

Promoting educational innovations in the accreditation of 3 industrial engineering programs in Bogota

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Abstract—This innovative practice full paper answers the question of how high-quality accreditation promotes educational innovation in accredited industrial engineering programs in Bogota. Using the case study method, Higher Education Institutions in Colombia were selected as the context, three industrial engineering programs in Bogota as cases, and educational innovation processes in the accreditation process as the unit of analysis. In each program, a professor or an administrative involved in the accreditation process was selected, and as categories of analysis the learning experience, teaching practices, curricula, and institutional policies were studied. These categories were studied using semi-structured interviews that allowed an understanding of the experience lived in the accreditation process, and the documentary analysis was intended to make an analysis of the learning experience, the teaching practices, the curricula, and the institutional policies. It was concluded that educational innovation is a learning process in programs with only one accreditation since strong educational changes are promoted in the first accreditation. In comparison, programs with more than one accreditation do not need to include strong educational changes. Finally, it is recommended to focus the accreditation policy in Colombia on programs that want to be accredited for the first time, evaluating the learning experience in the student factor, the teaching practices in the teacher factor, and the curricula in the academic processes factor.

Keywords—accreditation, educational innovation, industrial engineering, engineering education.

I. INTRODUCTION

The accreditation process is carried out in five phases, a first phase of initial conditions, a second phase of self-evaluation, a third phase of external evaluation, a fourth phase of final evaluation, and a fifth phase of public recognition. [1]. Likewise, accreditation involves three evaluations: self-evaluation, external evaluation, and final evaluation. The National Accreditation Council makes a first visit to assess the initial conditions of the higher education institutions, to guide them in their self-evaluation processes, and to know whether or not they have the conditions to continue the accreditation processes successfully. The examination of the quality of programs is made according to the quality characteristics grouped in factors. These factors represent the elements of academic work, the development of academic processes, and the impact on the environment influenced by Higher Education Institutions and their programs.

The final concept of the National Accreditation Council on the quality of a program is the integrated consideration of the ten factors so that the fulfillment of each quality characteristic will be defined using the integral evaluation of the aspects to be evaluated. Therefore, the final concept synthesizes the judgments on the sets of elements such as the characteristics,

aspects to be evaluated, and factors [1]. The evaluation factors are fundamental for assessing programs and are grouped into four dynamics that a high-quality program should have. The first dynamic consists of what the academic program does, which must be coherent with the mission, vision, and Institutional Educational Project of the Higher Education Institution, and this relationship must be known and appropriated by the academic community. The second dynamic is to do what it says it does, that is, to relate what it says it does and what the program does to achieve it, through evidence in teaching qualifications, teaching quality, excellent research, outstanding students, adequate funding, and academic freedom. The third dynamic is to prove it, i.e. the program must demonstrate the high quality of what it says and what it does, through processes of self-regulation, self-evaluation, and external evaluation. The fourth dynamic is improvement, understood as the capacity of a program to develop a continuous improvement and innovation plan, which responds to the needs of self-evaluation [1].

Ensuring the quality of engineering education programs is a problem in developing countries, moving from state control to private control determined by market forces, so that education will be an industry-based commercial activity, with increased privatization and reduced access due to higher fees [2]. In Latin America during the 1990s, accreditation processes were introduced at the national and regional levels with Mercosur and NAFTA [3]. In 2010, among Latin American accreditation systems for engineering programs, the oldest is the Council for the Accreditation of Engineering Education in Mexico, followed by the National Accreditation Council in Colombia and the National Commission for University Evaluation and Accreditation in Argentina. However, university systems such as the Peruvian and Bolivian have isolated accreditation processes generated by the structural and economic problems of the State [4].

The objective of this research is to establish the relationship that may exist between the promotion of educational innovation and high-quality accreditation processes. This innovation can be generated by stakeholders who find a need and an opportunity for improvement. However, developing educational innovations requires overcoming faculty burnout, securing resources, involving more institutional stakeholders, and ensuring the sustainability of the innovation [5]. These challenges can be solved with multidisciplinary networks that share the same interests and values as their members. Likewise, it is possible to guarantee the sustainability of innovation through a sense of belonging, transforming existing practices, allowing feedback and continuous improvement, and a policy of incentives for innovative teachers [6]. With all the above, it will be possible to demonstrate greater commitment and positive evaluations in the institutional context [7].

II. METHODOLOGY

The methodology proposed below sought to solve the research question "How does educational innovation promote high-quality accreditation in accredited industrial engineering programs in Bogotá?" through a qualitative design from the hermeneutic paradigm of educational research, which implements Yin's multiple case study method [8].

A. Research approach

This research focused on the hermeneutic paradigm, which relates to the understanding of a phenomenon and its subsequent interpretation [9]. This paradigm recognizes that we are beings of language, which gives meaning to the world and is the best framework from which to analyze how organizations construct meaning around the processes of accreditation and innovation [10].

B. Research method

The method chosen was the case study since it sought to guide a decision, which turns out to be an empirical question that investigates a contemporary phenomenon when the boundaries between it and its context are not evident. This question addresses the specific situation in which there are more variables of interest than data, which allows us to rely on the various sources of evidence and guide the data collection [8].

