to ensure a broad perspective and consistency with other programs [8]. The final approval of the graduate's attributes is carried out by the dean through a resolution, thus formalizing his acceptance and endorsement. Finally, the program coordinator drafts these attributes and disseminates them widely to students, teachers, and other interested groups.

B. Review process of attributes in the Electronic Engineering program

This process entails regular assessment and updating of student attributes to ensure their relevance and suitability in response to evolving industry demands and trends. It involves periodically presenting and discussing graduate attributes with stakeholders, with scheduled reviews conducted every three years. Meetings are arranged with professors, students, alumni, employers, and a committee of career experts, during which a validation form for student attributes is presented. Data collected and stakeholder feedback are analyzed and compared against existing attributes, documented in a review report. Furthermore, evidence such as videos, photographs, and forms is generated throughout this process.

C. Direct measurement process

The direct measurement of the graduate's attributes implies concretely and specifically evaluating the skills and competencies that students must develop throughout their training in academic programs. The process begins with the role of the quality committee reviewing the attributes to be measured, in parallel the alignment of the courses is carried out according to the current study plan, making an alignment using a double entry table, since it is a tool that shows how the Different courses and components of the academic program are designed to develop and strengthen specific skills and competencies defined in the desired attributes. In this stage of the process, the correspondence between the required attributes and the courses offered is defined, through an alignment matrix, to select in which to apply the most appropriate rubric-type tools so that the direct measurement is optimal. This process is observed in Figure 1, where this double-entry matrix is made by aligning the courses, mainly from the last three semesters, with the eleven results expected for the Electronic Engineering program, to be able to select the most appropriate that can corroborate that the achievements related to the attribute to be analyzed have been achieved [9]. For the specific case of this research, the analysis of the course "Formulation and Management of Electronic Projects" has been selected, which guarantees the achievement of the second and the fifth attribute, that is Ethics and Project Management, respectively. This choice has been made given that the course presents a project that is quite aligned with the rubric and that has gone through previous versions of the internal accreditation process, after an analysis carried out among the teachers who made up the quality committee, it presents the necessary characteristics to be the pilot course needed in this research [10] [11].

SEMESTER	COURSE	ATTRIB. 1	ATTRIB. 2	ATTRIB. 3	ATTRIB. 4	ATTRIB. 5	ATTRIB. 6	ATTRIB. 7	ATTRIB. 8	ATTRIB. 9	ATTRIB. 10	ATTRIB. 11
8	COURSE A	X			X						X	
	COURSE B	X						X	X	X		X
	COURSE C							X	X	X		X
	COURSE D							X	X	X		X
	COURSE E	X				X		X	X	X		X
9	COURSE F	X	X		X						X	
	FORMULATION AND MANAGEMENT OF ELECTRONIC PROJECTS	X	X	X		X				X		
	COURSE G	X		X			X	X	X	X		X
	COURSE H	X						X		X		X
10	COURSE I	X	X		X						X	
	COURSE J	X	X									
	COURSE K	X		X			X	X	X	X		X
	COURSE L					X	X					

Fig. 1 Alignment matrix between program courses and attributes required for accreditation.

Following the alignment of courses with graduate attributes, the next step involves aligning performance criteria with these attributes. Subsequently, courses to be assessed using rubrics are identified, with responsible teachers assigned, and subjects selected, including the integrative subject, where graduate attribute achievement can be effectively demonstrated for direct measurement. After this, a comprehensive plan for measuring and evaluating attributes is formulated. This plan encompasses both direct and indirect measurement methods, outlining the evaluation instrument (be it an analytical rubric or a survey targeting employers and instructors), evaluation frequency (semesterly or annually), subjects chosen for each graduate attribute, evidence to be evaluated (such as final projects, surveys, etc.), percentage allocations for each piece of evidence relative to the established goal, designation of responsible teachers, and semester measurements, alongside established goals expressed as percentages [12].

The direct evaluation of the graduate's attributes involves the use of specific evaluation instruments, such as rubrics designed for each attribute to be measured [13]. These assessment instruments are developed appropriately, establishing clear and objective criteria to evaluate student performance about each graduate attribute [14]. These criteria define the expected level of mastery and the specific indicators that will be used to evaluate student performance. Teachers are responsible for evaluating student performance according to established criteria. The quality committee provides the proposed rubrics to the teachers of the selected courses [15] [16]. Figure 2 shows a rubric model for the “Formulation and Management of Electronic Projects” course, which aligns with the second and fifth attributes.

