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Measurement of Graduate Attributes as a Tool for Educational Improvement: Case study of the Civil Engineering program in the University of Costa Rica

Medición de atributos de egreso como herramienta de mejora educativa: el caso de la Licenciatura en Ingeniería Civil de la Universidad de Costa Rica

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Abstract

This paper aims to show the advances in the measurement of graduation attributes for the Civil Engineering program at University of Costa Rica, including a thought on the scope of this process and its contributions on the improvement of the quality of academic work. The results achieved until now have followed a mixed methodology, which combines qualitative interviews with quantitative surveys. It is evident how critical and reflexive thinking in the framework of curricular reforms, requires the involvement of different populations and the homologation of criteria to achieve solid and timely results. Finally, it is exposed the intimate relationship between the measurement of graduate attributes, graduate profile and curricular design, and how these tasks have been approached from the example program.

Keywords: graduate attributes, educational measurement, curricular design, civil engineering, accreditation

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Resumen

El objetivo primordial de este artículo es mostrar los avances en la medición de atributos de egreso en la carrera de Licenciatura en Ingeniería Civil de la Universidad de Costa Rica, incluyendo una reflexión acerca de los alcances de este proceso y sus aportes al mejoramiento de la calidad de la labor académica. Los resultados alcanzados hasta el momento siguen una metodología mixta, que conjuga la realización de entrevistas cualitativas con encuestas cuantitativas. Se evidencia cómo el pensamiento crítico y reflexivo en el marco de las reformas curriculares requiere el involucramiento de diferentes poblaciones y la homologación de criterios para alcanzar resultados sólidos y oportunos. Finalmente se expone la relación que existe entre la medición de atributos de egreso, el perfil de egreso y el diseño curricular, y cómo se han abordado estas tareas desde la carrera en cuestión.

Palabras clave: atributos de egreso, medición educativa, diseño curricular en ingeniería, ingeniería civil, acreditación

The measurement has proven to be an ideal instrument to promote the improvement of the quality of higher education. What is not measured is difficult to evaluate and what is not evaluated cannot be improved. This is why the University of Costa Rica (UCR) has been promoting an educational evaluation culture for more than 20 years. To this end, general dependencies have been created at the institutional level and resources have been given to the academic units, so they have trained staff in this area.

Certainly, the self-evaluation and peer evaluation processes encourage the measurement of knowledge. Since 1999, the Civil Engineering degree of the UCR has been actively involved in these processes, being the first major in the country to undergo a quality measurement, which set the precedent that contributed to the beginning of university accreditation at the national level. Since then, the program was in the need of a certification process for this degree to facilitate student exchange and the mobility of its graduates to other countries. In this sense, the *Canadian Engineering Acreditation Board* (CEAB) was contacted in order to obtain the accreditation. Thus, the results have constantly improved their teaching and learning processes to the present. The continuous measurement of the academic work has become a common task, not easy or routinary, but rather imperative in the higher education endeavor.

It is not a secret that throughout these years the influence of the accrediting agencies has been demonstrated in the criteria related to the educational process and the pedagogical approach to follow. For the case study presented in this article, the introduction of the graduation attributes in engineering programmes has been proved by the CEAB. This has implied not only an adaptation an appropriation of the concept, but also the creation of an evaluative measurement methodology that accounts for them. The results presented show, on the one hand, the process that has been carried out in the School as part of the reflection linked to the adaptation of this concept, and on the other hand, the first steps to the construction of a methodology, adapted to the reality of the program.

So far, the process has showed the need to search for tools that allow a formative evaluation, understood as a critical learning activity, capable of changing the common conception that only the evaluations with quantitative results are good. In the engineering field, it is usual to believe that the best evaluations are those that give direct numerical scores, nevertheless, this new challenge requires to broaden the possibilities to those modalities that allow valuing more qualitative and multivariable aspects.