The multiple case study method made it possible to analyze three conditions: the type of investigation of the problem posed, the degree of control over the behavioral events, and the degree of focus on contemporary events. Analyzing these three conditions, the multiple case study was used in this research, because it has a "how" research question, no control over the behavioral events, and a focus on contemporary events.

First, concerning the type of research question, a "how" question is used in this case study because it inquires about a contemporary set of events over which one has little or no control. Second, the relevant behaviors of the objects of study cannot be manipulated and an emphasis is placed on examining contemporary events. Therefore, the use of the case study was confirmed for its ability to deal with evidence beyond the conventional historical study, which includes two sources of evidence such as direct observation of the events studied and the systematic interviewing of those involved in these events [8].

C. Cases

Following the case study method, a multiple case study with preset categories was implemented. This case study had as context the Higher Education Institutions in Colombia, as cases the industrial engineering programs, and as a unit of analysis of the processes of educational innovation.

Regarding industrial engineering programs, at the end of 2019, there were 35 undergraduate programs accredited with high quality by the National Accreditation Council. According to their geographic location, most are in major cities, 31.4% of these programs are in Bogotá, 17.1% in Cali, 14.3% in Barranquilla, 11.4% in Medellín and 8.6% in Bucaramanga [11]. These SNIES statistics and industrial engineering programs were chosen as cases since they are the undergraduate programs with the most accredited programs in Colombia.

Bogotá was chosen because it is the city with the largest number of accredited programs. Given that this is a multiple case study, the preset categories must be comparable, so to answer the research question it is required that the three cases chosen allow evidence of findings of educational innovation that are comparable between programs with qualified registration and programs with high-quality accreditation. Therefore, the three cases chosen were a program with three accreditations since 2001 (case 1), a program with a single accreditation in 2020 (case 2), and a program with a single accreditation in 2019 (case 3). These three selected cases have memberships in the Institute of Industrial and Systems Engineers, so, as Assistant Vice President of the Central and South America Region, the researcher contacted the participants through this network [12]. The participants were actors involved in the process of high-quality accreditation of their program. In other words, for each of the three programs, at least one professor or manager who had experienced accreditation was selected.

D. Data collection

The accreditation reports as a source of information are documents that contain the necessary information to demonstrate the four categories of analysis through documentary analysis, which allows the selection and collection of information through the reading and critique of these documents [13].

The documentary analysis responds to three informative needs: first, to know what each of the three selected programs reports as an educational innovation in the accreditation documents; second, to know the specific segments that talk about educational innovation in those documents; and finally, to know all the important information about educational innovation during the accreditation process [14]. In addition, for Pinto, documentary analysis will make it possible to affect the content and form of accreditation documents to transform them into representative documents that facilitate their identification, recovery, and dissemination [15]. To this end, we began with an analysis of form, which consisted of a documentary description that made it possible to provide an individual identification to distinguish these documents from others. Next, an analysis of the thematic contents of the document was carried out to represent the information in the document using an indexing (characteristic description), a summary (substantial description), and a classification [16].

In the semi-structured interviews, pre-established questions were defined to guide the conversation, allowing the interviewees to respond freely. These interviews generate a flexible dialogue, in which the interviewees express their experiences and understand the topics around which the conversation revolves [17]. The semi-structured interview applied to the selected sample of the 3 industrial engineering programs, collected as much information as possible from the four categories of analysis on signs of educational innovation in accreditation, through the experiential learning of the participants in this process.

E. Data analysis

The documentary analysis consisted of a formal analysis and a content analysis. In the formal analysis, a physical description was made, including the document title, author(s), publication

number, and date of publication. The content analysis was followed by indexing, summarizing, and classifying. In the indexing process, the keywords that designate the subject matter and the descriptors that are standardized terms in a documentary language such as the UNESCO Thesaurus system were identified. Then, in the summary, the content of the document was represented in abbreviated form and, finally, the classification made it possible to group the content of the document by class [16].

After the interview data were collected, they were transcribed in a text editor. They were then open-coded. In this sense, for Strauss and Corbin, the open coding made it possible to extract thoughts, ideas, and meanings, which were classified into the four categories of analysis: learning experience, teaching practices, curriculum redesign, and institutional mechanisms [18]. Once coded in each of the categories, the textual quotations were interpreted to include the voice of the researcher in his role as interviewer.

This third stage consisted of axial coding, which made it possible to identify the relationships between the four categories of analysis, to highlight the processes of educational innovation, distinguishing by color if there were evident changes in the entire category (green), if there were partial changes in the category (yellow) and if there were no evident changes in the category (red).

III. RESULTS

The evidence of each of the three cases is presented, followed by the transversal analysis of all the cases based on the four preset categories, such as learning experience, teaching practices, curriculum redesign, and institutional mechanisms. For each case, the analysis was structured from the four categories of analysis. The cross-sectional analysis made it possible to compare cases and discuss the complex relationship between high-quality accreditation processes and innovation in educational programs.

