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Modelo de evaluación de los atributos de egreso de un programa educativo de ingeniería del TecNM en Celaya

Evaluation model of the Graduation Attributes of a TecNM engineering educational program in Celaya

Modelo de avaliação dos atributos da graduação de um programa de ensino de engenharia do TecNM de Celaya

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Resumen

En este artículo se ofrece una propuesta alternativa para garantizar la calidad del programa educativo (PE) de Ingeniería Mecatrónica en el Tecnológico Nacional de México en Celaya (TecNM en Celaya). En 2021, el Consejo de Acreditación de la Enseñanza de la Ingeniería (CACEI), entidad encargada de evaluar los programas educativos en términos de enseñanza-aprendizaje, otorgó una acreditación internacional al PE de Ingeniería Mecatrónica. Como parte de un proceso metodológico de mejora continua, el objetivo general de este trabajo es desarrollar un modelo de evaluación de los atributos de egreso del PE. Además, se ha diseñado un *dashboard* para el procesamiento de los datos dirigido tanto a profesores como a alumnos. En cuanto a lo metodológico, se empleó la técnica de investigación documental exploratoria, la cual abarcó la revisión del estado de la cuestión en relación con los criterios para la acreditación de carreras por parte de CACEI, así como la creación de un modelo que incluye un instrumento de medición validado y estadísticamente confiable. A partir del análisis descriptivo estadístico de

las evaluaciones realizadas por los docentes durante el periodo de enero a junio de 2023, se ha determinado que más del 90 % de los alumnos evaluados logran alcanzar el atributo en su totalidad o parcialmente. Asimismo, se ha observado que en tres cuartas partes de las asignaturas evaluadas existe una coincidencia entre los valores obtenidos en la evaluación realizada por los docentes y la autoevaluación efectuada por los alumnos, así como en el nivel de correspondencia entre lo enseñado por los docentes y lo aprendido por los alumnos.

Palabras clave: acreditación de la enseñanza, atributos de egreso, CACEI, *dashboard*.

Abstract

This article proposes an alternative to ensure the quality of the educational program (PE) of Mechatronic Engineering at the Tecnológico Nacional de México in Celaya (TecNM in Celaya). The " Consejo de Acreditación de la Enseñanza de la Ingeniería" (CACEI), an accrediting body that evaluates educational programs in their teaching-learning processes, in 2021 internationally accredited the PE of Mechatronic Engineering. As part of the methodological process of continuous improvement, the general objective of this work was established to develop an evaluation model of the PE graduation attributes. In addition to the proposed evaluation of graduation attributes, a Dashboard for data processing were designed for teachers and students.

The exploratory documentary research technique was applied in the review of the state of the art regarding studies on the criteria for the accreditation of careers by CACEI, as well as in the development of a model that includes a validated and statistically reliable measurement instrument. From the evaluations carried out by teachers in the subjects of January-June 2023, it was obtained through a statistical descriptive analysis that more than 90% of the evaluated students achieve the attribute or partially achieve it. It was also observed that in three quarters of the subjects evaluated, the values of the evaluation carried out by the teachers coincide with the self-evaluation carried out by the students in the subjects and in the level of correspondence between what the teachers teach and what the students learn. students.

Keywords: Teaching accreditation, graduation attributes, CACEI, Dashboard.

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Resumo

Este artigo oferece uma proposta alternativa para garantir a qualidade do programa educacional (EF) de Engenharia Mecatrônica do Tecnológico Nacional do México em Celaya (TecNM em Celaya). Em 2021, o Conselho de Credenciamento do Ensino de Engenharia (CACEI), entidade responsável pela avaliação dos programas educacionais em termos de ensino-aprendizagem, concedeu credenciamento internacional ao EF de Engenharia Mecatrônica. Como parte de um processo metodológico de melhoria contínua, o objetivo geral deste trabalho é desenvolver um modelo de avaliação dos atributos de saída do PE. Além disso, foi projetado um painel para processamento de dados voltado tanto para professores quanto para alunos. Em termos metodológicos, utilizou-se a técnica de pesquisa documental exploratória, que abrangeu a revisão do estado da arte em relação aos critérios de acreditação de carreiras pela CACEI, bem como a criação de um modelo que inclui um modelo validado e estatisticamente instrumento de medição confiável. Com base na análise estatística descritiva das avaliações realizadas pelos professores no período de janeiro a junho de 2023, constatou-se que mais de 90% dos alunos avaliados conseguem atingir o atributo total ou parcialmente. Da mesma forma, observou-se que em três quartos das disciplinas avaliadas existe uma coincidência entre os valores obtidos na avaliação realizada pelos professores e na autoavaliação realizada pelos alunos, bem como no nível de correspondência entre o que é ensinado pelos professores e o que foi aprendido pelos alunos.

Palavras-chave: acreditação docente, atributos da graduação, CACEI, dashboard.

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Introduction

Currently, education in general and university education in particular constitute one of the fundamental tools to improve the conditions of society (Calderón *et al* ., 2017; United Nations Organization [UN], 13 from December 2017), since they contribute to the preparation not only of citizens, but also of professionals and scientists who enhance the development of sciences and humanities. These professionals, in fact, must be trained to propose solutions that respond to the social, political, economic, ideological and cultural changes that occur in the world.

Due to these constant transformations, higher education institutions must adapt to new trends to be more effective and efficient, as pointed out by Villalba (2017), who highlights the

increased demand in the search for quality in academic programs in recent years. years. In accordance with these demands, the Tecnológico Nacional de México in Celaya, in its 2020-2024 institutional development plan, has committed to accrediting its courses through the Engineering Education Accreditation Council (CACEI) (15 February of 2019) with the aim of consolidating the quality and competitiveness of its educational offer. This accreditation involves subjecting the educational programs to a periodic and permanent evaluation by external organizations such as CACEI, a voluntary process, but fundamental for the continuous improvement of educational processes.

According to Durán (6 of June of 2017), these organizations are regulated by the Council for the Accreditation of Higher Education (COPAES) and their objective is to grant formal recognition and supervise organizations to accredit higher level educational programs. In the specific case of CACEI, its 2018 framework establishes 30 indicators distributed in six categories to evaluate the quality of engineering programs: 1) academic staff, 2) students, 3) study plan, 4) assessment and continuous improvement, 5) infrastructure and equipment, and 6) institutional support.

