ACREDITA CI
AGENCIA ACREDITADORA COLEGIO DE INGENIEROS DE CHILE S.A.

MASTER MANUAL FOR THE ACCREDITATION

OF SCIENCE-BASED ENGINEERING PROGRAMS

VERSION 2.0

Valid for the 2023-2024 accreditation cycle

This Master Manual is complementary to the following documents:

- Manual of Rules and Procedures for the accreditation under international criteria of science-based engineering programs version 4.0 – September 2020
- Self-Evaluation Guide for the accreditation under international criteria of science-based engineering programs version 1.0 cycle 2023 - 2024
- External Evaluation Guide for the accreditation of science-based engineering programs version 1.0 cycle 2023-2024.

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1. Introduction

Acredita CI makes available to higher education institutions this Manual in which the evaluation criteria and the main guidelines for the development of accreditation processes for science-based engineering programs under international quality criteria are established.

The International Engineering Alliance, IEA, in its document entitled: "Graduate Attributes and Professional Competencies" version 2021.1[1], defines: “Engineering is an activity that is essential to meeting the needs of people, economic development and the provision of services to society. Engineering involves the purposeful application of mathematical and natural sciences and a body of engineering knowledge, technology and techniques. Engineering seeks to produce solutions of which the effects are predicted to the greatest degree possible, in often uncertain contexts. While bringing benefits, engineering activity has potential adverse consequences. Engineering therefore must be carried out responsibly and ethically, use available resources efficiently, be economic, safeguard health and safety, be environmentally sound and sustainable and generally manage risks throughout the entire lifecycle of a system.”

The Acredita CI accreditation model is based on evaluation criteria comparable to those used internationally by accrediting agencies that are members of the Washington Accord that are oriented to science-based engineering programs. This criteria have the purpose of contributing to the best practices to ensure the quality of the training that future engineers receive in Chile, in such a way that this training is substantially equivalent to that received by engineers worldwide.

2. Accreditation

Accreditation is a quality certification that is awarded to an engineering program after a process of review and evaluation of the training it provides. For a program to obtain accreditation, it must demonstrate that it meets the accreditation criteria of Acredita CI.

Accreditation ensures that graduates of the degree are prepared to enter the professional practice of engineering and that they are people capable of designing and/or developing solutions to complex engineering problems. In these design and/or development processes, graduates demonstrate that they possess the attributes of the graduate[2] established by the Agency.

The design and/or development of solutions to complex engineering problems refers to the design of systems, components or processes that meet specific needs with due regard to public health and safety, cultural, social, and environmental issues, where appropriate[3].

[1] Updated to June 2021
[2] Chapter 4 of this Manual
[3] See examples in Annex 9 of this Manual

3. Requirements to access accreditation process

A program may submit to the accreditation process when:

a. Have two cohorts of graduates, and graduates practicing the profession.
   In the event that a program presents two current study plans, a plan that is finishing that has graduates practicing the profession and a plan as a result of a curricular innovation process that still does not present graduates, Acredita CI will apply the following policy:

   Acredita CI Policy
   The accreditation is granted by results, with evidence of the performance of the graduates. It should be noted that if the program does not have graduates from the innovated curriculum, it must have graduates from the plan that is finishing. In this scenario, the program could even be running two curricula, in parallel, which is common in practice.

   The program may be submitted to the process. The Self-Assessment Guide provides specific guidelines to carry out the process under these conditions.

b. It is taught during the day, with regular admission in face-to-face mode. In addition, if the program is taught in more than one location, in the evening (either face-to-face or blended) or in a special degree program, all these locations, daytime or evening and modalities must be submitted to the process simultaneously.
c. The program must be taught by an autonomous Higher Education Institution as established by Chilean law.

4. Graduate attributes

The Graduate Attributes are indicators of the potential of the graduate to acquire the necessary skills for engineering practice. An accredited program ensures that the graduate includes these attributes in their educational process.

In this way, the quality of a program depends on a set of factors, among which are the curricular design, the committed resources, the organization and execution of the teaching and learning process, and the evaluation of the students, including the confirmation of that the attributes of the graduate are satisfied.

Attributes are chosen to be universally applicable, to reflect minimum acceptable standards and to be objectively measured, and while all attributes are important, individual attributes do not necessarily carry the same weight. These are established generically, being applicable to all engineering disciplines. The program applies them within a disciplinary context, giving them a particular emphasis, but the individual elements applicable to each discipline should not be altered in substance or ignored.

This document presents the current attributes of the graduate and that will be required in the accreditation processes from the year 2024.

5. Evaluation criteria

As we said, for a program to obtain accreditation, it must demonstrate that it meets the Acredita CI evaluation criteria. The evaluation criteria are defined so that, through their application, it is possible to get to know in the most reliable way possible to what extent the program ensures the quality of its educational process. Specifically, Acredita CI has defined the following 9 criteria:

1. Organization and Administration.
2. Educational Objectives.
2. Graduate Profile.
4. Curriculum.
5. Faculty.
6. Infrastructure and Resources for Learning.
7. Connection with the Environment.
8. Result of the Educational Process.
9. Self-regulation and Continuous Improvement.

In order to facilitate and clarify the application of these criteria, a set of “aspects to consider” has been defined for each of them.

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CRITERION 1: ORGANIZATION AND ADMINISTRATION

The unit has an adequate government system and an effective and efficient teaching and administrative management of the resources necessary to fulfill the declared commitments.

1.a. The academic unit has a qualified management body and sufficient dedication to fulfill the established responsibilities, functions and powers.

1.b. The unit plans academic and economic management to achieve the purposes of the program.

1.c. The academic unit has administrative, technical and support personnel duly trained, sufficient in number and with time dedication in relation to the day/modality to fulfill their functions and meet the needs of the curriculum.

1.d. The program has at least one manager who supervises the allocation of tasks, the provision of resources, the registration and processing of information for administrative management control. It also summons teachers, support personnel and other instances that attend the program, as established in the curriculum and in accordance with existing regulations and obligations.

1.e. The program has systematic academic guidance mechanisms for students while studying the curriculum and demonstrates the effectiveness of their application.

1.f. The program is organized to grant the necessary facilities to carry out professional practices, terrain outputs, qualification and thesis work or any other activity contemplated in the curriculum.

