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Rosalva Leal Silva
Dra.
Institution: Universidad Autónoma del Estado de México (UAEM)
Address: Facultad de Química, Universidad Autónoma del Estado de México, Paseo Colón esq. Paseo Tollocan, s/n, Col. Residencial Colón, C.P. 50120, Toluca, Estado de México, México
E-mail: rosalvaleal@gmail.com

Martha Diaz Flores
Dra.
Institution: Universidad Autónoma del Estado de México (UAEM)
Address: Facultad de Química, Universidad Autónoma del Estado de México, Paseo Colón esq. Paseo Tollocan, s/n, Col. Residencial Colón, C.P. 50120, Toluca, Estado de México, México
E-mail: marfalda08@gmail.com

Ana Margarita Arrizabalaga Reynoso
M. E. P.
Institution: Universidad Autónoma del Estado de México (UAEM)
Address: Facultad de Química, Universidad Autónoma del Estado de México, Paseo Colón esq. Paseo Tollocan, s/n, Col. Residencial Colón, C.P. 50120, Toluca, Estado de México, México
E-mail: amarrizabalaga@gmail.com

María Esther Aurora Contreras Lara Vega
Dra.
Institution: Universidad Autónoma del Estado de México (UAEM)
Address: Facultad de Química, Universidad Autónoma del Estado de México, Paseo Colón esq. Paseo Tollocan, s/n, Col. Residencial Colón, C.P. 50120, Toluca, Estado de México, México
E-mail: mecontrerasl@uaemex.mx

Sandra Luz Martínez Vargas
Dra.
Institution: Universidad Autónoma del Estado de México (UAEM)
Address: Facultad de Química, Universidad Autónoma del Estado de México, Paseo Colón esq. Paseo Tollocan, s/n, Col. Residencial Colón, C.P. 50120, Toluca, Estado de México, México
E-mail: slmartinezv@uaemex.mx

Eduardo Martin del Campo López
M. C. S
Institution: Universidad Autónoma del Estado de México (UAEM)
Address: Facultad de Química, Universidad Autónoma del Estado de México, Paseo Colón esq. Paseo Tollocan, s/n, Col. Residencial Colón, C.P. 50120, Toluca, Estado de México, México
E-mail: emartindelcampol@uaemex.mx

José Francisco Barrera Pichardo
M. S. CH. E.
Institution: Universidad Autónoma del Estado de México (UAEM)
Address: Facultad de Química, Universidad Autónoma del Estado de México, Paseo Colón esq. Paseo Tollocan, s/n, Col. Residencial Colón, C.P. 50120, Toluca, Estado de México, México
E-mail: jfbarrerap@uaemex.mx

César Pérez Alonso
Dr.
Institution: Universidad Autónoma del Estado de México (UAEM)
Address: Facultad de Química, Universidad Autónoma del Estado de México, Paseo Colón esq. Paseo Tollocan, s/n, Col. Residencial Colón, C.P. 50120, Toluca, Estado de México, México
E-mail: cpereza@uaemex.mx

ABSTRACT
The objective of this work was to reflect on the responsibility that the educational program in Chemical Engineering at UAEMex has in translating its intentions into actions, as well as establishing an organised process for continuous planning and systemic evaluation which is reflected in a continuous improvement plan. This process entails the inclusion of tools that permit the evaluation or self-evaluation of the measurements and forms in which the educational program is improving its actions in achieving the criteria established by the acreditory organisation *Consejo de Acreditación de la Enseñanza de la Ingeniería* (CACEI) (Accreditation Board for the Teaching of Engineering) in their *Marco de Referencia* (Frame of Reference) 2018 in the international context.

Keywords: planning, evaluation, continuous improvement, chemical engineering, accreditation.

1 INTRODUCTION

Public universities in Mexico and Latin America face global challenges that are imposed on knowledge, information, and expertise by society through educational policies that cause important changes in the organisational structures for the development of substantive activities. As such, the planning - evaluation necessitates a deep reflection of the pertinence of evaluation processes in public universities, and their impact on the professional training process in an ever-more dynamic and complex global stage (Bazán et al., 2022; García, 2009).