Now, in the case of the TecNM Mechatronics Engineering educational program (PE) in Celaya, in December 2021 it obtained its accreditation for three years, however, since this process is part of a constant update, it is crucial to carry out intermediate evaluations, especially in category 4 (assessment and continuous improvement). In fact, in the next evaluation the objective is to demonstrate, through evidence, that the PE has allowed students to acquire the necessary skills in accordance with the attributes established in the program.

However, given that the current PE is not completely consolidated, this project proposes to develop a tool that facilitates the collection of information through surveys and rubrics that allow its analysis automatically. In addition, it is planned to use a *dashboard* to manage the data and graphs, which will facilitate analysis and decision making by the PE academy. Likewise, the creation of a historical database that records the semiannual evaluations of the predefined PE subjects is contemplated to simplify this process, given that these evaluations are carried out on a regular basis.

The question formulated to try to fulfill the previous purposes was the following: is it possible to measure the discharge attributes using semiquantitative methods that facilitate their analysis and decision making? In order to answer this question, the objective was established to develop an evaluation model of the graduation attributes of the PE of Mechatronic Engineering at TecNM in Celaya. This is presented as a proposal for continuous improvement to strengthen

the skills that the graduate of the program must have. Likewise, a null hypothesis was formulated, which suggests that the results of the evaluations carried out by the teachers towards the students and the students' self-assessment are not different.

Background

In recent years, there has been an increase in the number of public higher education institutions that have carried out the evaluation of CACEI attributes with the common purpose of improving educational quality to train professionals capable of functioning in a globalized environment, in accordance with the study plans of engineering careers (Murrieta, 2019). A particular case is that of the Autonomous University of San Luis Potosí (UASLP), where Espericueta *et al*., (2019) carried out the evaluation of graduation attributes for the Administrative Mechanical Engineering degree.

To carry out this process, three mandatory subjects were selected (*IMA Integrative Project* , *Quality Management Systems and Continuous Improvement* and *Mechanical Design*) and two optional subjects (*Advanced Manufacturing Topics* and *Seminar*). In addition, learning activities were implemented by subject in order to achieve the desired attributes, which consisted of an individual exam on the Didactic platform, PBL (Project Based Learning) technique exercises, collaborative work through the Kahoot software and a workshop from DMAIC.

The evaluation system was designed to obtain values between 1 and 4, which are interpreted as null, insufficient, sufficient and outstanding, respectively. The stated purpose was for 85% of the students to achieve values between 3 and 4. After completing the assessments, an analysis of the results was carried out using a regression equation, which revealed an average of 86% in the means of egress attributes. This indicates that the data collected in the evaluation process was satisfactory.

In another case, in the Industrial and Systems Engineering degree at TecNM in Sonora, the Visual Basic programming language for applications was used along with formulas and functions for the generation of dynamic tables and graphs in dashboard *format*. In addition, the attributes and indicators established specifically for the students of the program were evaluated using Google forms. After evaluating a total of 423 students, it was found, on average and through a cohort evaluation, that the attributes are partially met. Likewise, it was observed that of the 7 attributes declared before CACEI, numbers 4, 6 and 7 obtained better performance than attributes 1, 2 and 3. According to the evaluators, this suggests that the students have better developed the transversal generic competencies that critical skills for the program in the first

semesters. In addition to this, it was identified that the greatest weakness is found in attribute 1, related to problem solving, which indicates that students in the first semesters find it difficult to identify variables, apply reference models and/or integrate knowledge. to formulate and solve problems (Carballo and Arellano, 2019).

On the other hand, Soto *et al*., (2022) applied a remote evaluation process of graduation attributes at the TecNM in Celaya, specifically in the Economic-Administrative Sciences (CEA) career. The study focused on the evaluation of attribute 3 of the CACEI in the subject Finance in Organizations. Using a scale from 1 to 4 (with the Likert scale description of poor, initial, medium and advanced), the levels of achievement of the attribute were evaluated. The average values obtained by subject were the following: 0% in poor, 1.8% in initial, 18.4% in intermediate and 79.8% in advanced level, starting from a goal level to be reached of at least 70%.

After presenting the results to the Advisory Council and the CEA academy, it was concluded that the data met the goal proposed by the academy. As proposals, it was suggested to continue working on improving the process and implementing new proposals in the curriculum, as well as providing constant training to all those involved in the accreditation process.

In accordance with the above, Mora (2004) points out that constant evaluation in any institution must be a fundamental process that can be used in various ways depending on the purposes or objectives set, such as control, measurement and assessment of the objective. Likewise, for Lara (September 13 of 2018) the function of evaluation is to provide information on the performance of programs by detecting gaps between reality and the ideal, as well as strengths and weaknesses so that decision makers can propose improvements in management.

For the evaluation to be successful, it must be carried out through the systematic collection of data focused on indicators, which allow indicating the degree of compliance and monitoring or following up on objectives and goals (Castaño et *al*., 2006). According to Cecchini (2005), these indicators can be facts and perceptions, quantitative or qualitative, simple or composite. In this sense, computer decision-making support systems are very useful tools for calculating and visualizing these indicators. Therefore, its design must guarantee the generation of dynamic, flexible and interactive reports quickly, that is, with short response times to analyze large volumes of information. In addition, they must allow the generation of historical information to compare current data with that of previous periods to facilitate decision making (Tundidor *et al*., 2010).

Currently, it is crucial that the information required to maintain the accreditation level of an educational program is provided in an automated manner through tools that standardize this

task and that they are used uniformly in formats and evaluation criteria for graduation attributes.

The present work, therefore, is justified because it seeks to achieve at least one of the goals established in the institutional development program of the TecNM in Celaya, that is, "increase and maintain the number of academic degree programs recognized nationally and internationally." for its quality through accreditation." For the development of the project, the following objectives have been considered:

General objective

Develop a model to evaluate the graduation attributes of the Mechatronics educational program as a proposal for continuous improvement to strengthen the TecNM degree programs in Celaya.

Specific objectives

- Conduct an exit survey of the students of the program in the pre-established subjects and in accordance with the graduation attributes that impact the rubric prepared by the academy.
- Develop a tool for the teacher to evaluate students according to a rubric established by the academy.
- Design a database to store historical information from the analysis of the student self-assessment survey.
- Create a *dashboard* to compare the information obtained from both students and teachers.
- Analyze the information collected using descriptive statistics and computational tools for subsequent discussion and decision making.