1.g. The program has effective instances of communication and participation of teachers. The program demonstrates that these instances facilitate coordination with the authorities of the program regarding the subjects of teaching functions.

1.h. The Academic Unit has information and administrative management systems appropriate to the management and communication needs in the program.

1.i. The institution has committed financial resources that guarantee the sustainability of the program and ensure the projected permanence of students over time. As a result, the academic unit has sufficient financial resources and an updated and founded annual budget, which allows it to maintain adequate conditions for the operation of the program, with effective budget control mechanisms.

CRITERION 2: EDUCATIONAL OBJECTIVES

The program has a clear definition of its educational objectives, which respond to the institutional mission.

2.a. The program declares its educational objectives and the occupational field formally and expresses them clearly.
2.b. The educational objectives of the program are consistent with the institutional mission.

Definition
Educational Objectives: Declaration on the aspiration of the professional who wants to form and is verified after at least two years of professional practice. It is synonymous with professional profile.

CRITERION 3: GRADUATE PROFILE

The program has an updated graduate profile required for professional performance, which responds to educational objectives and includes the graduate attributes. It is known by students and the academic community in general and is disseminated to the external environment relevant to the program.

3.a. The graduate profile is formalized and expressed clearly. If there are mentions, these are described in the graduate profile.

3.b. The graduate profile has been defined according to the institutional purposes, the educational model and the educational objectives of the program.

3.c. The graduate profile is consistent with the title delivered and the educational level of the program.

3.d. The graduate profile considers the following graduate attributes.

The competencies of the graduate profile indicated below are declared in a generic way and are applicable to science-based engineering. Each statement can be extended and given a particular emphasis on a specific disciplinary context through an own graduate profile that considers the institutional educational model and the specialty, but this statement must not be altered in its essence or omit its individual elements.

The graduate attributes that will be required in the accreditation processes from 2024 are presented below. The programs may choose to work with these attributes for their accreditation processes of the year 2023, if they define it.

Graduate Attributes	Engineer Graduate
Engineering Knowledge:	**1:** Apply knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialization as specified in Knowledge Profile 1 to 4 respectively to develop solutions to complex engineering problems
Problem Analysis	**2:** Identify, formulate, research literature and analyze *complex* engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences with holistic considerations for sustainable development* (Knowledge profile 1 to 4)
Design/ development of solutions:	**3:** Design creative solutions for *complex* engineering problems and design systems, components or processes to meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required (Knowledge profile 5)
Investigation:	**4:** Conduct investigations of *complex* engineering problems using research methods including research- based knowledge, design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions (Knowledge profile 8)
Tool Usage:	**5:** Create, select and apply, and recognize limitations of appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to *complex* engineering problems (Knowledge profile 2 and 6)
The Engineer and the World:	**6:** When solving complex engineering problems, analyze and evaluate sustainable development impacts* to: society, the economy, sustainability, health and safety, legal frameworks, and the environment (Knowledge profile 1, 5, and 7)
Ethics:	**7:** Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (Knowledge profile 9)
Individual and Collaborative Team work:	**8:** Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multi-disciplinary, face-to-face, remote and distributed settings (Knowledge profile 9)
Communication:	**9:** Communicate effectively and inclusively on *complex* engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, taking into account cultural, language, and learning differences (Knowledge profile 9)
Project Management and Finance:	**10:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
Lifelong learning:	**11:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change (Knowledge profile 8)

*Represented by the 17 UN Sustainable Development Goals (UN-SDG)

3.e. The graduate profile is known by the students and academic community in general and disseminated to the external environment relevant to the program.

CRITERION 4: CURRICULUM

The design of the curriculum is consistent with the educational model and knowledge profile of a science-based engineering program. The program demonstrates that the curriculum is oriented to the achievement of the graduate profile and attributes.

4.a. The program structures its curriculum, subject programs and curricular activities according to the graduate profile and the educational model.

4.b. The program establishes learning outcomes in each subject so that students achieve the competencies of the graduate profile, including the attributes of the graduate. Learning outcomes can also be established at cycle level or training levels to demonstrate the achievement of competences.

4.c. The program demonstrates that the curriculum includes at least the following knowledge and attitude:

Knowledge Profile:

The curriculum for a science-based engineering program provides:
1: a systematic, theory-based understanding of the **natural sciences** as well as **social science topics** applicable to the discipline.
2: conceptually-based **mathematics**, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
3: a systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline
4: engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
5: knowledge that supports **engineering design and operations** using the technologies of the discipline's engineering practice area. This includes, for example, the efficient use of resources, environmental impacts, life cycle cost, reuse of resources, net zero carbon and similar concepts.
6: knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline. Recognize the efficient use of technologies as decision-making tools and the optimization of processes in different areas.
7: knowledge of the **role of engineering in society** and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development*.
8: engagement with selected knowledge in the current **research literature** of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
9: ethics, inclusive behavior and conduct, communication, team and collaborative work. Knowledge of the ethics, responsibilities, and professional standards of engineering practice. Development of inclusive attitudes and understanding of diversity resulting from ethnicity, gender, age, physical ability, etc., considering mutual respect and developing effectively as an individual and as a member or leader in diverse teams. Communicates and collaborates using multiple means of communication in a clear and inclusive manner with the engineering community, with multidisciplinary teams and with the target audience during all its activities. Understands, writes, and presents topics relevant to their field of action before a variety of audiences.

*Represented by the 17 UN Sustainable Development Goals (UN-SDG)

4.d. The curriculum considers theoretical and practical activities in an integrated manner.

4.e. The curriculum considers professional practices consistent with the graduate profile. The program provides guidance on places of practice to students. Guidance mechanisms can be varied, such as agreements or alliances, among others.

4.f. The curriculum and curricular activities are formally and systematically made known to students, who have access to the syllabuses of the subjects.

4.g. The actual academic work of the students is quantified in comparable units (credits or chronological hours), according to a reasoned and proportional standard. It is suggested to adhere to the Transferable Credit System (SCT-Chile).

4.h. For the title process, the program has defined one or more activities, according to the graduate profile. These activities are part of the curriculum and are considered within the declared duration of the program.

CRITERION 5: FACULTY

The program has a sufficient and suitable teaching staff to comply with the activities and learnings committed in the curriculum, which allows its students to systematically advance towards the achievement of the graduate profile and attributes.