The display of the second attribute can be seen in Table II, which specifies the scope of the specific criterion of “ethical principles” as part of the professional development of the program student. In contrast, Table III specifies the scope of that same attribute, but specifically under the focus of “professional ethics”.

TABLE II
RUBRIC FOR THE ATTRIBUTE OF ETHICS IN THE CRITERION “C1=ETHICAL PRINCIPLES”

Achievement level	Description
Advanced	Outstandingly applies ethical principles, adhering to the relevant legal framework and respecting the diversity of human groups.
Accomplished	Applies ethical principles appropriately, adhering to the relevant legal framework and respecting the diversity of human groups.
Developing	Applies ethical principles partially, adhering to the relevant legal framework and respecting the diversity of human groups.
Initial	It does not apply ethical principles, does not adhere to the relevant legal framework, nor does it demonstrate respect for the diversity of human groups.

TABLE III
RUBRIC FOR THE ATTRIBUTE OF ETHICS IN THE CRITERION “C2=PROFESSIONAL ETHICS”

Achievement level	Description
Advanced	Applies professional ethics in electronic engineering in an outstanding manner, adhering to the relevant legal framework and respecting the diversity of human groups.
Accomplished	Applies professional ethics in electronic engineering appropriately, adhering to the relevant legal framework and respecting the diversity of human groups.
Developing	Applies professional ethics in electronic engineering partially, adhering to the relevant legal framework and respecting the diversity of human groups.
Initial	It does not apply professional ethics in electronic engineering nor adhere to the relevant legal framework, respecting the diversity of human groups.

Table IV shows the scope of the specific criterion called "project management principles" as part of the fifth attribute, while Table V specifies the scope of that same attribute, within the "economic decision-making" criterion.

TABLE IV
RUBRIC FOR THE ATTRIBUTE OF PROJECT MANAGEMENT IN THE CRITERION "C3=PROJECT MANAGEMENT PRINCIPLES"

Achievement level	Description
Advanced	Excellently applies management principles in electronic engineering, as a member and leader of a team, to manage projects in multidisciplinary environments.
Accomplished	Appropriately applies management principles in electronic engineering, as a member and leader of a team, to manage projects in multidisciplinary environments.
Developing	Partially applies management principles in electronic engineering, as a member of a team, to manage projects in multidisciplinary environments.
Initial	Does not apply management principles in electronic engineering.

TABLE V
RUBRIC FOR THE ATTRIBUTE OF PROJECT MANAGEMENT IN THE CRITERION "C4=ECONOMIC DECISION MAKING"

Achievement level	Description
Advanced	Excellent application of economic decision-making considering possible risks, as a member and leader of a team, to manage projects in multidisciplinary environments.
Accomplished	Appropriately applies economic decision-making considering possible risks, as a member and leader of a team, to manage projects in multidisciplinary environments.
Developing	Partially applies economic decision-making considering possible risks, as a member and leader of a team, to manage projects in multidisciplinary environments.
Initial	Economic decision-making considering possible risks does not apply.

RUBRIC					
PROGRAM	ELECTRONIC ENGINEERING	SEMESTER	IX	GOAL	60%
COURSR	FORMULATION AND MANAGEMENT OF ELECTRONIC PROJECTS	ACADEMIC PERIOD	2023-2	GROUP	A
CODE	IET-FE9324	MEASUREMENT FREQUENCY	BIYEARLY	VERSION	1.0
Attributes:					
[ATTRIB.2] Ethics: It uses ethical and professional principles, as well as engineering regulations, conforms to the applicable legal framework and shows respect for the diversity of human groups. **[ATTRIB.5] Project management:** Applies the principles of engineering management and economic decision making, considering possible risks, as a member and leader of a team, to manage projects in multidisciplinary environments.					
Criterion		Achievement levels			
		Advanced	Accomplished	Developing	Initial
		Score:4	Score:3	Score:2	Score:1

Fig. 2 Heading of the rubric applied to the course "Formulation and Management of Electronic Projects".

D. Indirect measurement process

This procedure commences with the scheduling of indirect assessment, conducted annually. The coordinator of pre-professional practices suggests a questionnaire to evaluate the attributes of graduates. Subsequently, the program coordinator endorses the questionnaire for its execution, collecting data indirectly about graduate attributes through surveys. Despite its inclusion in the improvement plan, this aspect remains insufficiently scrutinized in the current study.

E. Continuous improvement process

Continuous improvement is integral to the cycle, drawing from results of both direct and indirect measurements, along with feedback from diverse stakeholders. These insights inform decisions to adapt the curriculum, teaching approaches, and other pertinent factors.