The hypothesis established for this work was the following:

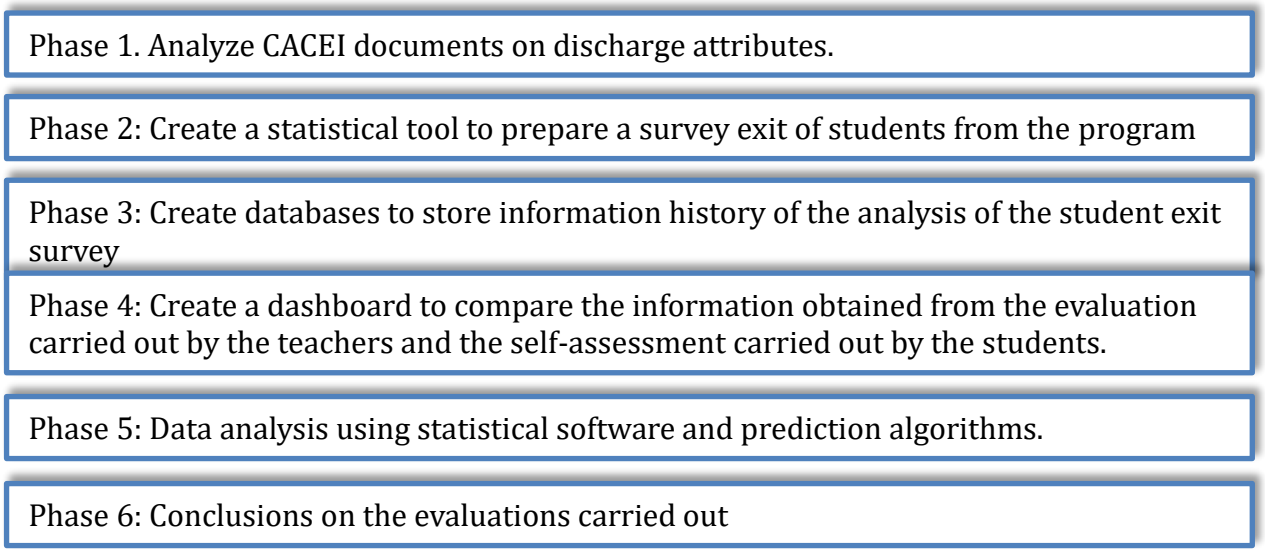
Null hypothesis: The results resulting from the teacher's evaluations of the students and the student´s own self-evaluation are not different.

Methodology

In the work carried out, the exploratory documentary research technique was used to review the state of the matter and search for information in various alternative spaces. This included consulting CACEI documents to obtain career accreditation criteria, reviewing accreditation files for the Mechatronics program, as well as exploring studies carried out at other

institutions that have gone through similar accreditation processes. To carry out the evaluation of the attributes, a methodology based on six phases was followed, as shown in Figure 1.

Figure. 1 . Diagram of the phases of the attribute evaluation project



Source: self made

Likewise, a survey for self-assessment on a Likert scale was developed in order to assess the attributes of the CACEI at three levels: introductory, intermediate and advanced. In each case, the characteristics that the student must have to consider the level of achievement of the attribute were established in three output levels: does not reach, partially reaches and reaches. Furthermore, for each item raised, the indicators associated with each attribute were identified, measured as the percentage of students who achieve or exceed each defined attribute. With these supporting elements, an evaluation scheme was proposed for the Mechatronics Engineering Department of the Tecnológico Nacional de México in Celaya.

The survey was administered online through questionnaires in Gmail and was disseminated to the institutional emails of students and teachers. In addition, computer equipment and a storage system were used through the departmental Drive. To determine the sample size, a target population of 630 students was estimated, considering the 21 selected subjects with an average of 30 students per subject. However, only 256 students responded to the survey. Although only 41% of the target population participated, this amount was considered to constitute a significant amount according to the intentional non-probabilistic sampling criterion in the opinion of the expert or facilitator (Hernández and Mendoza, 2018).

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Analysis methodology

In general terms, the methodology used to evaluate the CACEI graduation attributes consists of selecting subjects from the Mechatronics Engineering program, and at the end of the semester applying surveys to the students. Additionally, teachers evaluate attributes based on the rubrics established for each subject.

The diagram shown in Figure 2 presents the final idea of evaluation of both parts: from the teacher to the student and the self-assessment carried out by the student himself. The difference between these provided the necessary information to determine if there is agreement between the teacher's evaluation and the student's perception.

Figure 2 . Process diagram for data correlation

Source: self made

Table 1 shows the relationship of the graduation attributes and the subjects of the study plan according to the consensus made in the Mechatronic Engineering academy.

Table 1. List of graduation attributes by subject evaluated

egress attribute	Level	Subjects to be evaluated
AE1	I M A	Static Dynamic of systems Robotics
AE2	I M A	Design of mechanical elements Computer-aided design Applied power electronics
AE3	I M A	Analysis of electrical circuits Instrumentation Applied power electronics
AE4	I M A	Research foundations Hydraulic and pneumatic circuits Research workshop II
AE5	I M A	Ethics workshop Intelligent Systems Research workshop I
AE6	I M A	Digital electronic Programation advance Industrial communication protocols
AE7	I M A	Electronic analogue Microcontrollers Programmable logic controllers

Levels: I = Introductory M = Medium A = Advanced

Source: self made

Table 2 shows the criteria defined in the academy and aligned with the CACEI attributes, indicating how many each of them has and the details of how they would be evaluated.