5.a. The endowment, permanence and dedication of the teaching staff guarantees the implementation of the curriculum, direct teaching and the activities of the teaching-learning process (evaluations, practical work, preparation of tasks and exercises, use of information and communication technologies), as well as the attention and guidance of students outside the classroom.

5.b. The program has qualified and competent teachers for the achievement of the objectives or learning results of the curriculum and the graduate profile. The qualification and competence of the teaching staff considers the academic and pedagogical training, as well as the trajectory in the scientific, professional or technical field.

5.c. The program has a body of stable teachers that gives sustainability over time to the educational project of the program, in all its locations, conferences and modalities.

5.d. Known systematic rules and mechanisms for the selection, recruitment and disengagement of teachers apply.

5.e. Systematic policies and mechanisms are applied for the updating and improvement of program teachers in pedagogical aspects of the institutional educational model.

5.f. Systematic policies and mechanisms are applied for the updating and improvement of the teachers of the program in disciplinary aspects ensuring a permanent improvement of their qualifications and competences, according to the institutional purposes.

5.g. Systematic mechanisms are applied for the evaluation of the activity of teaching staff, in particular their role in achieving learning outcomes. These mechanisms consider the opinion of students and program authorities. The results of the evaluation are used to improve their performance, where appropriate.

CRITERION 6: INFRASTRUCTURE AND LEARNING RESOURCES

The program has the infrastructure, resources for learning and equipment required for students to achieve learning outcomes. Mechanisms are also in place for the development, replacement, maintenance and security of such facilities and resources.

6.a. The program uses infrastructure, such as classrooms, laboratories, places of study, among others, for the teaching-learning process consistent with the graduate profile, sufficient and functional to the needs of the curriculum, the number of students, locations, daytime or evening and modalities.

6.b. The program uses technological, computational and support resources to the teaching-learning process that agree with the graduation profile and the curriculum and available to students according to locations, daytime or evening and modalities.

6.c. The library has collections, facilities, equipment, personnel specialized in librarianship, access to networks and technical processes consistent with the graduation profile and the curriculum and available to students according to the locations, daytime or evening and modalities.

6.d. There are the necessary financial resources to continuously meet the needs of provision, replacement, maintenance and updating of infrastructure, equipment and resources for teaching.

6.e. There is an appropriate balance between the number of students in each course and the total resources available.

6.f. It has universal accessibility and security protocols that are rigorously applied in all enclosures.

CRITERION 7: CONNECTION WITH THE ENVIRONMENT

The program maintains a systematic interaction with its significant environment, in accordance with the policy of linking with the environment of the institution, as well as with the purposes of the academic unit. Mechanisms for evaluating the results of activities related to the environment are applied periodically, in accordance with the purposes of the institution and the unit.

7.a. The program plans the activities, has resources for their realization and applies mechanisms to evaluate their result. The link with the environment responds to the institutional policy in the matter, as well as to the purposes of the academic unit.

7.b. The activities of connection with the environment make known the professional environment to the student.

7.c. The unit and the program systematically evaluate the result of the contribution of the activities of connection with the environment to the formative process, in accordance with the institutional policy and the purposes of the academic unit. The result of the evaluation is used for the continuous improvement of the activities.

CRITERION 8: RESULTS OF THE EDUCATIONAL PROCESS

The program has policies and mechanisms aimed at supporting the teaching-learning process, monitoring the consistency of evaluation instruments and verifying the academic progression towards the title. The results of policies and mechanisms are periodically evaluated and corrective measures are applied where appropriate, in accordance with existing self-regulatory mechanisms. The program presents substantive evidence of compliance with the graduate profile, as well as educational objectives.

8.a. The program has explicit and publicly known regulations and admission mechanisms. These standards are applied systematically in admission and are consistent with the requirements of the curriculum. The program explains its special admission system where applicable.

8.b. The program takes into account the conditions of entry of students with respect to the requirements of the curriculum and provides resources and activities for leveling, whenever required.

8.c. The program has articulated policies and mechanisms to:

i. Strengthen study habits and techniques of its students.
ii. Intervene with support strategies, for the improvement of student outcomes, when appropriate.

iii. Disassociate students from the program when appropriate, in accordance with current regulations.

8.d. The program, with the participation of teachers, ensures and demonstrates that pedagogical strategies are adequate to produce student learning and that evaluation instruments allow to verify that this learning is achieved, which in turn ensures that the competencies of the graduate profile and the graduate attributes are achieved. The mechanisms used consider the opinion of students on these assessment instruments. According to the results, the program applies corrective measures that lead to the continuous improvement of learning**.**

8.e. In the title process students demonstrate their ability to design solutions to complex engineering problems in accordance with the graduation profile, which includes the attributes of the graduate.

A complex engineering problem is one that cannot be solved without a thorough knowledge of engineering that considers the theory, the fundamentals of engineering necessary in the discipline, specialized knowledge at the forefront of the discipline and involving one or more of the following characteristics:

a. Matters of great technical or non-technical scope such as ethical, sustainability, legal, political, economic and social and the consideration of future requirements.
b. They have no obvious solution and require abstract thinking, creativity and originality in analysis to formulate appropriate models.
c. Involve rare situations or novel problems.
d. Address problems that are not covered by the standards and codes of professional engineering practice.
e. They involve collaboration between engineering disciplines, other fields, and/or diverse interest groups with a wide variety of needs.
f. These are high-level problems that include many components or sub-problems that may require a systemic approach.

8.f. The academic progression of students towards their curriculum is a permanent concern of the program, which carries out a systematic analysis of the causes of desertion, early detection of retention problems, critical subjects, time of permanence, timely qualification, and degree rates of students, considered by cohorts, locations, daytime or evening and modalities. Defines and applies actions that improve results, safeguarding compliance with the graduation profile and making decisions regarding the results obtained, when necessary.

8.g. The program has a record of the academic performance of its students, who have access to information on their curricular progress.

8.h. The program systematically applies mechanisms to know the occupation rates, the type of employment and the characteristics of the professional performance of its graduates. The program compares this information with the educational objectives to verify the achievement of these. This information is used to improve the training process, where appropriate.