Theoretical Framework

Graduation Attributes Conceptualization

The objective of the graduation attributes evaluation of a major is to determine, in some systematized way, the degree to which the students who attended it, upon graduating, developed a series of skills, knowledge and attitudes that are crucial to perform in the social and work context. Society demands higher education instiutions a type of professional that is oriented towards a responsible activity and commits to it and to the environment in which it operates (Ysunza, 2010). It is for this context that the graduation attributes seek to establish minimum expected criteria.

The model that the CEAB proposes, offers a list of 12 attributes, which was taken as a basis for its study and adaptation within the School of Civil Engineering (from now onwards EIC, as abbreviated in Spanish). These attributes can be classified as either hard or soft, depending on the type of characteristics they seek to represent. Hard attributes such as design, research and problem analysis have always been directly explicit in the curricula of engineering programmes and, thus, are easier to interpret. Soft attributes, on the other hand, such as the ability to adapt to the national context, professional ethics or learning for life, acquire a fundamental sense in the development of future professionals, and, at the same time, pose significant challenges for the conceptualization and definition of tools for their measurement, since it is not the usual job of engineering professors.

Some years ago, the evaluative trends in the area of engineering, as in other technical areas and applied sciences areas, were focused on some curriculum improvement aspects based on the competency approach. Its ultimate goal was to determine the suitability of graduates to perform or be competent in a determined work environment. Nonetheless, in the last three years, this approach has shifted to the evaluation of the graduation attributes, based on the premise that the program trains people that could competently perform in the workplace, although not exclusivel, as it was mentioned before, but in society as a whole. Therefore, they are not directly designed for the work performance, but they go beyond.

This change of focus has slightly shifted the object of evaluation: from one that was exclusively focused on the individual results of graduates, to one focused on the major as such (from a set of individual results). The contribution of the canadian evaluators seeks to establish the measurement of graduation attributes as an instrument to achieve a better vision of the quality of the training that students are receiving. Several countries are making emphasis in this aspect, and still different methodologies that offer systematic, efficient and affordable results are exploring it. Issacson (2016) establishes a series of general steps to follow; however, the methodological decision always depends, ultimately, on each university.

As part of the revision and adaptation process of the attributes, firstly, its definition was established as the set of individually achieved and evaluable results, which indicate the graduates potential to acquire competences for the subsequent professional practice (adapted from Frank, McCahan and Wolf, 2013; Canadian Engineering Accreditation Board, 2014). From this definition, we worked on answering the following questions: What to measure? How to measure? And when to measure?

In fact, one of the crucial points is that the attribute is measurable both in graduates and in the development process of the attribute in students, that is, throughout the educational process to which they are exposed during the major. In this way, the attribute must be measured in at least three levels: initial, intermediate (or in process) and advanced, which makes it a complex task at a logistic level. The definition of each level is established by the CEAB and its goal is to obtain a notion of progress in the acquisition of each attribute before the student body leaves the system, in order to assess in which points the curriculum should be adjusted and the corresponding course programmes, with the purpose of covering the gaps detected.

The necessary relationship between the attributes and the curriculum

A fundamental conceptual aspect to address the measurement of graduation attributes is related to the graduate profile. It is important to understand that the attributes, by constituting this list of desirable qualities that students should have at the end of their studies, directly feed the graduation profile. It is for this reason that, although the list of attributes is first determined by the CEAB, each academic unit can and must decide to adapt it according to the purpose of its program. In other words, designing a measurement of attributes establishes the need to know its relationship with the graduation profile and, hence, with the purpose (unique and of its own) of the program. This explains and justifies in a special way the link between the evaluation of attributes and the process of continuous improvement.

It is important to clarify that the purpose of any major of the UCR must be established from a set of criteria defined by the academic unit in charge and in at least three frameworks: socioprofessional, epistemological and pedagogical (Bolaños, 2015). From these criteria, the different decisions for the updating of the graduate profile, the curricular materialization of the purpose of the major (previous endorsement of the respective School Assembly) must be derived. In other words, the institutional curricular methodology is a methodology whose core is the graduate profile. From this perspective, it is evident that the evaluation of the graduation attributes requested by the CEAB constitutes an oportunity to enrich the evaluation processes of the graduate profile (since the attributes nurture the profile), in a new and systematic way.