At first, the program coordinator gathers and merges direct and indirect assessments of the graduate's attributes. Subsequently, they scrutinize and assess the outcomes to comprehend comprehensively the students' performance concerning these attributes. By examining and evaluating attribute measurements, the coordinator subsequently showcases and records the results and their analysis.

Utilizing the results and analysis, the quality committee identifies areas necessitating enhancement. They then formulate a detailed improvement strategy outlining specific steps to rectify identified shortcomings or areas for growth. Subsequently, the program coordinator oversees and tracks the execution of these improvement measures. A monitoring tool is employed for this purpose, ensuring each action proceeds according to plan. The faculty dean reviews and sanctions the improvement plan via a resolution, officially endorsing the proposed enhancement endeavors.

With assistance from the program coordinator, sanctioned improvement measures are executed according to the outlined plan. Following each action, a report is generated detailing its execution, outcomes, and observed effects. This iterative improvement process ensures ongoing evolution and enhancement of the program, aligning with quality standards and expectations linked to desired attributes.

F. Measuring system

This systematic approach is crafted to continuously and efficiently assess whether students are progressing in acquiring the desired skills, competencies, and attributes throughout their academic program. The research framework we operate within comprises five distinct stages:

- It commences with defining and establishing attributes, laying out the objectives and expectations for student training.
- Attributes undergo periodic review and updating.
- Direct evaluation of graduate attributes is conducted, employing specific methodologies and tools to gauge student-acquired skills and competencies.
- Indirect evaluation is carried out, providing a broader and more comprehensive perspective through surveys and feedback from employers and pre-professional practitioners.
- Finally, the continuous improvement process prioritizes identifying areas for enhancement and devising tangible actions to elevate the quality of training.

This cyclical process is consistently reiterated to guarantee alignment between the academic program and graduate attributes, ensuring students are thoroughly equipped for their future endeavors. Continuous feedback and ongoing enhancement constitute pivotal components within this process.

III. RESULTS

The pilot rubric was applied within the course "Formulation and Management of Electronic Projects" directly onto the integrative project, which entails crafting a solution proposal. During the evaluated semester, the project's theme revolved around an action framework focusing on the utilization of prototype measurement systems to gauge radiation and contamination levels across different areas of the city. To accomplish this, students engaged with a theoretical framework and a procedural scheme, implementing a technological setup centralized on a microcontroller for monitoring various sensors and actuators. Additionally, they navigated a logistical framework, applying management principles to collaborate within an interdisciplinary environment. Finally, a reference framework necessitated establishing ethical assessments throughout the process to ensure the development of the requested product.

The rubrics outlined in preceding sections provided a guideline for understanding what the instructor sought in the assigned task: it wasn't solely about the technological aspects, but also encompassed evaluation of the ethical considerations and the application of management principles.

It's important to highlight that achieving the 60% goal on the rubric required the quality committee to conduct multiple consultations with peers who had implemented similar processes in related programs. Additionally, we actively participated in various virtual seminars hosted by accrediting organizations, where we received guidance on developing the instrument. We recognize that its effectiveness heavily relies on the context of its application and various factors such as the curriculum framework and the duration of courses within the program. Once the proposal was formulated, it underwent expert evaluation, and upon receiving their validation, it was deemed suitable for implementation.

Figure 3 illustrates the graphical representation of the extent of the objective's scope, whereas the comprehensive outcomes of the application to the fifteen students are delineated in Table VI.

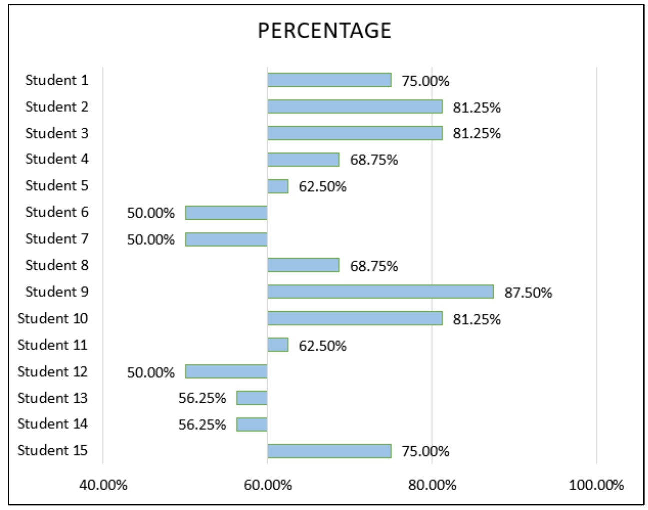

Fig. 3 Results of the application of the rubric.