CRITERION 9: SELF-REGULATION AND CONTINUOUS IMPROVEMENT

The program has mechanisms of self-regulation and continuous improvement; to do this, it uses the available information, from the diagnoses made, to design and implement actions to improve its training process. In addition, the program presents evidence of the commitment of the estates and people with the culture of quality, demonstrating that it implements the actions committed in its improvement plans.

9.a. The program has a quality assurance system for its training process that promotes the strengthening of the capacity for self-regulation and its continuous improvement.

9.b. The program reviews and keeps updated the educational objectives through consultation with graduates and employers, of all its locations, daytime or evening and modalities. The review is periodic and also considers the institutional mission.

9.c. The program reviews and keeps updated the graduate profile through consultation with sources and internal and external stakeholders, including graduates and employers, of all its locations, daytime or evening and modalities, ensuring consistency with the educational objectives. The review is periodic, considers the institutional educational model and is carried out within a maximum period of time than the formal duration of the curriculum.

9.d. The program reviews and keeps updated the curriculum through consultation with sources and internal and external stakeholders, including graduates and employers, of all its locations, daytime or evening and modalities, ensuring consistency with the graduate profile. The review is periodic and systematic, considers the institutional educational model and is carried out on a permanent basis.

9.e. The self-evaluation process was participatory and the conclusions have been elaborated considering the opinion of teachers, students, graduates and employers, with a wide level of participation.

9.f. In the self-evaluation report, the program has identified its weaknesses, if any, in accordance with the evaluation criteria and has committed improvement actions to correct them. The improvement plan has the support of the institutional authorities for its realization.

9.g. The program demonstrates that it has implemented the actions committed in its improvement plans and that it has evaluated its achievement periodically, as evidence of the culture of internal quality present in the program.

6. The accreditation decision

The accreditation decision is made by the Acredita CI Technology Council and depends on the assessment that this Council makes of each of the evaluation criteria. The assessment is carried out according to the following definitions:

A criterion **is met** when there is evidence that policies and mechanisms are known and applied systematically showing results that are periodically reviewed.

Otherwise, we are in the presence of a weakness: the criterion **is not met** and will be valued either as **developing** or as **non-existent**. A criterion that is not met is in development when policies and mechanisms are known and applied, with preliminary results, but there is no evidence yet that it is systematic. A criterion that is not met is non-existent when the program presents defects in its design or does not have formal or systematic policies or mechanisms in its training process, or there are only statements, but without evidence of its application.

The accreditation decision is based on the following information:

a. The program self-assessment report,
b. The final report of the peer review committee
c. Program comments and observations (if any)
d. The result of the analysis of the comments and observations of the program in conjunction with the president of the committee of peer reviewers.

When the program is taught at different locations, daytime, or evening, in face-to-face or blended modalities, all of them will be evaluated (as a whole). The accreditation decision will consider the weakest evaluation, to decide.

The process leads to one of the following results.

a. Accredits
b. Not Accredited

The accredited program and this accreditation will be for the total period of 7 years:
The program demonstrates that meet the evaluation criteria of Acredita CI. The program contemplates in its design the graduate attributes, which are incorporated through their own graduate profile. It has continuous improvement mechanisms for the achievement of committed training having evidence that policies and mechanisms are known and applied systematically showing results that are reviewed periodically. The program demonstrates that the graduate profile is achieved.

The program accredits, but presents some weaknesses in quality Does not meet – In Development:
The program will be visited in three years. In this case it meets the evaluation criteria of Acredita CI, being able to present some criteria with weaknesses in the category "does not meet-in development". The program contemplates in its design the graduate attributes, which are

incorporated through their own graduate profile. The program demonstrates that the graduate profile is achieved. However, the evidence is recent, lacking to verify its permanence over time.

The program does not accredit
The program does not accredit when it has one or more evaluation criteria with weaknesses in the category "Does not meet – Non-existent", because it presents defects in its design, does not contemplate all the graduate attributes or does not have formal or systematic policies or mechanisms in its training process, or there are only statements, but without evidence of its application, or there is evidence that the graduate profile is not achieved.

More details on the accreditation decision are described in the **Manual of Rules and Procedures for the Accreditation of Science-Based Engineering under international criteria version 4, September 2020**.

7. Self-evaluation process and report

To submit to accreditation, the program must develop a self-assessment process and prepare a self-assessment report as a result of that process. In the self-evaluation process, it carries out a critical, detailed and reflective analysis about the fulfillment of the 9 evaluation criteria of Acredita CI. Self-evaluation is always an internal form of evaluation that is aimed at strengthening the management capacity of the unit to lead to a systematic planning of actions to improve its training process and to monitor them, which strengthens the internal culture of quality.

The Self-Assessment Report is the document where the progam presents its arguments to account for the achievement of the evaluation criteria, citing the evidence that supports the evaluative judgment it makes about its fulfillment. The arguments and evidence must clearly and explicitly reflect the situation of the program in each locations, daytime or evening or modalities in which it is taught. The Self-Assessment Report may present strengths and weaknesses that result from the reflection that the program has made, separated by locations, daytime or evening or modalities when appropriate.

As a conclusion of its reflection, the program is committed to establishing actions to maintain its strengths and overcome its weaknesses. The commitment to overcome the weaknesses will be explicit in the Improvement Plan, clearly indicating the locations, daytime or evening or modalities in which it applies, when appropriate. The Improvement Plan is a guide to future actions, which may be incorporated into the Program Development Plan to ensure its achievement. Acredita CI provides the format for the Self-Assessment Report through the document "*Self-Assessment Guide for the Accreditation under international criteria of Science-Based Engineering Programs*" published on its website.

The Report will make a critical analysis of the mechanisms of evaluation and measurement of the graduate attributes, in each locations, daytime or evening or modalities, when appropriate. And of the organization and planning of improvement actions if the results are not as expected. In general, the program will make the analysis of the achievement, measurement and evaluation of their graduate profile and graduate attributes, presenting that evidence as an annex to the Self-Assessment Report.

Acredita CI requests the submission of three specific and mandatory annexes:

TABLE 1: Matrix of contribution of the subjects to the graduate profile and graduate attributes.
TABLE 2: table of correspondence between graduate attributes and learning outcomes of the subjects.
TABLE 3: table of enrollment, retention and graduation of the last 10 years.

More details on this point are described in the **Self-Assessment Guide for the Accreditation under international criteria of Science-Based Engineering programs**.