A. Case 1 (Program with three accreditations from 2001)

This industrial engineering program was accredited for the first time in 2001 for seven years. Subsequently, it was accredited in 2011 for eight years and on December 27, 2019, for eight years through resolution 17325 of the National Accreditation Council. Regarding the latter accreditation, data collection for this case study was done through a documentary analysis of the Self-Evaluation Report submitted by the Department of Industrial Engineering to the National Accreditation Council. This 518-page document is titled "Self-evaluation Report: For renewal of the accreditation of the Industrial Engineering undergraduate program" and was written in September 2018 in the city of Bogotá.

Likewise, the analysis of the individual interviews with an associate professor (CR), an assistant professor (FM), and the graduate assistant of continuous improvement (PB), as actors involved in the reaccreditation, was carried out. The documentary analysis and the analysis of the interviews were integrated into structured coding in the four pre-established categories. For the accreditation renewal process, the Department of Industrial Engineering was already prepared with a rhythm within the context of continuous improvement, from

which the ABET reaccreditation was carried out one year before the reaccreditation. Therefore, a preparation phase was not necessary, since the people involved in the previous accreditation were still working in the Department. In this process, some students, all the professors, the Department Council, the coordinator, and the director participated. These also made up the two teams dedicated to accreditation, which were the Technical Committee for Accreditation and the Accreditation Council.

Learning experience

Students can be advised in their academic and personal decisions through different units and programs that the University has available to provide support and counseling. Likewise, when students have academic doubts about their courses, they can solve them in a personalized way or in small groups, through spaces where they can express their difficulties and strengthen their weaknesses.

Regarding the pedagogical model of the program, this can be evidenced in the curriculum, which seeks to promote autonomy, flexibility, and integrality. To this end, 11 learning goals by competency are proposed, which are based on ABET skills. These learning goals do not require students to memorize; on the contrary, they seek to develop situational intelligence to understand how to act in a specific situation. In addition, specialized learning software is used for undergraduate courses, as well as project-based learning through the development of interdisciplinary projects in real contexts.

Regarding the ways of evaluating learning, the interviewees stated that "there was nothing about the evaluation of learning (CR), [...] because it was already being done before by asking about the correspondence between the forms of academic evaluation of students, the nature of this and the pedagogical methods used for its development" (PB). It can be evidenced that, in this aspect, the last accreditation did not promote changes, because it is something that was already being done by asking students about the correspondence between the forms of academic evaluation, the nature, and the pedagogical methods used for its development. However, the main opportunity for improvement is the number of students, for which the Department has the accompaniment program, through which students in the last semesters of undergraduate studies are linked to monitoring the performance of first-semester students, monitors who are supervised by master's students working as graduate assistants, who in turn are coordinated from the continuous improvement team. This program makes the University one of the few universities that have strong support to develop large classes well.

Finally, "the profile has not changed, the requirements have not changed" (CR), so it is observed that the entry profile has been constant because the industrial career is the most demanded at the University and it is also the career that is most shared with other careers. Therefore, the accreditation did not change the profile, and the requirements have not changed, because the target population remains the same.

Teaching practice

Teaching practices involve teacher training, educational materials, and teaching practices to improve undergraduate

courses. Regarding teacher training, the reaccreditation did not introduce changes, since the Department of Industrial Engineering has been aligned with the entire School of Engineering in having classes with more active pedagogies, which has allowed teachers to work with methodologies such as the inverted classroom, Problem-Based Learning, Project Based Learning, among others. To this end, the School of Engineering has an Active Learning Committee in which professors from all engineering departments participate. However, this work is not the result of a recommendation of the National Accreditation Council, but an initiative of the School of Engineering, which wants to be at the forefront.

Regarding the educational materials, "that was a comment of the previous accreditation, but in this case, we did not have that comment" (FM), so it was solved by working with our educational materials and its implementation could be validated through student surveys. These surveys showed that 85% of the students surveyed affirmed that the educational material produced by the professors contributes to their learning, 88% affirmed that this material corresponds to the objectives of the course, and 85% qualified it as of good quality. Among these educational materials, there are high-impact publications, indexed journals, and textbooks of the Department's professors. However, for the last reaccreditation process, no changes were suggested regarding educational materials, so the accreditors were given a presentation on the new laboratories to generate new production management practices, and they liked that very much. Likewise, in 2018 a survey on academic resources was conducted, in which 77% of the students, 93% of the staff professors, and 91% of the chair professors consider to a high degree that the available academic resources are sufficient.

Regarding teaching practices, the reaccreditation did not have much effect on professors, because "we are making more progress in having a counseling system and I believe that communication and, let's say, availability to attend and talk with students, have been issues that we professors have been internalizing" (FM). In this sense, the Department has already been working on this system, which allows professors to attend and talk with students. In this regard, in an internal survey in 2018 on whether the teaching methodologies used favor student learning, among the respondents it is evident that 71% of the students, 79% of the staff professors, 93% of the lecturers, 78% of the graduate assistants and 100% of the directors consider them fully coherent and to a high degree.