Based on the CEA curricular methodology, the categories according to which a graduate profile is organized are the “to know”, the “to know how” and the “to know how to be”. For its part, the list of attributes to be measured must respond to those three dimensions of knowledge: the first, the “to know”, makes reference to the theoretical knowledge that graduates should have acquired at the end of their studies; the second, the “to know how”, the skills and abilities that they will have developed based on knowledge and opportunities for their implementation throughout the curriculum; finally,

the third, which refers to all the attitudes, values and ethical principles that must accompany the professional practice (Odio, 2015). From this perspective, it is also observed why the attributes and profile are so linked. The construction of the first must go in hand in hand with the second and everything contributes to the continuous improvement of the program.

Methodologically, it is essential to insist that this educational measurement focuses on the major and not on each individual student. This means that it is necessary to design measuring instruments to be applied on the work students do throughout their studies, without this constituting an alteration in the assignments load or implying a consequence in the qualifications of each one of them. In other words, we seek to obtain results that reflect the quality of what is being taught in the discipline from the recollection of material elaborated by students of different courses (usual assignments of each course) but evaluated with an attribute-oriented tool (and not the course itself).

This also implies that some professors, besides developing and evaluating their course in the usual way, will evaluate the major, following the methodology and the instruments designed for this purpose. It is evident that creating the system that allows these measurements in a systematic and practical way requires the training of the teaching staff, so that they have inputs that allow them to generate tools and devise a way to adapt the process without this implying a significant increase in their usual teaching work. There is no doubt that the process of attribute measurement requires a change in the university's evaluation culture that allows it to transcend the different populations, since these are a fundamental part of the curriculum and its evolution.

The curricular revision process

There are many educational theories to design, evaluate and update the graduate profile of a program. As it was mentioned before, the design methodology and extended curricular update in the UCR starts from a systemic approached based on three main axes (or evaluation frameworks). Figure 1 shows a general scheme where these three curricular axes are visible, each of which raises a series of motivating questions that allow the understanding of what each one encompasses and the interrelationships between them. Once again, when analyzing it, one can observe its close relationship with the graduation attribut

The socio-professional axis, in turn, reflects the reality of the exercise of the discipline. It seeks to define the common practices of the discipline in relation to the needs of the society (the common good) and what the labour market demands, without one of them needing to be, a priori, more important than the other. The methodology encourages to define daily practices of the job: those present over many years and still in force (dominant), others that have been disappearing (decadent) and, finally, those that are innovative and respond to the latest technological trends (emerging). It must be deepened, here too, the relationship between civil engineering and other related areas. In the different experiences of self-evaluation that have been developed in the EIC, the need to make this interrelation more explicit has been pointed out as a weakness, especially with other engineering disciplines from a theoretical and practical perspective.