TABLE VI
QUANTITATIVE RESULTS OF THE APPLICATION OF THE RUBRIC

Student	C1	C2	C3	C4	PERCENTAGE	REACH THE GOAL?
Student 1	4	3	3	2	75.00%	Yes
Student 2	4	4	3	2	81.25%	Yes
Student 3	4	4	3	2	81.25%	Yes
Student 4	3	3	3	2	68.75%	Yes
Student 5	3	3	2	2	62.50%	Yes
Student 6	2	2	2	2	50.00%	Not
Student 7	2	2	2	2	50.00%	Not
Student 8	3	3	3	2	68.75%	Yes
Student 9	4	4	3	3	87.50%	Yes
Student 10	4	3	4	2	81.25%	Yes
Student 11	3	3	2	2	62.50%	Yes
Student 12	2	2	2	2	50.00%	Not
Student 13	3	2	2	2	56.25%	Not
Student 14	2	3	2	2	56.25%	Not
Student 15	4	3	3	2	75.00%	Yes

Five students did not attain the designated goal of 33.33%, whereas the remaining students surpassed it. From a statistical perspective, the average results indicate 67%, suggesting an overall enhancement beyond the targeted benchmark. Notably, one student achieved an impressive 87.50%, positioning them in the highest percentile, while three students attained 81.25%, placing them in the upper echelon.

IV. Discussion

In general terms, the first point that we have validated with this application is the value of the proposed goal of 60%, where it is observed that two-thirds of the students achieved it, evidencing compliance with the attributes as a fundamental part of the learning process, continuous improvement, and internal quality review in our curriculum.

From the above it also follows that a third of the students did not achieve that 60%, remaining very close to obtaining it; This invites us to reflect on the specific characteristics related to the decision to apply similar but lower-level projects in the courses that align with the second and fifth attribute, or perhaps in the face of further investigation that will probably lead us to develop a post-research to modify the curricular framework to conduct the objectives that the accreditor (as an external and international reviewing entity) requests of us. Another point that was addressed, but to a lesser extent, was the relevance of the project, although, after the review of the quality committee, it was concluded that this topic was necessary to achieve the objectives that the university required of its future professionals.

Likewise, within the review of the specific results, it is observed that the lowest scores have been given in attribute 5 (Project Management), while in attribute 2 (Ethics) the results were better. This also raises a question about the economic decision-making criteria as a weak point of the evaluated group. The hypotheses put forward after knowing the results are two:

- The first is that although students take project management courses and general economics frameworks, these are often not addressed by specialists in technology subjects, and that, despite the guidance that the course teachers have provided during the semester, has not been enough to equate the knowledge that the student has about technological implementation with knowledge about budgets; For example, do not skimp on deciding on the choice of a sensor but that in the end will make the project not economically viable.
- The second is that the evaluated group has been conditioned by knowing that they were going to be evaluated with a specialized rubric (for the first time) and they have put greater effort into the hard part of the degree: technology; thus neglecting the complementary aspects of professional training that will lead them to their final goal at the university, which is to be complete and competent engineers.

Finally, as we understand that this application is part of a great plan for continuous improvement, we are in continuous conversation with the teachers and researchers who have addressed the other important topics of this plan to reach a consensus and be able to propose the Measuring system that will help us. lead to optimizing the instruments created and processes worked on in this stage, seeking to generally exceed the proposed goal of 60% in the application of the rubric in the “Formulation and Management of Electronic Projects” course and being quite attentive to the results. historical records that from now on we are going to obtain.

V. Conclusions

- This study underscores the significance of implementing a well-structured measurement and evaluation system to gain a clear and objective insight into student performance. This forms a robust basis for pinpointing areas for enhancement and making informed decisions.
- The assessment process identifies both strengths and weaknesses, providing valuable insights for the institution to ascertain its areas of excellence and areas requiring improvement.
- Emphasizing the necessity of adopting a comprehensive approach encompassing all pertinent aspects of measuring, evaluating, and continually improving student outcomes. This entails selecting suitable evaluation methods, gathering, and analyzing pertinent data, and implementing improvement strategies based on the findings.
- Indirect measurement tests are deemed necessary to reinforce and supplement the desired standards. While it's acknowledged that the responsible areas oversee the achievement of set objectives, it's imperative to develop a valid instrument to confirm and address these indicators, establishing baseline points and quantitative benchmarks.
- Finally, despite the absence of a pre-existing measurement system, the choice of the pilot course and its alignment with accreditation standards have produced positive results. These results serve as a precedent for implementing similar approaches in other courses that encompass the remaining nine desired outcomes.

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