Curriculum redesign

The Department developed a continuous improvement system that implemented the 2006 curricular reform and has been coordinating the new curricular reform since 2018. The Industrial Engineering curriculum was last updated in 2005, going from 157 to 137 credits, which reduced its duration from ten to eight semesters. Its structure is divided by level of training, among integral training (24 credits), basic sciences (29 credits), fundamentals of engineering (21 credits), fundamentals of industrial engineering (36 credits), deepening of industrial engineering areas (15 credits), free electives (6 credits) and projects (6 credits). In the deepening of industrial engineering areas, which are Operations Research, Production and Logistics, and Organizational Management, students choose a major area

in any of these areas, and a minor area of these areas plus the area of Economics and Finance. This curriculum was evaluated in the basic line of professional training, as recommended in the previous accreditation, assigning the credits and actual hours of independent work in the core subjects of that line. To this end, in 2018 a workshop was held with staff professors to rate the comprehensiveness and flexibility of the curriculum, characteristics that obtained 4.6 and 4.7 respectively, i.e., they are fully complied with because very well-defined strengths were identified.

Since then, the curricular proposal has been aligned with the guidelines established by the Institute of Industrial and Systems Engineers (IISE) and the Accreditation Board for Engineering and Technology (ABET). Therefore, the curriculum in force since 2005 was redesigned based on the redefinition of learning outcomes. Regarding the curriculum, there were no changes because of the reaccreditation, because before the accreditation the curricular reform process that is now being implemented was being designed. However, in organizational management, the accreditors asked why we did not go deeper into the subject of human resources, but at the University we look at it from a different point of view and this has always been defended. The accreditation peers also asked "Why do we not have in the contents of our courses, topics of ergonomics, human factors, salary issues, and for that is part of the differentiation of the distinctive mark of industrial engineering of the University. So, we did not consider it, and the evaluators took it well" (CR).

Institutional mechanisms

In the previous accreditation, it was commented that the teaching staff was not sufficient to attend to many students, as a consequence of the retirements of permanent professors those who are in the teaching staff order without including the professors, the latter being very few in the Department. In this sense, whether for reaccreditation in the National Accreditation Council or ABET, use was made of the observations made by national and international universities with which we work, as well as the comments of the peer evaluators and the resolution. For the reaccreditation in the National Accreditation Council, a committee of professors, coordinators, and directors of the Department was formed, who participated "without any kind of discharge, without any kind of bonuses, without any kind of anything" (FM). For this purpose, inputs were used, as well as the experience of professors and coordinators who were involved in the previous accreditation, and who continue working at the University contributing to the reaccreditation. Additionally, there is an organizational culture, in which the entire Department understands that it is in accreditation mode and is willing to collaborate with the subject.

Accreditation is deeply rooted in the Department, since "everyone is in accreditation mode and people understand what it refers to and everyone is willing to do whatever has to be done because it is something urgent" (PB). Likewise, it was a structured process that facilitated the obtaining of information, because of the definition of roles on who and when participated in each moment of the process, and the designation of two people dedicated all the time was important. Likewise, concerning the Committees created for the reaccreditation, the Technical Committee was operational and made up of an

academic coordinator, an assistant professor, an academic manager, an instructor, and a graduate assistant. In contrast, the Accreditation Council made up of full professors, was a more directive committee that contributed from its experience in the previous reaccreditation.

B. Case 2 (Program with one accreditation from 2020)

This Industrial Engineering program was accredited on March 5, 2020, by Resolution 3251 of the National Accreditation Council for four years. For the data collection of this case study, a documentary analysis was made of the Self-evaluation Report submitted by the program to the National Accreditation Council. This 305-page document entitled "Self-evaluation document for accreditation purposes", was submitted on June 8 of 2018 in the city of Bogotá. An analysis was also made of the interviews with the academic coordinator the professor leader of the quality committee in the program and the leader of internationalization in the faculty, as actors involved in the accreditation. The documentary analysis and the analysis of the interviews were integrated into structured coding in the four pre-established categories. The accreditation process was long since the self-evaluation began in 2009 with the curricular evaluation of the components and criteria to be analyzed. This process was led by the quality committee of the industrial engineering program, which is formed by the director, the coordinator, and 4 professors of the program. This committee supports the review of the micro-curricula, the improvement plan, the Institutional Development Plan, and specific quality issues of the program. In addition to the quality committee, 18 academics, 4 students, 5 graduates, and 3 administrative staff participated in the self-evaluation.

Learning experience

Since 2010, the University has been implementing Professor Fink's meaningful learning, in which institutional learning objectives, program learning objectives, and course learning objectives are defined, allowing reflection on the relevance of curricular content and the pedagogical models of the programs. In the same year, the 5 engineering programs (electronics, systems, industrial, environmental, and bioengineering) were unified into a single Faculty of Engineering. In this sense, the mission of the Industrial Engineering program is manifested in the training profile, based on generic and specific competencies, and developed through the curriculum centered on learning and the meaningful learning approach.