In the current context of higher education in Latin America, important changes can be observed that should be considered for the development and implementation of public policy specific to this level of studies. Mexico finds itself in a process of modernisation, within which the mechanisms of evaluation - accreditation have a fundamental role for the implementation of actions that should directly impact the quality of the professional training process. This is a growing topic of interest in the assessment procedures of academic activities.

As such, the evaluation of an educational program aims to provide information with evidence on the quality of academic - administrative actions, as well as that of management, considering the improvements of their actions in executing their plan. This is derived from the self-evaluation carried out in the program, which becomes a guide for the tracking and fulfilment of the continuous improvement of the educational program (Ocampo, 2022).

At the same time, an educational program is efficient when the impact of its achievements or results surpasses that which is expected of it. These results can be measured or quantified under the Frame of Reference of the accreditor organisation, whose main objective is to offer a strategic mechanism that guarantees the improvement in the teaching - learning process of the educational program. Through this, the organisation aims to guarantee graduation attributes and educational objectives which graduates of the program find in the world of work. In order to achieve this, is is necessary to propose and understand an improvement plan which considers the following documents:

- Self-evaluation of the educational program, considering the frame of reference criteria from the accreditor organisation
- Educational program development plan
- Accreditation verdict
- Areas of opportunity and strengths

(Perez-Juste, 2000) mentions that "the evaluation of educational programs is framed in this complexity with the requirements towards all social programs in western societies and the development of the understanding of the services".

The above frames the necessity of performing one's own self-evaluation for planned improvement, and that the community of the program be committed to the change that the self-evaluation indicates. This involves generating new challenges, priorities, and lines of action for evaluation criteria based on recommendations made by the accreditor organisation. This considers self-evaluation as a permanent attitude of both the program and the institution for reviewing and monitoring that what they are doing is prior to a decision-making analysis.

2 METHODOLOGY

2.1 CASE STUDY

This investigation corresponded to a case study, understanding this as the "investigation that has as its purpose the identification of different strategies of universality and particularity present in a studied circumstance" (Erickson, 1989). The fundamental aspect is to revise the application of indicators of the different analysis criteria and their impact on the continuous improvement of the educational program in Chemical Engineering of the Chemistry Faculty at the *Universidad Autónoma del Estado de México*

(UAEMéx) (Autonomous University of the State of Mexico). This is in addition to the constant modernisation of the analysis that involves the planning - evaluation process of the educational program; the obtained results should express the singular aspects of the analysed situation, and as such it does not have the purpose of generalisation in a quantitative or qualitative sense.

(Stake, 1998) identifies three different types of case studies: “intrinsic, instrumental, and constructive”. The purpose of these is not to construct a theory, but that the case itself be of interest.

> *The studies of instrumental cases are examined in order to provide inputs of knowledge into an investigation subject or problem. The collectives serve in the construction of a theoretical body, finding common elements, differences, and the accumulation of information (Stake, 1998).*

For the investigation characteristics, an intrinsic case study was carried out given that the intention is to attract interest regarding the impact that the performance indicators have on the continuous improvement of the the educational program through the following list of variables:

Criteria for the self-evaluation of a CACEI educational program

1. Academic staff
2. Students
3. Study plan
4. Assessment and continuous improvement
5. Infrastructure and equipment
6. Institutional support

These criteria make up a total of 30 indicators and, considering the nature of the study, they are geared towards obtaining a holistic assessment of the areas of importance that intervene in the self-evaluation process. This is done through the standardised evaluation mechanisms, and as such the observation and analysis variables are centred on institutional and curricular aspects, as well as educational policies.

2.2 GENERAL INVESTIGATION DESIGN

A non-experimental transactional design was considered, which is an information system designed in order to collect, store, and retrieve all kinds of information. This is not carried out through manipulating the variables, but instead through analysing their occurrence and interrelation. It pertains to a case study with a mixed qualitative - quantitative focus because it is carried out as an analysis in which all “the characteristics that are implemented as collective or group samples, and must be treated with depth,

seeking a complete understanding of its nature", circumstance, and context can be applied (Hernández-Sampieri, 2018).