8. External evaluation by the peer evaluators committee

The accreditation process is not complete without external evaluation by peer reviewers. The committee of peer evaluators is made up of teachers, academics or professionals who understand the scope of action of the program whose role is key for the Agency. Son technically updated people, of excellent interpersonal treatment, with highly developed communication skills, who act with professionalism because their observations stimulate innovation in the program so that they extend their efforts towards a continuous improvement in the training process. His gaze is objective and well-intentioned.

The external evaluation is enriched when the academic unit presents all its program to the accreditation process simultaneously. This implies a simultaneous analysis of the academic unit and the fulfillment of its purposes and a specific look by program. In this way a complete and efficient process is achieved. Each committee will be headed by a cross-sectional evaluator, whose function is to analyze and verify the role of the Unit in the performance of the programs and its internal consistency in relation to the institutional purposes leading the entire committee during the fulfillment of its purpose in the visit. Each program will be in charge of an evaluator, who, accompanied by the visiting secretary, will carry out the external evaluation process of the program.

The external evaluation is responsible for verifying in the field the fulfillment of the evaluation criteria, based on the Self-Evaluation Report provided by the program and on the evidence collected during the review and documentary analysis carried out prior to the visit. More details of the activities prior to and during the visit carried out by the peer evaluators can be found in the **Manual of Rules and Procedures for the accreditation under international criteria of engineering, version 4 September 2020**, published on the Acredita CI Website.

<u>The visit program for the accreditation process</u>
The visit program is defined by Acredita CI and is put to the consideration of the program. It will be elaborated according to the definition of the committee of peer evaluators in relation to the characteristics of the program.

Type visit program

The following proposal for a visiting program considers a visit to an academic unit with three programs in process with a common plan among them. The programs are taught in one location, in daytime. In the case of a visit to more than one location, daytime and evening or diferent modalities, the necessary adjustments will be made, which may include increasing the number of visiting days or the number of evaluators.

Day 0	
20:00	Internal meeting of the Peer Review Committee in hotel, prior to the start of the visit.

Day 1	
08:30	Transfer of the Peer Review Committee from hotel to the Institution.
9:00 – 9:30 The entire committee participates	Meeting with institutional authorities. *(For the review of the institutional policies on teaching and results of the educational process, institutional resources, internal assurance of quality and connection with the environment).*
09:35 – 11:00 hrs. The entire committee participates	Meeting with authorities of the unit that dictates the programs and with those in charge of curriculum design. *(For: the review of the definition of the purposes of the unit and its impact on the management of the programs; the review of the design of the graduation profile and the curriculum based on the educational objectives; and to know the support services to the students)*
11:05 – 12:05 hrs. The entire committee participates	Meeting with teachers / academics of the Common Plan. Attendees must not be authorities of the program.
12:10 – 13:10 The entire committee participates	Meeting with Common Plan students
13:15 – 15:00 The entire committee participates	Lunch and internal committee meeting.
15:15 – 16:30 The entire committee participates	Tour of the Common Plan subject facilities
16:35 – 18:45 The entire committee participates	Committee Review Meeting
19:00 – 20:00	Meeting with employers of graduates of the program, **without contractual ties with the Institution, if they are graduates of the program, they must have more than 10 years of graduation**. Minimum assistance of 5 employers who are direct managers of the graduates. *(For the review of the professional performance of the graduates).*
20:05	Transfer of the Committee to Hotel.

Day 2 - each committee separately meets with representatives from each program repeating this schedule by program	
08:30	Transfer of the Peer Committee from hotel to the Institution.
09:00 – 10:00	Meeting with program authorities. *(To know in detail the teaching-learning mechanisms).*
10:05 – 11:00	Meeting with teachers of specific subjects of the curriculum to verify mechanisms of achievement of learning results. *(Especially those related to the subjects in which results are committed for the design or development of solutions to complex engineering problems).*
11:05 – 11:45	Meeting with representative students from each cohort and including students in the process of graduation. *(For the revision of the activities of the subjects, as well as of the services of support to the students).*
11:50 – 12:50	Tour of specialty facilities *(To learn know specific laboratory activities that support student learning).*
13:00 – 14:45	Lunch and internal committee meeting.
15:00 – 16:00	Meeting with students of specific subjects of the study plan. *(To discuss the design or solutions of their complex problems, those that the evaluator asked to look at in detail).*
16:05 – 17:30	Other meetings to review the evidence of achievement of student learning.
18:00 – 19:00	Meeting with graduates of the program that represent different generations, **without contractual links with the Institution**. Minimum attendance of 10 graduates with 6 months of work experience. *(For the review of the professional performance of the graduates).*
20:05	End of activities on day 2.Transfer of the Committee to Hotel.

Day 3	
08:30	Transfer of the Peer Review Committee from hotel to the Institution.
09:00 – 13:00	Internal work meeting of the Peer Review Committee. Joint committee meeting to analyze results by unit and by program.
13:00 – 14:00	Lunch and internal committee meeting.
14:15 – 14:30	Socialization of findings between the Peer Evaluators Committee and the program authorities.
14:35	End of the visit.

- It is requested to consider a work office for the Peer Review Committee with a computer and printer and that it be adequate for the work to be carried out during the first day with the information of the unit in charge of the activities transversal to the programs.
- It is requested to consider a work office for each committee, for the activities of day 2, which will have at the committee's disposal the information required in the mandatory annexes, for detailed analysis of each committee.
- The program will make available to the committee a person to support administrative management and rigorous compliance with the program of the visit in the timeliness of the meetings.
- Each committee will be accompanied by a visiting secretary.

9. ANNEXES

9.1 Definition of Complex Engineering Activities

The educational process could consider this type of activities to strengthen the graduate's competencies. **Complex activities** means engineering activities or projects that have all or some of the following characteristics:

Attribute	Definition
Range of resources	**1:** it implies the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies).
Interactions level	**2:** it requires the resolution of important problems that arise from the interactions between technical, engineering or other, long-range or conflicting problems.
Innovation	**EA3:** involves the creative use of engineering principles and research-based knowledge to produce changes or new looks.
Consequences for society and the environment	**EA4:** have significant consequences in a variety of contexts, characterized by the difficulty of prediction and mitigation.
Familiarity	**EA5:** it can be extended beyond previous experiences by applying criteria based on principles.