Table 2 . CACEI graduation attributes performance criteria

egress attribute	Performance criterion
Attribute 1: Identify, pose and solve problems related to Mechatronics Engineering by applying principles of basic sciences and engineering.	1. Expresses engineering problems in mathematical models based on the foundations of basic sciences and engineering principles. 2. Solve engineering problems based on the foundations of basic sciences and engineering. 3. Validates the results of engineering problems from the comparison and analysis of the results obtained analytically and/or computationally.
Attribute 2: Analyze, synthesize, design, simulate and build products, processes, equipment or mechatronic systems, to positively impact their environment with a research attitude, according to technological and social needs.	1. Generates engineering design proposals that meet the specified needs, demonstrating technical and economic feasibility. 2. Build or implement a system based on an engineering design that meets specific needs.
Attribute 3: Carry out experimentation by analyzing and interpreting the information obtained from the behavior of the systems that make up Mechatronic Engineering with the objective of validating the operation of said system.	1. Perform experiments based on an established protocol considering safety regulations. 2. Validate the operation of systems by analyzing and interpreting information obtained from experimentation. 3. Designs and carries out experiments that allow you to obtain information that will be used in the validation or control of systems.
Attribute 4: Possess communication and personal interrelationship skills to transmit ideas, facilitate knowledge and work with collective responsibility in the search for solutions to problems and the development of projects with a critical and self-critical sense.	1. Express ideas and knowledge clearly and opportunely through words, adapting to the characteristics of the situation and the audience. 2. Communicate correctly and clearly in writing, structuring the content of the text with graphic supports to facilitate understanding and interest in the various topics in engineering. 3. Create, select or use appropriate modern engineering and ICT techniques, resources and tools.
Attribute 5: Identify your ethical and professional responsibilities by	1. Identify an ethical problem and justify the solution based on compliance with professional ethics.

exercising your profession legally and responsibly to comply with the national and international standards that apply.	2. Identify ways to solve an ethical problem based on compliance with professional ethics in the social, environmental and economic context. 3. Solve engineering problems taking into account the national and international standards that apply in the context of their professional field.
Attribute 6: Be at the forefront of the scientific and technological changes that occur in the exercise of your profession through continuous and autonomous professional updating to integrate and apply this knowledge appropriately.	*software* and *hardware* technology tools that facilitate problem solving. 2. Has the ability to appropriately select cutting-edge scientific and technological contributions to solve engineering problems. 3. Apply innovative knowledge and technologies to solve engineering problems autonomously.
Attribute 7: Participate, coordinate and/or direct multidisciplinary groups through teamwork to ensure quality, efficiency, productivity and profitability in the implementation of mechatronic projects with a sense of responsibility for their social and cultural environment in a framework of sustainable development .	1. Collaborate in work teams to solve engineering problems. 2. Do teamwork. 3. Plan tasks and delivery dates, establishing objectives and goals for solving a specific problem.

Source: Academy of Mechatronics

The measurement instrument used a weighting of 1 to 4 in the self-assessment, associated with a level of scope using a Likert scale as shown in Table 3.

Table 3 . Weighting of the attribute on the Likert scale

SCOPE LEVEL	SCALE 1 TO 4
Never	1
Hardly ever	2
Almost always	3
Always	4

Source: self made

Table 4 presents the levels obtained based on the final average, according to the evaluations carried out by the teachers and the students' self-assessment. These levels are used to verify the degree of mastery achieved by students in relation to the graduation attribute after completing the subject. Table 4 shows the levels based on the ranges.

Table 4. Average-level

AVERAGE	LEVEL
Less than 1	It's not enough
Between 1 and 2.99	Partially reaches
Greater than or equal to 3	Achieves

Source: self made

After considering the agreements of the academy and the proposal of the coordinator of the accreditation process, a consensus was reached to evaluate only one attribute per subject, with the exception of Applied Power Electronics, where two attributes would be evaluated. The semiannual evaluation of student attributes in selected subjects is currently carried out in a departmental Drive shared by teachers, using an Excel format. Figure 3 shows an example of the format used by teachers to evaluate the attribute in one of the subjects through a file shared on Drive.

Figure 3. Excel format used by teachers to evaluate an attribute

Course	Subject	Cluster	TO				Grades	
Period	Agodic 2023	Teacher	Teacher's name					
Activity(s) used to evaluate		First midterm homework problem					Each rating is from 0 to 3.	
Attribute level		Reagent 1 (0-3)	Reagent 2 (0-3)	Reagent 3 (0-3)	Reagent 4 (0-3)	Reagent 5 (0-3)		
Attribute 1: Identify, pose and solve problems related to Mechatronics Engineering by applying principles of basic sciences and engineering.		Analyzes problems proposing alternative solutions.	Expresses mathematical models of engineering problems based on the foundations of basic sciences and engineering principles, selecting the variables and parameters that intervene in the system.	Applies procedures that allow solving engineering problems based on the foundations of basic sciences and engineering principles.	Validate the results by correlating the theoretical and computational analyzes and explain the reasons for the similarities or differences in the data obtained.	Designs and carries out experiments that allow you to obtain information that will be used in the validation or control of systems.	Total rating	Scope level
No.	Student							
1								
2								
3								
4								
5								

Source: self made

Table 5 shown below presents examples of the self-assessment questionnaires applied to students of the Mechatronics Engineering program for attribute 1 at its introductory level. These questionnaires were structured in three dimensions: the first, intended to collect general information such as name, gender and semester attended by the student; the second, focused on items related to the level of the attribute, and the third, composed of generic information items to determine whether teachers are using the evaluations in accordance with the regulations and delivering results in a timely manner, among other aspects. Table 5 also shows an example of the questionnaires used to evaluate the graduation attribute at its three levels.

Table 5. Example of a questionnaire for graduation attribute 1 at its introductory level

DISCHARGE ATTRIBUTE: AE1

Subject: Statics Level: Introductory

No.	Ask	Always	Almost always	Hardly ever	Never
1	You recognize the theory involved in solving problems and apply it appropriately to propose alternative solutions.				
2	You carry out mathematical developments of clearly structured problems and understand the importance of said approach.				
3	You require help to apply the physical principle that builds the development of a mathematical model.				
4	You solve engineering problems that are clearly structured where the variables and parameters involved in the system are investigated, chosen and established.				
5	You use a methodology to solve engineering problems and propose alternative solutions.				
6	You apply computing tools to simulate systems.				
7	You require help to obtain results for engineering problems.				
8	You validate the results by correlating theoretical and computational analyses.				
9	By correlating the theoretical and computational analyzes you clearly explain the reason for the similarities or differences in the data obtained.				

Source: self made

It should be noted that similar questionnaires were prepared for each of the remaining six exit attributes, according to the format presented above. The evaluation by the teachers was carried out using an Excel file hosted in a shared folder on the Drive intended for the teachers of the Mechatronic Engineering academy. In this file, teachers evaluated students with respect to the graduation attribute corresponding to their level in each subject.