Mixed focus is a process that collects, analyses and links quantitative and qualitative data in a single study in order to respond to an approach to the problem involving the conversion of quantitative and qualitative data and vice versa. This new focus, particularly in Ibero-America, is named Interpretive Synthetic Methodology. It should be highlighted that this focus goes further in data collection than different manners of the same phenomenon.

In mixed focus, the theoretical creativity is enhanced, with sufficient critical assessment procedures. It is important to indicate that without one of these investigation elements, a study can find weaknesses. The world and its phenomena are complex to the point that a method for investigating dynamic and highly intricate relationships is required; mixed focus is the best tool for achieving this. Mixed models allow "that we explore and exploit" the data in a better way. In summary, mixed focus is equal to a higher extent, depth, diversity, interpretive richness, and sense of understanding. With access to quantitative and qualitative data, both sources of data can be used in order to understand the investigation problem to a greater extent and depth.

Both the qualitative and quantitative focuses equally require a qualification and to be open to change. Carrying out both types of study is equally important. A mixed investigation requires time, the management of extensive volumes of data, and the carrying out of various analyses. In order to bring this to fruition, the collection of qualitative and quantitative data is required.

The characteristics of revised information will involve its analysis with a quantitative focus in the part that corresponds to the opinion survey of the curricular committee members, students, and administrative personnel of the Educational Program in Chemical Engineering at UAEMéx. The quantitative analysis was carried out through the collection of documents of the regulatory framework. Among them, the educational program curriculum, the institutional development plans 2018-2021, the development plans 2012-2016, and 2016-2020 of the Chemistry Faculty with their corresponding annual evaluations, such as the CACEI self-evaluations 2010 to 2015, in addition to the viewing of the instances that contribute to the professional training process. With these elements, it was possible to carry out the corresponding qualitative and quantitative analyses, which form a central aspect of this investigation process, in which the mixed model proved to be a fundamental tool.

2.3 INVESTIGATION - ACTION

For carrying out this investigation, it was necessary to consider concepts and paradigms that provide the theoretical - methodological basis that sustains the implementation of the continuous improvement strategic model. In a thorough analysis of many of them, it was determined that the

investigation - action model provides this basis, in large part, given that the objective of investigation - action is to solve immediate and daily problems, and to improve correct practices. Its fundamental purpose is centred on providing information that guides decision-making for programs, processes, and structural reforms, which are appropriate considerations to be applied in a case study such as this.

Investigation - action is described as “reflection related to the assessment”. Investigation - action in schools analyses the human actions and social situations experienced by professors, such as:

a) Unacceptable in some aspects (problematic)

b) Susceptible to change (contingent)

c) Require a practical response (prescriptive)

The expression “investigation - action” was coined for investigations with the following characteristics:

1. Involving an activity which is undertaken by groups or communities with the objective of changing their circumstances. It re-enforces and maintains the sense of community as a means of achieving “the common good”, instead of promoting exclusively individual good.

2. A reflexive practice in which there is not a distinction between the practice that is investigated and the process of investigating the practice. The instructional and administrative strategies in the management process of an educational program such as that of Chemical Engineering supposes the existence of practical theories regarding the manners of embodying the educational values in concrete situations. When they are reflexively carried out, they constitute a form of investigation - action.

Investigation - action is related to daily practical problems experienced by professors, instead of “theoretical problems” defined by investigators. The purpose of investigation - action consists of strengthening the understanding of the professor (assessment) regarding their problem. As such, an exploratory posture regarding the initial definitions of the same situation that the professor detects is adopted. Upon explaining “what’s happening”, investigation - action constructs a “guideline” on the incident in question, relating it with a mutually interdependent contingency context, which is to say, incidents that are grouped due to the occurrence and variance of one depending on the appearance of the others (Elliott, 2004). Investigation - action interprets “what happens” from the point of view of those that act and interact in the problem situation, such as professors and students, or professors and the director. As investigation - action considers the situation from the point of view of the participants, it will describe and explain “what happens” with the same language they used. This is to say, the language of common sense that people use in order to describe and explain educational actions and situations that are addressed.