Through the taxonomy of meaningful learning, which includes the human dimension, the student's self-management of learning, and the disciplinary dimensions, this taxonomy defines the learning goals. This learning takes place through active methodologies, which seek that the learning experience ensures the construction of knowledge. Therefore, the following learning activities are proposed as learning activities: workshops and laboratories, integrative projects, and academic outings.

There were no changes in the entry profile. The entrance profile has a psychosocial and cultural approach where the person is the priority, so it is guaranteed that regardless of how the student arrives, he/she must be well educated. Therefore, there are no ICES or entrance exam limitations. Regarding professional internships, it was a strength that the peers saw,

"because the semester before they do their professional internship, more or less in the eighth semester, we do a process called apprenticeship" (SV). This is a process in which they are trained on how to face the working world. This is a differential factor for employers, since students arrive with knowledge of personal branding, protocol, and business etiquette, how to address a boss, and how to write an email with netiquette. Additionally, students must do an engineering project in the organization in addition to their job functions.

Peers also liked the support provided to students. The first contact is the professional practice monitor, but when it gets out of hand, the student is referred to the guidance office, where there are two psychologists for the program when the student has personal problems and poor academic performance that are harming their practice. This same process is repeated in the subjects, the first contact is the professor and then the psychologists.

Teaching practices

Of the 48 teachers attached to the program, 20.8% have been with the program for more than 10 years, 20.8% have been with the program for between 6 and 10 years and 58.3% have been with the program for between 0 and 5 years. According to their training, between 2013 and 2017, teachers with PhDs increased from 1 to 8 and teachers with master's degrees from 19 to 37. For faculty development, 25% of the program's professors are pursuing Master's or Doctorate studies, as well as training and permanent updating courses.

Regarding teacher training, the University trains professors in the methodology of meaningful learning, for the design of courses, contents, and syllabus. However, this is not a product of self-evaluation, but of the University's previous work long before accreditation. It is also sought that professors have a higher education in undergraduate, postgraduate, and doctoral programs.

Concerning teaching practices, the custom of reviewing the micro-curricula and lines of learning makes teachers look favorably on curricular updating and review of their practices and competencies. In this sense, there was "a review of the micro-curricula and lines of learning, because it made teachers also look favorably on updating, and they were constantly reviewing [...] but this is not a product of accreditation but of constant self-evaluation (MI)". Regarding educational materials, shortcomings were identified in guides that had to be structured, such as laboratory guides. Likewise, work began with the professors on materials to support teaching.

Curriculum redesign

The current curriculum is the same as that of the qualified registration obtained in 2017, which includes 68 subjects in 179 credits. The undergraduate program lasts 10 semesters, so it has an average of 18 credits per semester and 30 classroom hours per week. The program is structured in four training units such as basic sciences, basic engineering, applied engineering, and socio-humanistic. This plan responds to the bio-psycho-social-cultural and environmental approach of the University and the social constructivist pedagogical model. The Industrial Engineering program presents a social constructivist model, based on the systematic design of its courses, its situational

factors, its learning goals, and its feedback and evaluation processes.

Regarding the curriculum, work was done on the microcurricula. Although the curriculum has not changed much over time, according to the recommendations of the accrediting peers, the contents of the subjects were adjusted, and a market study is currently being carried out to see if a curricular reform can be made. In the Faculty, the curricula of all the engineering programs are being updated so that they are the same in the basic cycle of the first four semesters, to facilitate double degrees and the interdisciplinary work of the professors within the Faculty. As a result of the self-evaluation, "the lines were revised so that there would be continuity in the contents and they would not be repeated, especially in the contents of computer science" (MI).

Institutional mechanisms

Regarding the institutional arrangements for accreditation, the University previously had co-faculty professors, with an administrative load in addition to their teaching load, who are close to the administrative part of the University and the program. The recommendations of the peers regarding the institutional aspect were specific for "showing more of what we do and showing ourselves to the community [...] we are trying to organize events, for example, scheduling congresses and organizing events in collaboration with other institutions" (CL). Therefore, work is being done to make the research group known outside, and to develop joint research and projects, participating in international events and doing events in collaboration with other universities.

Regarding graduates, "it is one of the weaknesses, greater support to graduates, because many times there is no follow-up of where the graduate is at the moment, whether he/she is employed or not, what he/she is doing or is an entrepreneur, and these statistics were the greatest weaknesses" (SV). The alumni association has a leader for each faculty and a leader for the program. However, it is one of the weaknesses and it is necessary to be close to the alumni to introduce institutional changes in the program and keep it updated and competitive" (SV).

Regarding internationalization, the accrediting peers recommended increasing international agreements in graduate programs, because "there are very few professors or graduate students who leave or make an incoming or outgoing mobility" (SV). The program has two specializations, one in production and the other in project management, whose students and professors do not do much international mobility. However, in the undergraduate program, there is constant mobility, with the double degree agreement with a French university, sending 2 or 3 students every semester, and in general, with other agreements, 6 students are mobilized. Therefore, the relationship with foreign universities should be improved to share experiences and good practices in educational innovation.