The *dashboard* developed for this purpose is used as an information management tool to monitor, analyze and graphically display the key indicators of the attributes, as well as the essential metrics and data to track the scope of the output attributes. The purpose of this

dashboard is to automate and standardize the evaluation process for both teachers and students, and to establish a comparison between what teachers teach and the perception of what students learn through their self-assessment of the same attribute.

dashboards have been created for teachers and students, which are located and shared in Google Drive. This will allow teachers to grade students directly on each attribute assigned by the CACEI. Figure 4 shows a part of the *dashboard* with the basic buttons for teachers to evaluate their students in the corresponding subject and graduation attribute. A significant advantage of this *dashboard* is that teachers can evaluate students directly, using the same list previously generated in Excel or PDF from the same Drive that was previously worked on.

Figure 4. Partial list of the content of the *dashboard graphical interface* for evaluation by teachers.

Source: self made

The *dashboard* has several important functions that allow you to carry out and manage attribute evaluations efficiently. These functions are described below along with the corresponding buttons and the actions they perform:

1. Activate attributes: This button allows you to select the attributes that will be evaluated in each subject. Attributes 1 to 7 can be activated according to the needs of the evaluation.
2. Evaluation: By pressing this button, the corresponding evaluations of the selected attributes in the specific subjects are carried out.
3. Bring list in Excel: This function allows you to import and download student lists in Excel format.
4. Bring list in PDF: With this button you can select the student lists in PDF format.
5. Get Averages: When you activate this function, the averages per attribute and the overall average of averages are calculated.

6. Save data: This button allows you to save the evaluation carried out, which facilitates its use in a *dashboard* and the creation of corresponding statistical graphs.
7. Clear data: This optional function allows you to clean the *dashboard data* to perform another evaluation or save it to continue with the evaluation at another time.

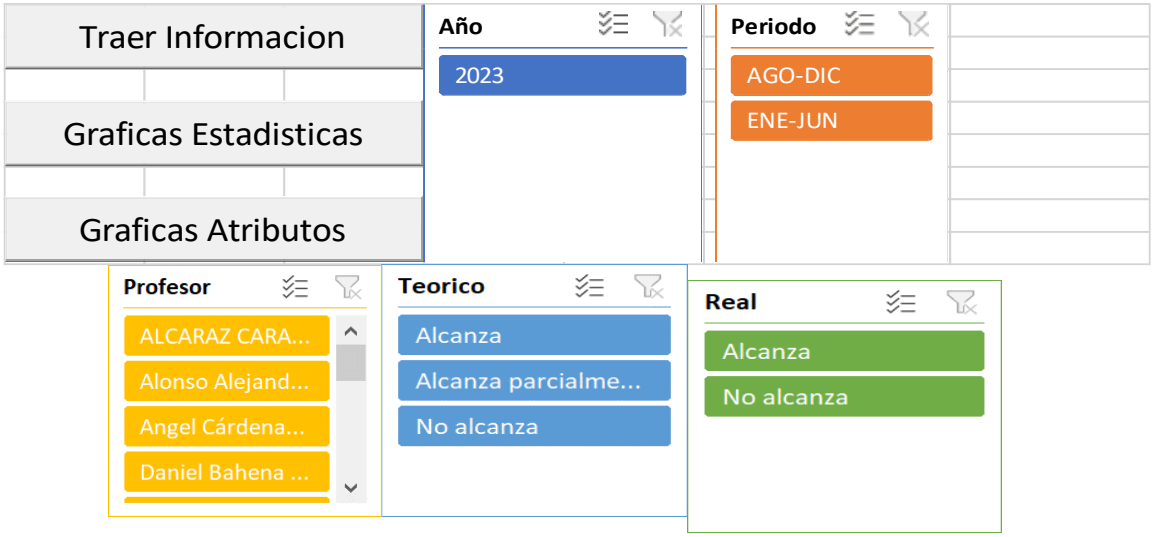
Other important fields are identified in the graphical interface, such as those intended for filling in the teacher's name, subject, group, semester and period. The *software*, in its base structure, already includes the type of attribute to be evaluated once the subject is selected, and through a button the corresponding evaluation criterion is chosen, which automatically incorporates the subject and the evaluation level, whether introductory , medium or advanced. In the *dashboard* you can see the final status of the evaluations, which highlights its interactivity and ease of use.

This report includes an example of the results obtained through the *dashboard*, as well as the graphs generated by this tool. One of the notable advantages is the possibility of carrying out evaluations directly in the *dashboard*, even if they have not been previously carried out in Drive, which demonstrates the future intention of using the *dashboard exclusively* as an evaluation platform.

To evaluate the reliability of the instrument, Cronbach's alpha test was applied (Hernández and Mendoza, 2018), which produces a coefficient between 0 and 1 (it is recommended that it be greater than 0.8). The test carried out in SPSS returned a value of 0.831, which indicates high reliability of the questionnaires and guarantees the reliability of the information collected, ready to be used in decision making. Furthermore, the validation of the instrument was reinforced through consultations with specialists on the subject, including two coordinators of the accreditation process of the Mechatronics Department and the institutional coordinator of said process.

Figure 5 shows a part of the graphical interface of the *dashboard* used for the evaluation of students by teachers.

Figure 5. Graphic interface of *dashboard instructions* for information capture, data processing and graph generation.

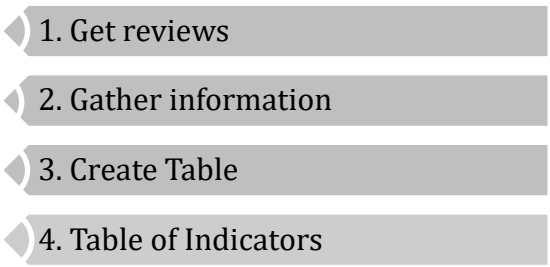


Source: self made

Results

To carry out the evaluations using the *dashboard*, you access the application for teachers, where you will find the following interface with these buttons as shown in figure 6.