As investigation - action contemplates problems from the point of view of those that are involved, it can only be validated through free, open, critical, reflexive, and purposeful dialogue that takes place between the members of the work group. In this case, the curricular committee is considered, in principle, to be the group that carries out this process. This allows the collection of baseline results for the implementation of the model. Disciplinarily, investigation - action specifies a series of activities in the following sequence:

1. Clarification and assessment of the problematic situation in the practice.
2. Formulation of action strategies in order to resolve the problem.
3. Implementation and evaluation of the action strategies.
4. Clarification and assessment subsequent to the problematic situation (and so on in the following reflection and action series)

An important part of the investigation - action process is the clarification of the problem, making the “theory of action” of the practice explicit, and showing how elements can be joined in order to resolve a case study or a practical problem.

Regarding educational investigation - action, the first stage supposes the developments of explicative theories that analyse the institutional factors and the freedom of the professors to promote educational values in classes. This is in addition to achieving significant learning among the students in the interest of contributing towards the institutional mission and objective, and in our case, towards the educational program.

The investigation - action process considers it important to continue the formation of scientific hypotheses that require a new practical theory in order to change the situation towards one that is more coherent, and has better characteristics, in order to achieve superior levels of quality in the educational process. This is due to the current state of their scopes and advantages, but also their faults and limitations.

The investigation - action paradigm in professional practice is not easy to implement in educational institutions, considering that on occasions the organisation levels and management have been left behind in terms of an overriding need for change that the current circumstances of a globalised and ever-changing world demands of them.

The speed of social change in contemporary society creates unstable contexts for professional practice. The culture of individual work is incapable of developing new professional knowledge that is required in order to resolve practical problems of growing complexity. The educational investigation - action paradigm indicates the need for an association and integration of efforts in order to achieve the modernisation of tasks and activities in a more organised way. As such, the appearance of the investigation - action movement in the educational sphere represents a fundamental response in achieving this objective.

3 RESULTS

In accordance with the accreditor organisation of the oldest educational programs in Mexico (CACEI), the graduation attributes (CACEI, 2018) "they are a group of individually evaluable results that define the indicative components of the potential of graduates in acquiring the competencies or capabilities to exercise the practice of engineering at an appropriate level", which should be evidenced through learning outcomes.

In order to achieve the above, the consideration of five important elements after self-evaluation is required:

a) Continuous improvement plan

b) Evaluation plan

c) Development of attributes for learning unity

d) Evaluation through rubrics

e) Opinion of the groups of interest

The most important purpose of self-evaluation is not to test, but to improve, and to this effect, feedback as part of a 'continuous revision and improvement' process leads to the transformation.

It is defined as an improvement plan through the measures of change that an educational program takes in order to improve its positive impact on achieving the graduation attributes and educational objectives of their graduates - from three to six years of graduation in their working and social context. A greater development of the graduation activities should be the axis upon which any improvement will be based.

In order to make the improvement plan efficient, certain conditions must be met:

- Convince academic fields to convert to the educational program.
- Leadership of the directive team.
- Involvement and agreement of the teachers.
- Attitude towards continuous improvement.
- Carry out activities in different ways, mainly in the evaluation of lessons, as well as changes in attitude and focus.
- Performance indicators through monitoring and evaluation of the taken measures. Clear definitions of the problems and courses of action that should be focused on, as well as involving the responsible personnel and starting with small changes in order to achieve big changes.

3.1 DATA ANALYSIS PROCEDURE

In accordance with (Medina, 2006), upon making reference to Carreño, it is emphasised that "without evaluation, it will never be known if the most appropriate procedures for achieving the institutional objectives are being employed". Evaluation involves making reference to that which is observed, according to the definition by the Joint Standards Committee for Educational Evaluation (Hansen, 1994); the methods are diverse, and it is recommended that the qualitative methods be linked with the quantitative ones in order to obtain more complete and integral information. This is in addition to taking into account the achieved advances and establishing consulting channels with the social and production sector.

Evaluation is an integral part of planning; it is a permanent process, and has an impact on planning and scheduling, and considers each element of the system, which offers a complete overview. Evaluation must be cooperative, which involves the participation of all elements that intervene. This means that the academic - administrative community must take charge of the different analysis categories and their respective performance indicators.