C. Case 3 (Program with one accreditation from 2019)

This Industrial Engineering program was accredited on September 11, 2019, through resolution 9689 of the National Accreditation Council with validity for four years. For the data collection of this case study, an analysis was made of the two interviews with the program director, as an actor involved in the

accreditation. The analysis of the interviews was coded in the four pre-established categories. In this case, it was not possible to perform a documentary analysis, since the University did not authorize sharing the self-evaluation report, so the second validation interview was conducted with the program director.

The program was accredited, but lost the accreditation in 2016, for reasons that were not clear but ended in the decision of the National Accreditation Council that the program did not meet the conditions for reaccreditation. For such reason, there was a clean slate, so as not to remain in the past but to face accreditation as a new process, that the dean led decision. The loss of accreditation was not mentioned in the self-evaluation report, because it was an internal management product of a decision of the Faculty. Because of this refusal of non-reaccreditation, there was a change of dean, and the new dean decided to initiate the accreditation as if it were for the first time. The national directorate of quality assurance also agreed not to include it in order not to generate unnecessary noise with the peers, although they knew and were told that the reasons for not renewing the accreditation at that time were unknown. For this purpose, the analysis of the initial conditions was going to begin, but the National Accreditation Council said that it was not necessary because the program already had a previous history, so they recommended starting the process as if it were a reaccreditation, and thus the accreditation document was submitted to the National Accreditation Council.

In 2018, the process began, with the previous records of consultations survey instruments and focus groups of the ten factors and some improvement topics, so the weighting of the factors was achieved. This weighting showed that most of the factors exceeded 80% favorability, and some reached 90%. In contrast, the factors with lower scores were associated with institutional issues, especially welfare, mission, and vision. Primary sources were used, such as surveys and interviews with students, professors, graduates, and administrators. As secondary sources, institutional information such as regulations and quality procedures were used, as well as studies by referents such as the Colombian Competitiveness Council, IISE, and ANIF. This document was done collegially with professors of the program, so it was done with complementary reports that allowed to expand the answers to the peers. The self-evaluation report was filed in July and the peer visit was in September 2018. The peers weighted the document very well and requested a few clarifications. Their visit was also very qualified with positive comments, and finally, the accreditation resolution was obtained in September 2019.

In the accreditation process, a project team was created, together with the program's existing committees, which are the curriculum committee and the project committee. The National Directorate of Quality Assurance also participated, with the participation of the leader of the Bogota branch. This Directorate helped to design the strategy, the presentation of reports, the visit of peers, and the monitoring of the processes with the National Accreditation Council and its technical commissions. All professors were selected as the study population, and among the students, members of ANEIAP and IISE were randomly selected.

Learning experience

The PEI states that it seeks to train engineers not only from a technical but also from a human point of view, with a commitment to social issues and research. The pedagogical model proposes a direct evaluation scheme, so there is no self-evaluation but a hetero evaluation. Regarding the ways of evaluating learning, the changes are taking place at the moment, so this semester is being measured, because there has been no reading of how the evaluation process is going. The need to think about the forms of evaluation "arises from the improvement process, those exercises of Assessment, as evaluation of competencies. We have not done those exercises; we are still designing them" (AG). Then we need to have a mechanism before the Saber Pro, to have an internal management, which is the measurement of compliance with these competencies. "The entry profile has changed due to the accreditation since a profile closer to research is sought. Now, there is more attention to the entrance and graduation profile" (AG). The entrance profile is still being worked on, placing great value on students from technical schools, so that their good grades allow them to homologate courses in the first semesters. Using the synthetic index of secondary education, it was possible to weigh the best schools close to the University, with whom an approach is being made.

Teaching practices

The program presents an improvement curve in teacher training, with better professors and more exclusive dedication to the program. 100% of the professors have Master's degrees, some are doing doctorates, and more are approaching research. The microcosm of the University extends to the dialogue with other universities, such as the diploma course we had with the Universidad de los Andes on new engineering teaching strategies, such as project-based learning in which we are advancing in the Faculty. In the professor's factor, the highest score was given to the faculty development characteristic, due to the extensive trajectory and commitment of the professors, most of whom are graduates of the program. However, having so much stability and trajectory, the professors are of advanced age and are not in the mood to pursue a doctorate. To motivate them to do a doctorate, there is a scholarship committee that condones up to 100% of the tuition and therefore generates an obligation to develop research in a research group and to be more than twice as long in the academic exercise. The average number of professors has been maintained since 2015 because the trajectory and teaching stability are respected. On average there are 28 students per professor, and the peers verified that there are courses of 18, 28, and 30 students, so there was no problem for them.

Regarding educational materials, the program participated in a diploma course at the School of Engineering of the Universidad de los Andes. As a result of the accreditation, basic sciences became transversal in all engineering programs, with changes in the Syllabus, in the teaching methodologies with basic science courses oriented towards engineers, and in the project framework. Also, virtual tools are now used more in the courses, making virtual courses of Introduction to Engineering, and Colombian Institutions. The university has a Teacher Training School, where internal training is provided on the teaching pedagogical model, which is self-structuring cognitive-cognitive, which allows the teacher to be a facilitator of

knowledge and to build it with the student. It is mandatory to attend the course for new teachers, and also for monitors.