Figure 6. Teacher graph buttons



Source: self made

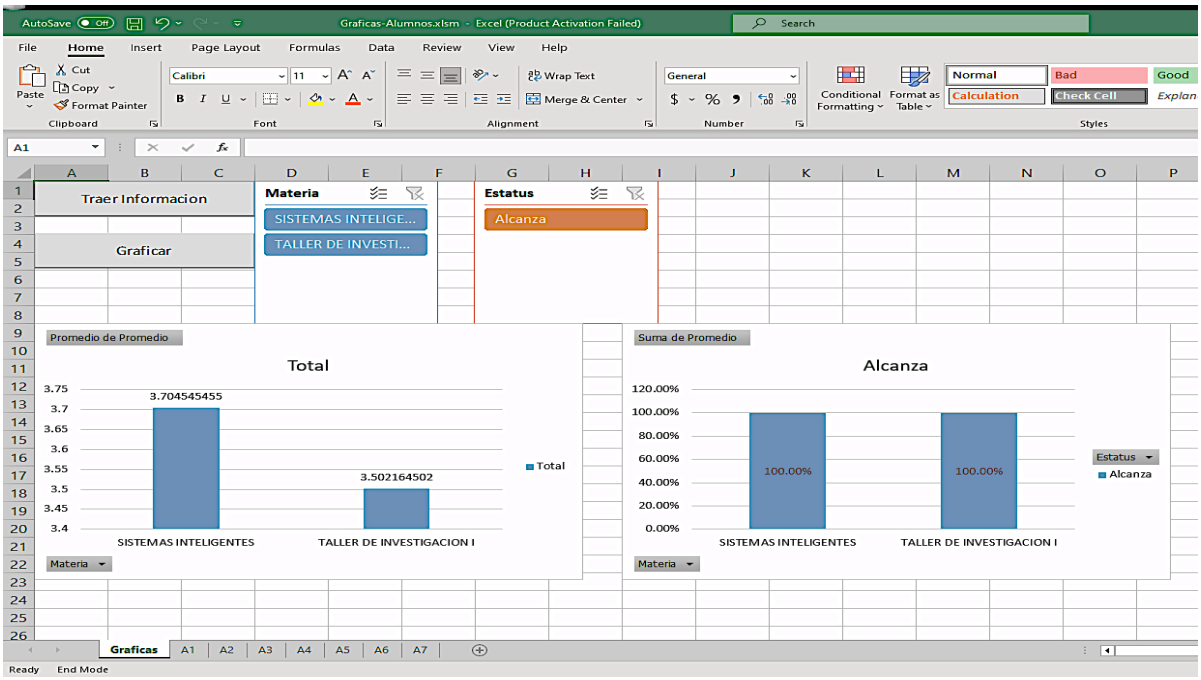
Below is a brief description of each of the buttons present in Figure 6:

1. Get assessments: Allows you to import files from Drive that contain assessments made by teachers. It also allows new evaluations to be carried out directly on the *dashboard* to capture data.
2. Combine information: After successfully importing the data, this button is used to combine the information. This is important to do so that the data collected is not segmented or altered.

3. Create table: Once the information has been gathered, this button is used to generate statistical tables where the averages obtained in the evaluations will be shown.
4. Table of indicators: By pressing this button you can obtain information on how the CACEI attributes are being managed within the subjects. This allows us to identify areas of improvement in the academic performance of students.

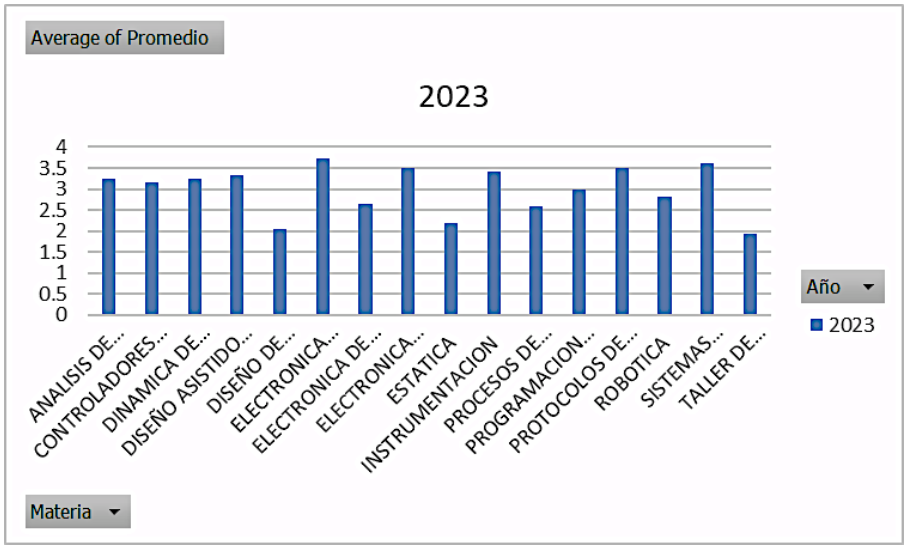
Initially, the data of the teacher and the students already evaluated are imported to have all the necessary information in the application file. Subsequently, you can see the graphs of the evaluations in figures 7, 8 and 9.

Figure 7 . Example of graphs of results by subjects in the teacher *dashboard*



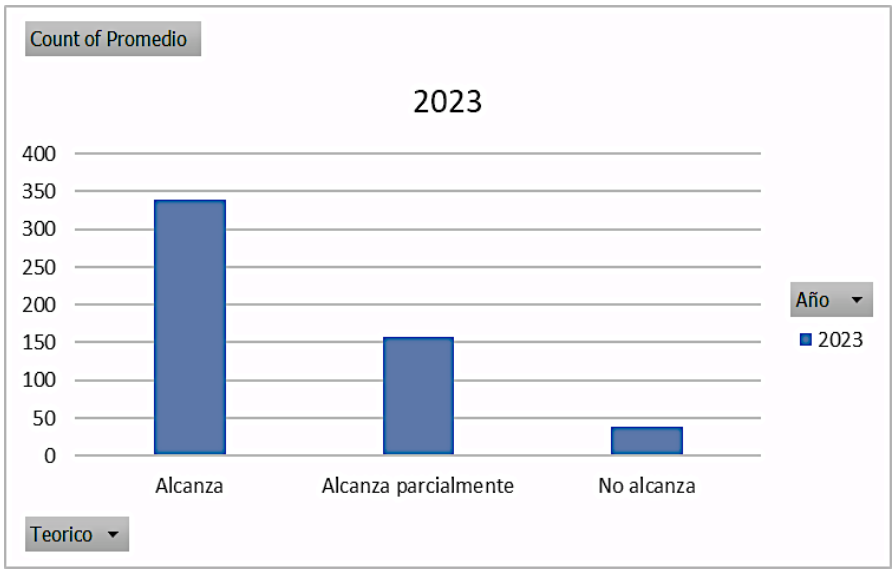
Source: self made

Figure 8. Graph of valuation averages in subjects Jan-Jun 2023



Source: self made

Figure 9. Graph of total values of the level achieved for the exit attribute



Source: self made

Table 6 shows value labels on the scope of the graduation attribute at the levels of reached, partially reached and not reached (January-June 2023).