An educational program should make an impact on and be subjected to three evaluation methods: external, internal, and self-evaluation. If the evaluation is carried out by those responsible for the design and operation of the program to be evaluated, then it is self-evaluation. If it is carried out by other members of the institution, it is an internal evaluation. If it is carried out by people outside the institution, then it is an external evaluation.

The evaluation types in terms of the period of information gathering are:

- Analysis: Current situation of the program.
- Training: Performance of the program in different categories
- Summative: Overview of the program.
- Prospective: Creation of scenarios that still do not operate in reality.

3.1.1 Qualitative analysis procedure

The qualitative designs are investigation designs, where there are not two that are the same or equivalent. They are artisanal, "hand-made" pieces, and are tailor-made (Hernández-Sampieri, 2018). This stage is initiated with the summary of the regulatory framework documents; the visit to the organisations that formally participate in the professional training process (chief of the educational program department, coordinations that offer information and data for the construction of indicators, sub-directors and director of the academic organisation), with the objective of obtaining necessary information. The documents that were considered for this study are: The *Proyecto Curricular del programa educativo* (The Curricular Project of the educational program), the *Plan de Rector de*

Desarrollo Institucional 2017-2021 (The Rector's Plan for Institutional Development 2017-2021), and the *Plan de Desarrollo de la Facultad de Química 2020-2024* (Development Plan for the Chemistry Faculty 2020-2024).

3.1.2 Quantitative analysis procedure

The sample for the processing of the data of the opinion survey given to the curricular committee, teachers, administrators, and students, applies as an instrument of opinion in the collection and construction of the indicators; it turned to the use of descriptive statistic tools: mean, mode, variance, and standard deviation, which were used for the quantitative analysis. One of the characteristics of quantitative measuring is that it allows greater precision with respect to that which is measured, seeking a greater expressed objectivity by the data.

The structure of the questionnaire that was used to collect and assimilate the information was designed considering the different categories and the respective performance indicators, which are contained in the reference framework of the external accreditor organisation (CACEI). The questionnaire is separated into two parts; the first contains three open questions that investigate the difficulties and good choices in compiling and constructing the performance indicators. The same is true for the activities that the academic organisation carries out in order to bring about self-evaluation progress. The second part refers to perception of the goal by substantial or adjective role regarding clarity, and the extent to which it is possible to achieve it. It also refers to the extent to which it can be shared through the management group of the educational program, and how the categories and their respective indicators for improving the educational program are inter-related.

The results obtained with the statistical processing allows for a clear vision of the opinion of the participants in the construction of indicators and categories, and the relationship between them, directing this to the improvement of the quality of teaching and learning. For this purpose, the results of the thirty applied surveys were analysed. Once the information from the surveys was revised and broken down, a statistical systemisation process was carried through a rubric that consisted of:

1. The concentration of the information in the questions in the applied opinion survey.
2. Analysis of the instrument guide with the objective of obtaining their opinion on the measurement indicators, grouping the questions based on these indicators in order to facilitate the metric process, and define the measurement scales.
3. How the type of instrument is expressed in a qualitative scale or Likert; it was decided that a scale from 1 to 5 (1 = nothing, 2 = a little, 3 = regular, 4 = acceptable, and 5 = completely) would be used.

For the data processing, a statistical model was designed that allows the gathering and processing of the responses regarding the opinion shown by the respondents. In order to achieve this, a statistical exercise was carried out, leading to: (i) the obtention of quantitative indicators of the general character and objective, (ii) the reduction of methodological biases, (iii) the reduction of fluctuations owing to academic personnel changes in each self-evaluation, and (iv) the possession of separated information regarding the distinct aspects that constitute the opinion of those who responded to the survey.

4 CONCLUSIONS

The strategic plan for continuous improvement, through analysis, informs whichever adjustment that should be carried out in the monitoring and contrast by academic year, integrating and monitoring the performance indicators. In this way, the performance of graduates in society can be identified qualitatively and quantitatively as a function of the performance of different processes that impact the training of the student. Additionally, it guarantees to interested groups that the educational program of the Chemical Engineering Degree, and its curricular committee, add value to their graduated students, whose social responsibility impacts society.

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