Regarding teacher training, it is divided between the use of ICT and project-based learning, to bring engineering education to more applied contexts. The challenge is that what one professor does can be replicated by another under a project structure. Professors from engineering programs were chosen to train them to pilot PBL, measuring and transferring this knowledge. The selection of professors changed because the number of professors was reduced in the elective subjects where experience is required, and we are looking for professors to qualify for doctorate studies to improve research and to promote students to join the research seedbeds as research assistants.

Regarding educational materials, educational processes are being supported with the use of ICT through the Moodle platform that the peers learned about. "That changed, because Moodle stopped being a repository of academic content to be an academic manager, applying what was learned in the diploma course with Conecta-TE of the Universidad de los Andes in 2019. In this sense, the aim is to virtualize the applied engineering subjects, which are taught by research professors" (AG).

Curriculum redesign

Regarding curricular aspects, the curriculum has been the same since 2016 when the resolution of the qualified registration was obtained, because it is not customary to make permanent revisions to the curriculum and because this curriculum responds to the key factors reviewed by the National Accreditation Council, especially research and the socio-humanistic aspect. The peers suggested that the curriculum was slowing down and losing competitiveness, although the University has multi-campus institutional accreditation in its seven branches. For this reason, the National Accreditation Council recommended institutional accreditation, to join efforts to build the same curriculum model for the seven branches. A dialogue was held with the sectional offices, but the approval of the internal and external entities is still pending. However, for the accreditation of the industrial program in Bogota, no changes were made to the curriculum. This new multicampus curriculum "has some optional lines of deepening to access a coterminal with a Master's or Doctorate" (AG). The peers asked about the ontological theme of ethics, which was answered with the coherence between the pedagogical model and the human component of the PEI of the University. They also asked about the hours dedicated by the professors, and how the basic sciences, basic engineering, applied engineering, research, and the economic-administrative area of the Faculty are articulated and related to each other. This interrelation could be evidenced in the last semesters when a student decides to formulate or evaluate a research project in the social practice or the business practice, for which reason the study plan did not change. The peers asked about the degree options. In this regard, it is evident that the professors of applied research were attached to research groups, which would allow the creation of seedbeds. In the beginning, there were few students in this degree option, but now there are quite a few who graduate through the research assistantship option.

Institutional mechanisms

Regarding institutional arrangements, professors and students have a very high level of affiliation and commitment. Accreditation was not seen as an effort, because the tasks performed were within the framework of institutional management with hours already contracted. "The factor with the lowest score was graduates, given that it is an opportunity to improve the relationship with graduates and measure its impact" (AG). There is no instrument to track the more than 4,500 graduates, so there are recent references, but not from cohorts far back in time. Therefore, it is necessary to follow up with graduates so that they can share their professional experience to produce institutional changes in the program. "We are looking to have more PhDs in the program, in addition to the five currently being trained" (AG). Therefore, the peers recommended that the relief of the academic load of a maximum of 12 hours be maintained and even reduced to make room for doctoral training. "Internationalization is given to students and not much to professors" (AG). So, more professors are needed in international networks, to travel and have classes in other scenarios, that is something that is being worked on with the office of institutional relations of the University, but that requires a good command of English to break the cultural and language barriers.

D. Cases analysis

Once the evidence of each case has been presented, we proceed to show the main results for each preset category. In other words, taking the defined definition of educational innovation, which is understood as a planned change in the learning experience, teaching practices, curricular redesign, and institutional mechanisms, we proceed to analyze whether high-quality accreditation promoted evident changes in each of the following categories. As can be seen in Table 1, the level of evident changes promoted by the most recent accreditation in each case was classified by color, with red representing no evident changes, yellow introducing at least one evident change, and green producing evident changes in the entire category.

TABLE I
RESULTS OF THE TRANSVERSAL ANALYSIS.

Category	Case 1	Case 2	Case 3
Learning experience	Reaccreditation did not promote changes in the pedagogical model, in the evaluation of learning, or in the entry profile, which remains constant.	The accreditation did not produce changes in the pedagogical model of meaningful learning the forms of evaluation or the entry profile with a psychosocial approach.	The accreditation did not introduce changes in the pedagogical model, but it did promote changes in the ways of assessing learning and in the entry profile to bring it closer to research.
Teaching practices	Reaccreditation did not introduce changes in teacher training, educational materials were changed by the previous accreditation, and teaching practices did not change as a result of re-accreditation.	The accreditation did not promote changes in teacher training since they have been previously trained, nor did it change teaching practices since they are the result of constant self-evaluation.	The accreditation promoted changes in teacher training by recommending improved research, as well as changes in educational materials and teaching practices towards the use of PBL in courses.