Table 6. Labels of values that reach, partially reach and do not reach (Jan-Jun 2023)

Scope level	Labels in January-June 2023	% of exit attribute achievement	Classification of whether or not the exit attribute is achieved
Achieves	340	63.32	92.74% achieves
Partially reaches	158	29.42	
It's not enough	39	7.26	7.26% not enough
Total	537	100	100

Source: self made

According to Table 6, it can be seen that of the evaluations carried out during January-June 2023, 63.32% of the students reached the level requested by the graduation attribute, while 29.42% partially reached it and 7.26% reached it partially. can not reach. In terms of a minimum achievement of the graduation attribute, these results can be interpreted as 92.74% of students achieving it and 7.26% not.

Once the data of all the subjects evaluated by teachers and students were collected, a comparison was made between them to verify the proposed hypothesis. The data were entered directly into the SPSS *software* to perform a statistical analysis due to its ease in data management and graph generation (SPSS *software* version 22 and AMOS V20 were used in this work). Below is an example of the descriptive statistical evaluation of the Electrical Circuit Analysis (ADCE) subject included in the evaluation.

Likewise, a summary of results is provided that includes descriptive statistics, test for homogeneity of variances, ANOVA table and graph of means. The descriptive table allows us to observe the behavior of the evaluations of both students and teachers, which shows a minimal difference between both groups as shown in table 7.

Table 7 . Descriptives of the ADCE subject with 95% confidence interval.

Descriptive ADCE Evaluation

	No.	Half	Deviation standard	Standard error	95% confidence interval for the average			
					Lower limit	Upper limit	Minimum	Maximum
Teachers	12	3.3500	.78682	.22714	2.8501	3.8499	2.20	4.00
Students	12	3.0658	.31590	.09119	2.8651	3.2665	2.56	3.67
Total	24	3.2079	.60405	.12330	2.9528	3.4630	2.20	4.00

Source: self made

In the case of the homogeneity of variances test, it is explained that the p value of the Levene test is greater than 0.05, which indicates that the variances are not significantly different from each other. In other words, the assumption of homogeneity of variance is met as shown in Table 8.

Table 8. Levene's test for homogeneity of variances

ADCE Evaluation			
Levene Statistician	gl-1	gl- 2	Next.
12.958	1	22	.07

Source: self made

On the other hand, table 9 shows an ANOVA table for the evaluation of the ADCE subject in question and indicates that the means between groups are equal because the F obtained from the data of the subject is 1.348 and the critical value of the statistical table is 4.30, that is, it is confirmed that the means are equal.

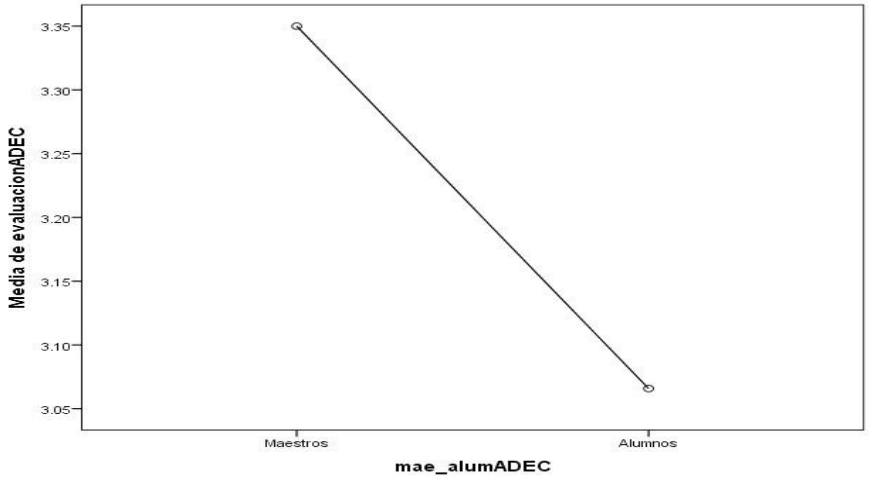
Table 9 . ANOVA table (ADCE subject)

ADCE EVALUATION								
Assessment			Sum of squares	gl	mean square	F		Next
Between groups	(Combined)		.485	1	.485	1.348	(Combined)	.258
	Term linear	Contrast	.485	1	.485	Linear term	Contrast	.258
Within groups			7.908	22	.359			
Total			8.392	23				

Source: self made

The graph in figure 10 shows the final comparative result of means obtained between the evaluation carried out by the teachers and the student's self-assessment.

Figure 10. Comparative graph of teacher versus student means.



Source: self made

Based on the graph presented in Figure 10, it can be concluded that there is no substantial difference in the mean values, which are 3.34 and 3.06, respectively. This supports the validity of the null hypothesis, which establishes that there is no significant difference between the values obtained in the evaluations carried out by students and teachers with respect to the evaluation of attributes.

After describing how the test of homogeneity of variances and the ANOVA table were obtained, Table 10 presents a summary of means and critical values of all the subjects evaluated. Only 16 of the 21 proposed subjects were evaluated due to lack of evaluation by teachers or

inconsistent evaluations that did not contribute to the study statistics.

In table 10, the first row shows the subjects evaluated, while the following rows show the degrees of freedom between groups, the degrees of freedom within groups, the quadratic mean between groups, the quadratic mean within groups and the level of significance. The F value (1.348), obtained from the ANOVA statistical table, and the critical value of the F table (4.32), indicate the difference between these last two lines. Furthermore, the fact that the F value in the table is greater than that of ANOVA allows us to determine if there is a correlation between the variables of the evaluation carried out by the teachers and that carried out by the students.

Table 10. Summary of means and critical values obtained in SPSS for all subjects evaluated.