9.2 Examples of Complex Engineering Problems

EXAMPLE 1:
Course exam: **Heat transfer**
Mechanical Civil Engineering Program.

The purpose of this exam is to operationalize the concepts or technological situations. The exam's theme is "Heat transfer in the Natural Gas industry".

1.-Sea transport in spherical containers (40%).
Natural gas (mostly methane) is a fuel produced mainly in Asian Pacific countries. For its use in Chile it must go through three processes: liquefaction at origin, maritime transport and regasification at destination. As liquefaction requires bringing the gas from ambient temperatures in the gaseous state to –160ºC in the liquid state, with considerable thermodynamic complexity, we leave this process aside, focusing on the other two.

It is carried out in boats of 5 to 6 ponds, of 20,000 m3 each. The tanks are made of aluminum (k = 177 W/mK), 4 cm thick, with an outer layer of insulation (perlite, k = 0.046 W/mK) and another outer layer of aluminum (5 mm) to protect the isolation. They have an equatorial flange that divides the two hemispheres and supports the tank in the cellar. During the trip the saturated natural gas at atmospheric pressure is kept at –160ºC, thanks to i) good insulation of the pond and ii) self-cooling produced by the evaporation (boil-off) of a small part of the gas. This gas serves as fuel for the boat's propulsion. The average air temperature is 12ºC.

a) You are asked to find the thickness of the insulation to allow an evaporation of only 0.05% of the initial gas content (by volume) per day during the trip. As a first approximation consider as the only significant thermal resistance that of the insulator.
b) With the found thickness, evaluate the evaporation rate using the complete formulation of the problem: The air temperature is 12ºC but there is a convective coefficient of 20 W/m2K between the air and the pond. An average solar gain of 350 W/m2 is considered, which affects a flat projection of the sphere (circle). There is also radiation from the entire surface of the pond into space, the effective temperature of which is estimated at –10ºC. The emissivity of the external face of the pond is 0.95.

2.-Regasification in plants located in Chile (60%).
The regasification of natural gas has as its central part a storage tank and a vaporizer. In coastal plants, seawater is used as a hot fluid. The water enters the evaporator at 18ºC and must be returned to the sea at no less than 13ºC for environmental reasons.

The equipment is the "Open Rack Vaporizer" (ORV) shown schematically in the attached figure. It is composed of vertical aluminum tubes. Inside, liquid natural gas rises, which evaporates completely and then heats up. Seawater descends from the outside of the tubes, available at 18ºC. Natural gas enters –160ºC (state saturated at 1 atm) and exits at 10ºC, therefore sensitive heat is transferred in the upper section of the tubes.

The tubes are 1 inch outside diameter (0.0254m × 0.0221m) and are arranged in a square arrangement 0.03175m apart. Unlike a shell and tube exchanger, the flow is not crossed but parallel to the tubes whereby an equivalent diameter must be defined to apply turbulent flow correlations. The following is requested:

a) First, set the ratio between the mass flow rates of water and natural gas to meet the goal of leaving water temperature. If you want to meet the goal of 13ºC, the water flow would be excessively large. A water outlet temperature of 5ºC is taken, counting that the water before returning to the sea will be brought to 13ºC by means of the combustion of the boil-off of the storage tank on land, in a certain equipment that is not studied in this control.
Now analyze an ORV tube with a flow rate of 250 kg/hr of natural gas.
b) Plot the temperature curves of both fluids along the tube. Determine the logarithmic mean temperature differences for the evaporation and sensible heating sections, and the corresponding heats to be exchanged.
c) Estimate the length of the pipe section for sensible gas heating. You can use the Dittus-Boelter equation to estimate the convective coefficients on both sides.
d) Estimate the length of the evaporation section, considering a simplified form of the Gungor-Winterton equation, using only the term of convective evaporation. This is:

Biphasic convective coefficient:

The two-phase flow parameter, X (also in a simplified version):

Methane Properties	Liquid	Gas	Units
Density	422,119	1,865	kg/ m3
Saturation enthalpies	287	797,7	kJ/kg
Specific heat	3497	2235	J/kg K
Viscosity	4,46×10-6	5,0×10-6	kg/m s
Thermal conductivity	0,26	0,013	W/m K

Property	Liquid	Units
Density	1000	m3/kg
Specific heat	4194	J/kg K
Viscosity	1,3×10-3	kg/m s
Thermal conductivity	0,587	W/m K

EXAMPLE 2:
Project of the subject **Engineering in Thermofluids**
Mechanical Civil Engineering Program

The project will be executed during the semester.
The students form groups of a 3. They have continuous supervision, with weekly presentations.
Project: Conceptual approach to the introduction of nuclear power in Chile

The national energy field in the first half of the 21st century will be increasingly stressed by the growing demand for energy (considering that electromobility will make transport more and more dependent on fixed plants).

In recent years, a strong incorporation of non-conventional renewable energies (mainly solar, wind and geothermal) has been observed, the possible decrease in water resources for hydroelectric generation, the resistance of coal to disappear, with new projects that have compromised areas so far unexploited, the increasing importance of natural gas, for whose distribution and use the country has made huge investments, among other related factors.

Considering that coal-based generation should gradually disappear, nuclear energy can be viewed as one of the alternatives for a fully connected electrical system at the country level. (It should be considered, of course, that small-scale generation with NCRE and outside national networks will continue to be the best alternative for small and isolated populations).

Some academic studies (university theses) have been carried out in Chile on nuclear energy, but they are 10 years old, that is, before the massive emergence of NCRE in the country. This changes the situation in favor of more variable energies over time, which require the availability of some less intermittent power plants.

However, the low availability of flat and sloping land in the Copiapó and Coquimbo regions, together with the enormous surface area required by solar power plants and the low availability of water, also make nuclear energy an alternative.

It is proposed to carry out the project of a nuclear power plant to be added to the interconnected system, with a capacity that is a significant addition to the national energy system. It is tried to know the advantages and disadvantages of this type of generation in a country like Chile based on a rigorous engineering study.

It is known that the project of a nuclear power plant has great importance in heat transfer phenomena, in an imposed flow system such as the nuclear fission reactor. The safety of the plant depends on the ability to extract the heat generated by the fission. This is the main reason why this problem is studied in this subject.