Curriculum redesign	Reaccreditation did not produce changes in the curriculum since its redesign was already being worked on for the curricular reform.	The accreditation did not introduce any changes in the curriculum, as it has remained constant since the 2017 accreditation.	Accreditation led to changes in the curriculum so that it would be multicampus in the 7 sectional areas and would have a coterminal to opt for a postgraduate degree.
Institutional mechanism	The reaccreditation did not introduce changes in the institutional mechanisms, since the process is well established in the Department, either for the National Accreditation Council or for ABET.	The accreditation recommended publicizing research and working together with other universities, especially by increasing international agreements for faculty mobility.	The accreditation promoted changes in the follow-up of graduates, as well as recommended reducing the academic load of doctoral students and increasing international agreements.

Learning experience: Reaccreditation did not promote changes in the pedagogical model, neither in the evaluation of learning nor in the entry profile, which remains constant. Accreditation did not produce changes in the pedagogical model of meaningful learning the forms of evaluation or the entry profile with a psychosocial approach. The accreditation did not introduce changes in the pedagogical model, but it did promote changes in the ways of evaluating learning and in the entry profile to bring it closer to research.

Teaching practices: Reaccreditation did not introduce changes in teacher training, educational materials were changed by the previous accreditation, and teaching practices did not have changes as a result of reaccreditation. Accreditation did not promote changes in teacher training since they have been previously trained, nor did it change teaching practices because they are the result of constant self-evaluation. Accreditation promoted changes in teacher training by recommending improvements in research, as well as changes in educational materials and teaching practices towards the use of PBL in courses.

Redesign of the curriculum: The reaccreditation did not produce changes in the curriculum since its redesign was already being worked on for the curricular reform. The accreditation did not introduce changes in the curricular mesh since it has remained constant since the 2017 qualified registration. The accreditation produced changes in the curriculum so that it would be multi-campus in the 7 sections and would have a coterminal to opt for a postgraduate degree.

Institutional mechanism: The reaccreditation did not introduce changes in the institutional mechanisms, since the process is well established in the Department, whether for the National Accreditation Council or ABET. The accreditation recommended making research known and working jointly with other universities, especially by increasing international agreements for faculty mobility. The accreditation promoted changes in the follow-up of graduates, as well as recommended reducing the academic load of doctoral candidates and increasing international agreements.

Firstly, in case 1 it was observed that this accreditation did not introduce evident changes in any of the four categories, since the documentary analysis and the interviews showed that being the third accreditation the changes were recommended in the

previous accreditation of 2011. Secondly, case 2 reported evident changes in the entire category of institutional mechanisms, for which it was recommended to improve the program's external relations to publicize its research groups and projects, as well as to improve its international agreements, especially for the program's professors. Thirdly, case 3 presented evident changes in all its categories. To begin with, in the learning experience category, accreditation introduced a single change in the forms of evaluation and the entry profile. It could also be observed that accreditation produced changes in the entire category of teaching practices, suggesting improvements in teacher training to strengthen research groups and improve educational materials and teaching practices to implement active methodologies such as PBL. In the category of curricular redesign, the peers recommended the design of a multi-campus curriculum with a coterminal degree option. In the category of institutional mechanisms, accreditation produced changes in the relationship and impact of graduates, as well as improving incentives for doctoral training of teachers and international mobility agreements.

Educational innovation is a learning process [10], which requires experimentation and can be learned from observation and reflection [19]. In this sense, finding evidence of educational innovation in accreditation depends on the experience of the program, to the extent that the more recent the accreditation has been granted, the more educational changes can be evidenced. Thus, for example, transformations can be seen in the four categories proposed in case 2, which obtained its accreditation in 2020, and in case 3, which obtained it in 2019. However, case 1 is not immune to educational changes, but it has already gone through three accreditation processes, in 2001, 2011, and 2019, so it learned from these previous processes and does not show evident changes in the last accreditation in 2019.

IV. CONCLUSIONS

Understanding that educational innovation is the product of evident educational changes in the four preset categories, it can be concluded that more educational innovation processes are evident in the cases with only one accreditation process, as was observed in cases 2 and 3. However, in case 1 there are no evident changes as a result of accreditation since there was previous learning with previous accreditations, evidenced in mature processes of educational innovation that ended up being institutionalized and consolidated in the program.

Additionally, it is proposed to exclude the category of institutional mechanisms, since it presents very general and transversal characteristics to the whole accreditation process, which does not allow tracking educational changes in a specific factor of accreditation. Thus, this research consolidates a model of educational innovation that includes evaluating the learning experience in the student factor, teaching practices in the teacher factor, and curriculum redesign in the academic processes factor.

There were time limitations that did not allow for a detailed analysis of the learning experience category, since the self-evaluation reports and the interviews with teachers and directors were not sufficient to track transformations in this category. Therefore, it is proposed as a future work, that this category include an instrument that allows analyzing the perceptions of

students as agents of their learning. In such a way that the experience of students in their last semesters allows them to recognize the changes resulting from the accreditation of a recently accredited industrial engineering program. Therefore, it is recommended to use as case studies, undergraduate programs with only one accreditation, especially those that have been recently accredited. In this way, processes of educational innovation that are just being experimented can be evidenced, as a result of accreditation and the evident educational changes that the actors involved can confirm that it generates.

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