Subjects	EST	ADCE	CHYN	DAC	DS	DISC	DE	EA	ED	INS	MIC	PA	PCI	PLC	ROB	T - I	T-II
df between groups	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
df within groups	58	22	14	16	20	16	10	8	38	14	14	30	18	6	18	16	8
Root mean between groups	0.432	0.485	0.092	0.938	0.289	0.247	0.19	0.006	0.127	0.018	0.263	3.713	1.568	0.045	0.409	1.105	0.404
Root mean square within groups	0.254	0.359	0.263	0.071	0.268	0.093	0.15	0.266	0.081	0.367	0.193	0.271	0.149	0.185	0.446	0.211	0.241
next	0.198	0.258	0.565	0.002	0.312	0.123	0.287	0.882	0.218	0.83	0.263	0.001	0.004	0.639	0.351	0.036	0.231
F (data)	1.699	1.348	0.348	13.243	1.076	2.657	1.266	0.024	1.572	0.048	1.358	13.701	10.555	0.243	0.918	5.239	1.678
critical value Table F (with $\alpha = 0.05$)	4	4.3	4.6	4.49	4.35	4.49	4.96	5.32	4.06	4.6	4.6	4.17	4.41	5.99	4.41	4.49	5.32
Difference	2.301	2.952	4.252	-8.753	3.274	1.833	3.694	5.296	2.488	4.552	3.242	-9.531	-6.145	5.747	3.492	-0.749	3.642

Source: self made

From table 10 previously seen, it is observed that in 12 of the 16 subjects evaluated, positive values of the difference are recorded, while in four of them the difference is negative. This indicates that 75% of them have a proximity of values between the evaluations carried out by the teachers and the students' self-assessment, which suggests that the values of the evaluation carried out by the teachers coincide with the students' perception of their own performance.

On the other hand, the possible reasons why 25% of the subjects do not match the

evaluation could include the following:

- Inconsistent assessments by teachers. That is, not everyone carries out the evaluation uniformly or with the same criteria. In fact, some teachers may not carry out the evaluation in the corresponding format.
- Students' self-assessment is influenced to some extent by the way they are evaluated in their subject, regardless of the graduation attribute being evaluated.

Discussion

The statistical results obtained in this study show a general coincidence in the scope of graduation attributes by the students of the Mechatronic Engineering career, when compared with similar studies carried out in other institutions such as the UASLP, the TecNM of Sonora and the TecNM in Celaya in the CEA Department of Economic-Administrative Sciences. In fact, it was observed that in each of these institutions the expected values of achievement of the attribute were reached, with an average of 92.7%, which reflects satisfactory compliance with the goals proposed in this work.

However, some significant differences stand out in the methodology used to evaluate the attributes, as well as in the refinement of the criteria to define the items in the surveys. Variations were also observed in the naming of the attributes evaluated, with terms such as *introductory* , *intermediate* and *advanced* in some cases, and *achieved* , *partially achieved* or *not achieved* in others. In fact, the most notable discrepancy was found in the method of evaluating graduation attributes, since at the UASLP only one subject was evaluated, while at the TecNM in Sonora evaluations were carried out by cohort, with an exclusive focus on the impact of these attributes in the students' competencies. On the other hand, at the TecNM in Celaya, in the CEA degree, an attribute (AE3) was evaluated in a subject that obtained a score of 79.8% at the advanced level. In contrast to these approaches, in this work the seven graduation attributes were evaluated in 16 subjects, which covered the introductory, intermediate and advanced levels, with an average achievement of the attribute “achieved” of 92.7% in all the subjects evaluated. which is considered highly satisfactory.

Another distinction of this study with respect to previous works lies in the use of dynamic tables through a *dashboard* , as well as in the comparison between the students' self-assessment and the evaluation carried out by teachers in the same subject. In this sense, this statistical analysis revealed a minimal difference between the means, which supports the null hypothesis that suggests that there are no significant differences between both perceptions. This finding is

crucial, since it demonstrates a concordance in perception between what is taught and what is learned.

On the other hand, given that a limit has been reached in the use of the currently established criteria, it is necessary to expand the evaluation of attributes in the selected subjects. This implies evaluating not only one attribute, but the two or three that were originally proposed in academia, with different levels of scope. Furthermore, it should be noted that the use of the *dashboard* presents challenges, since it requires continuous maintenance to update and adapt to the changing needs of the curriculum. Even so, this tool offers interesting possibilities in terms of database management, the collection and evaluation of information in a single file, as well as the integration of historical data.

Conclusions

This work has satisfactorily achieved the scope of the general objective, since a model has been developed for the evaluation of the graduation attributes of the Mechatronics Engineering educational program, as well as a proposal for continuous improvement that can be extended to the rest of the TecNM programs. in Celaya. To achieve these objectives, various activities were carried out that contributed to the success of the project, such as carrying out an exit survey to students on the graduation attributes with an impact on the rubric prepared by the academy, the implementation of a *dashboard* so that teachers evaluate the graduation attributes in the selected subjects, the creation of a database to store historical information from the analysis of the students' self-assessment survey, and the development of a *dashboard* to compare the information obtained from both students and of the teachers.

In this sense, it has been shown, first of all, that the mean values in the evaluation of attributes by the teachers do not differ significantly from those obtained by the students, which shows a high correlation in the ANOVA table between the socks. Furthermore, the results of the homogeneity of variances test suggest that they do not differ significantly from each other, thus meeting the assumption of homogeneity of variance.

Suggestions and recommendations

Given that a *dashboard* provides graphical representations that facilitate the interpretation of the results, the following actions are suggested to promote its subsequent use: give value and accessibility to the data, involve other departments of the institution in the evaluation of graduation attributes, have a global vision of the information and obtain reports that are easy to understand and efficient in their presentation.

Likewise, to maximize the effective use of the *dashboard* , it is recommended to make the necessary updates that save time and effort in its use, which can make it a fundamental tool for monitoring planned strategies.

In addition, it is suggested to continue working on the development of a tool at the institutional level that standardizes all the information necessary for accreditation purposes in all majors. This will facilitate the documentary collection required by certifying entities such as CACEI or other organizations.

It is important to note that there is currently variability in the way each program evaluates graduation attributes, which highlights the need to provide continuous training to teachers in this process, especially given the frequent rotation of subjects and teachers. It is recommended, therefore, to ensure that all teachers evaluate subjects in a timely manner and use consistent criteria in their evaluations.

Finally, as a future line of research, it is suggested to return to the proposal of a matrix that relates attributes, subjects and levels of scope. For this purpose, it will be necessary to adjust the measurement instrument to the new criteria and items derived from this proposal, so that a multidimensional situation can be generated that allows evaluating various attributes at different levels and obtaining more advanced correlations to continuously optimize the measurement process. accreditation of courses.

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