Of particular importance is addressing issues such as (non-exhaustive list):

a. Diplomatic, political, commitments, international treaties.
b. Scale of appropriate energy production in MW (e).
c. Choice of reactor and plant concept.
d. Waste flow and disposal.
e. Environmental impact.
f. Location of the plant (seismicity, population density, insertion of the plant in any region)-
g. Thermo-hydraulic design of the installation.
h. Specification of security systems.
i. Operation and qualification of personnel.
j. Useful life and dismantling.

Some basic notions

Nuclear reactor engineering is multidisciplinary. Nuclear physicists, structural engineers, environmentalists, etc., work on the subject in addition to thermofluidic engineers. We focus on light water reactors that use the water-steam system as a working fluid (others are: gases or liquid metals).

The energy source of a nuclear reactor is the fission process in fuel elements.

Power cycles

A primary coolant circulates in the reactor core to extract energy. Depending on the reactor design, the turbine will be powered by either the primary fluid or a secondary fluid that receives power from the primary.

Example of the first case is the boiling water reactor (BWR), which uses the Rankine power cycle.

In the pressurized water reactor (PWR) the primary coolant is kept in a subcooled liquid state. The turbine is powered by steam (secondary fluid) formed by heat exchange from the primary coolant.

Data of some plants that use the water / steam system:
(Take into account the critical data on water, p = 22.12 Mpa, T = 374.15ºC).

	BWR	PWR
Builder	General Electric	Westinghouse
No. of systems ref.	1	1
Total power, MWth	3759	3411
Net power, MWe	1178	1148
No. of primary circuits	2	4
No. steam generators	-	4 (tube type)
Primary Cooler (water)		
Pressure (Mpa)	7.17	15.5
Input T° (°C)	278	286
Output T° (°C)	288	324
Secondary Cooler (water)		
Pressure (Mpa)	-	5.7
Input T° (°C)	-	224
Output T° (°C)	-	273

EXAMPLE 3:

Subject:**Heat Transfer**
Chemical Civil Engineering Program

A heat exchanger is needed to cool 22,000 kg/h of a hydrocarbon mixture, from 80°C to 35°C. For this, water is available at 25°C, which can be heated to a maximum of 50°C. The hydrocarbon mixture is going to be circulated through the tubes. Cu ¾ ” BWG 16 tubes, 16 feet long, will be used in alternate (or triangular) arrangement with a "pitch" of 1”.

- It can be assumed that the heat transfer coefficients have values of 4,500 m^2 K/W for the hydrocarbon mixture side and 6,500 m^2 K/W for the water side. Consider scale resistors of $4x10^{-5}m^2$ K/W and $2x10^{-5}$ m^2 K/W for the tube side and the shell side, respectively.
    a. For a tube bundle exchanger 1-2 (1 pass through the housing and 2 passes through the tubes) determine a water outlet temperature that ensures that the correction factor for the temperature difference is greater than or equal to 0,8.
    b. For the temperature determined in part a., calculate the number of tubes per passage, in the exchanger, for a desirable velocity of the hydrocarbon mixture equal to 1.8 m/s.
    c. Considering the results of parts a. and b., select an appropriate casing size and type of exchanger 1-2. Your choice should be such that the velocity in the tubes does not have a deviation greater than 20% from the desirable value.

NOTE: As is well known, the selection of casings sizes and configurations can lead to many, few, or no results that meet the required requirements. Therefore, the score will be rewarded if you try one or more conclusions and recommendations regarding the selection, either by suggesting modifications in the requirements or in different configurations of the casings considered in this problem. For this purpose, only comment or suggest, but do not make new calculations.

EXAMPLE 4:
Electrical Civil Engineering Program.
Ballbot Project

Definition: A Ballbot is an autonomous robot designed to stabilize itself on a sphere having only one point of contact with the ground. Because of this, a Ballbot is extremely agile, being able to move in all directions of the plane. The Ballbot is a versatile design and is useful as a work or support surface, for carrying loads and even for transporting people.
The project consists of the construction of an autonomous Ballbot capable of remaining vertically stable on a fixed point. Performance will be evaluated against disturbances simulating a soft side impact and an increase in weight on the upper surface.

Specifications:

- The purchase of DIY kits is prohibited.
- The choice of structure is free and must be made by the students.
- The robot must be powered by batteries.
- The robot must have a smooth top surface of at least 20cm in diameter in which it must accept loads of at least 1kg.
- The purchase of motors and their control electronics is allowed.
- All processing must be done on board the robot.

9.3 Professional Competence Profiles

The program has incorporated the graduate attributes in the formative process. An engineer who is trained based on the guidelines of the previous pages, will have a professional performance according to the competencies detailed below. These competencies are not mandatory in detail, but reflect the essential elements that should be present in professional performance standards.

These professional competencies accommodate different types of work (e.g. design, research and development and engineering management) by using the major stages of the engineering activity cycle (problem analysis, synthesis, implementation, operation and evaluation) together with the necessary management attributes; and also include the personal attributes necessary for competent performance, regardless of specific local requirements in communication, ethical practice, judgment, assumed responsibilities and protection of society.

This profile is defined generically and is applicable to all engineering disciplines. The application of a professional competence profile may require extension in different regulatory, disciplinary, or environmental contexts. By interpreting statements within a particular context, individual statements can be expanded upon and given particular emphasis, but they should not be altered in their essence or ignored.

The program may use these general guidelines as support to verify its own results or educational objectives incorporating systematic consultations with graduates and their employers about the presence of these characteristics in their professional performance, to use it as feedback.

Characteristic	Professional Engineer
Comprehend and apply universal knowledge.	**1:** Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice
Comprehend and apply local knowledge.	**2:** Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice specific to the jurisdiction of practice
Problem analysis.	**3:** Define, investigate and analyze complex problems using data and information technologies where applicable
Design and development of solutions.	**4:** Design or develop solutions to complex problems considering a variety of perspectives and taking account of stakeholder views
Evaluation.	**5:** Evaluate the outcomes and impacts of complex activities
Protection of society.	**6:** Recognize the foreseeable economic, social, and environmental effects of complex activities and seek to achieve sustainable outcomes*
Legal and regulatory.	**7:** Meet all legal, regulatory, and cultural requirements and protect public health and safety in the course of all activities
Ethics.	**8:** Conduct activities ethically
Manage engineering activities.	**9:** Manage part or all of one or more complex activities
Communication.	**10:** Communicate and collaborate using multiple media clearly and inclusively with a broad range of stakeholders in the course of all activities.
Lifelong learning.	**11:** Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.
Judgement.	**12:** Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Exercise sound judgement in the course of his or her complex activities.
Responsibility for decisions.	**13:** Be responsible for making decisions on part or all of complex activities.

*Represented by the 17 UN Sustainable Development Goals (UN-SDG)

9.4 Classification of graduate attributes

Classification according to knowledge, skills and attitudes to be developed in students.

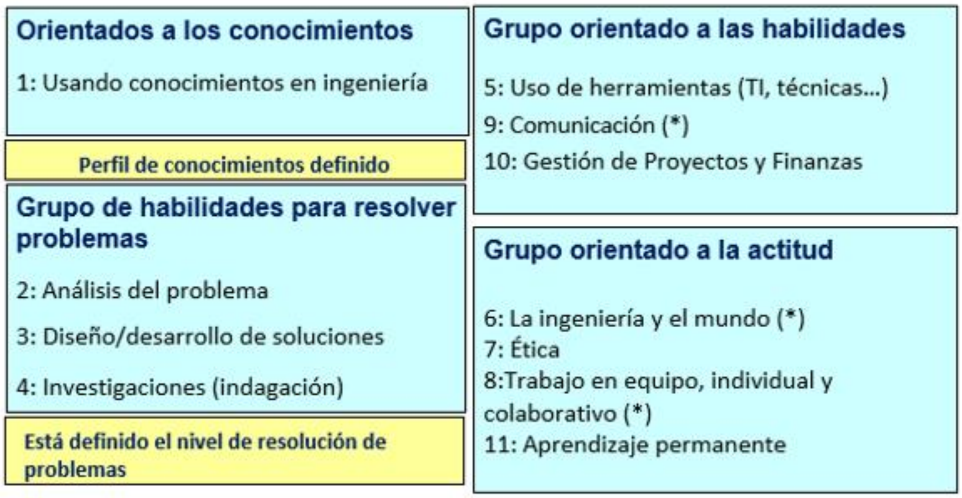

Figure 1: "Classification of the 11 competencies of the graduate's attributes"
(*) reference to the 17 UN Sustainable Development Goals, SDGs

9.5 Examples of subjects in mathematics, basic sciences and engineering sciences.

Mathematics and basic sciences	**Engineering Sciences.** **Example of traditional subjects that provide the fundamentals of engineering.** **They depend on the specialty.**
1.- Introduction to Higher Mathematics	1.- Materials Science and Technology
2.- Differential Calculus	2.- Solid Mechanics
3.- Integral Calculus	3.- Resistance of Materials
4.- Multivariate Calculus	4.- Fluid Mechanics
5.- Differential Equations	5.- Thermodynamics and use of Heat Energy
6.- Linear Algebra	6.- Electronics and Electrotechnics
7.- Probabilities and Statistics	7.- Environmental Engineering
8.- Introduction to Physics	8.- Economic and Financial Engineering
9.- Physics - Mechanics	9.- Operations Research with linear and dynamic programming
10.- Electricity and magnetism	10. Process mass and energy balance
11.- Waves and Modern Physics	11. Differential geometry
12.- Chemistry	12. Others specific to each specialty

9.6 Glossary of specific terms

Learning outcomes: refers to the knowledge, skills and attitudes, individually assessable, that each unit/module/subject of the curriculum of the engineering program is committed to achieving in the student.

The bachelor's degree: is the one awarded to a student from a university or equivalent academic body who has approved a study program that includes all the essential aspects of an area of knowledge or a specific discipline or specialty.

Practice area: in the educational context, synonymous with a generally recognized engineering specialty; at the professional level, a generally recognized or distinctive area of knowledge and expertise developed by an engineering professional by virtue of the course of education, training, and experience followed.

Engineering sciences: include the fundamentals of engineering that have their roots in the mathematical and physical sciences and, where appropriate, in other natural sciences, which extend knowledge and develop models and methods to give rise to applications and solve problems, providing the knowledge base for engineering specializations.

Natural Sciences: provide, as applicable in each discipline or area of engineering practice, an understanding of the physical world, including physics, mechanics, chemistry, earth sciences, and biological sciences.

Awareness: Recognize the context and implications when using or applying what has been learned. The demonstration of awareness can be more varied than the demonstration of knowledge. Asking the right questions, including among the assumptions made, complying or respecting a situation can be acceptable demonstrations.

Knowledge: It involves both learning and demonstrating what has been learned. Demonstration of specific knowledge is invariably done through work carried out based on that knowledge.

Complementary (contextual) knowledge: Disciplines other than engineering, basic sciences and mathematics, which support the practice of engineering, provide an understanding of its impacts and broaden the perspectives of the engineering graduate.

Engineering design knowledge: Knowledge that supports engineering design in an area of practice, including codes, standards, processes, empirical information, and knowledge reused from previous designs.

Formative development: the process that follows the obtaining of an accredited educational program and that consists of training, experience and expansion of knowledge.

Continuous professional development: the systematic and responsible maintenance, improvement and extension of knowledge and competences, as well as the development of the personal qualities necessary for the execution of professional and technical tasks throughout the program of a professional of engineering.

Engineering Specialty or Specialization: A generally recognized area of practice or major subdivision within an engineering discipline, for example, structural and geotechnical engineering within civil engineering.

Fundamentals of engineering: consider a systematic formulation of engineering concepts and principles that are based on mathematics and physics, and when appropriate, on other natural sciences, which provide the knowledge base for the different specialties. They are disciplines related to materials, energy, systems and processes and the environment, among others. They are intended to provide the conceptual basis and analysis tools for use in Applied Engineering and which need to be expanded to create theoretical frameworks and bodies of knowledge for the various areas of engineering practice.

Manage: means planning, organizing, directing and controlling risks, projects, changes, finances, compliance, quality, ongoing monitoring, control and evaluation.

Solution: It is an effective proposal to solve a problem, considering all relevant technical, legal, social, cultural, economic and environmental issues and taking into account the need for sustainability.

Subdiscipline: Synonymous with engineering specialty.

Vanguard of the discipline: defined by advanced practice in the specialties within the discipline.