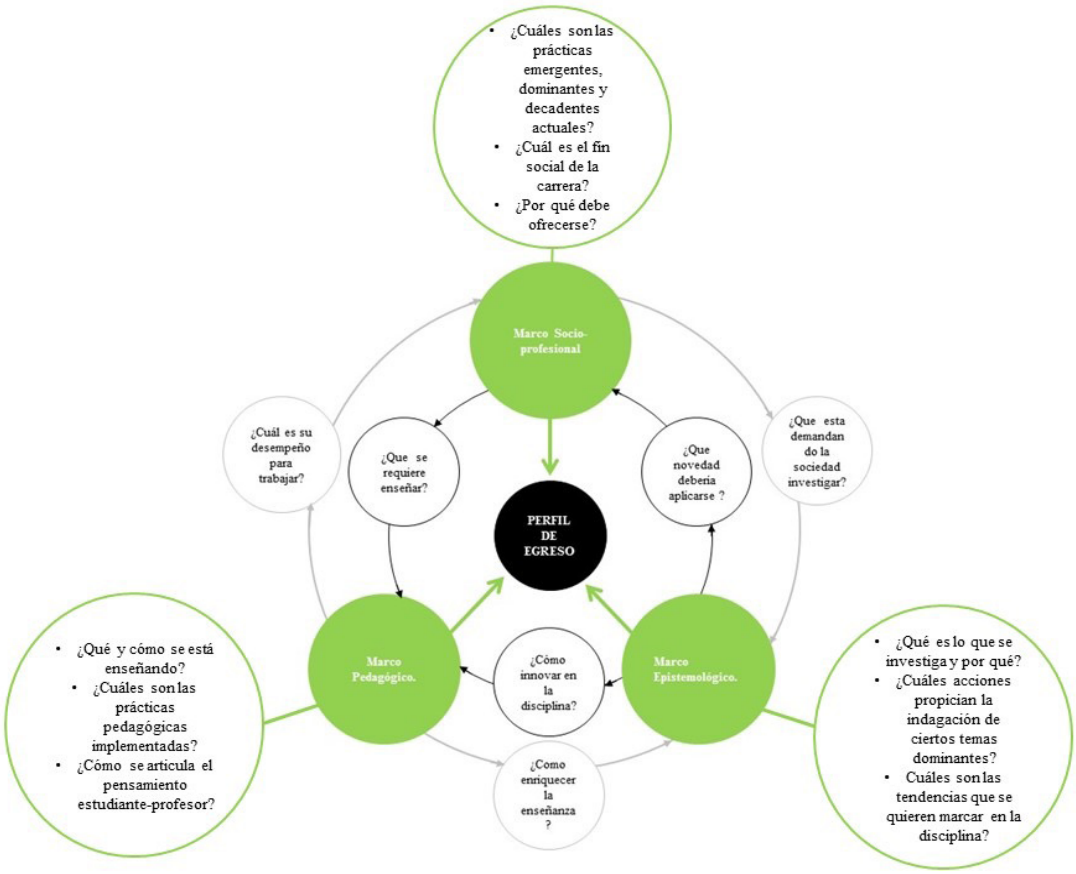

Figure 1. Relationship between curricular axes that make up the graduate profile.

The epistemological framework is key in order to understand and know in depth the object of study of the discipline: it presents the guidelines to understand how the production of knowledge in the area occurs. It seeks to answer questions such as *what is being investigated?* and *what are the research trends and needs in the medium and long term?*

The third framework, the pedagogical one, seeks to explain how it is taught and learned during the major. It is concerned with the transmission and construction of knowledge and skills of the discipline, from professors to students as well as in the opposite direction. This framework intends to go further, questioning the qualities that the teaching staff should possess and how to reinforce them, in the same way that it addresses the issue of the graduation attributes as the fundamental goal of the teaching and learning process. In other words, in the discussion regarding this framework, the graduation attributes that are currently in an evaluation process must be explicitly addressed.

The current dialogue between attributes and program profile: towards a new evaluation approach

From what has been presented, it can be deduced that: 1- The methodology of the CEA UCR proposes a path for the curricular design (or its integral revision) centered on the graduate profile; 2- The approach on the graduation attributes provided by the CEAB requires a systematic methodology for its evaluation. It is in this context that the major conducts its curricular revision process using as one of its fundamental inputs the evaluation of graduation attributes. Currently, this is carried out as part of a pilot plan that involves the CEA and other schools from the Faculty of Engineering.

As previously suggested, the attributes dictated by an accrediting agency must be adapted from a rigurous academic discussion. Hence why the Faculty of Engineering, jointly with the CEA, is on the process of defining its own methodology that adapts the steps suggested by the CEAB (Issacson, 2016) to the Civil Engineering program (its purpose), to the institution and the country. Lemaitre (2007) defines this type of educational evaluations as the "actions developed to evaluate the quality of higher education programmes, units or institutions, [in order to] provide public guarantee of their adjustments to previously defined criteria and work towards a continuous improvement of quality" (pp.10), so it is clear that ensuring quality implies a joint construction process, with a view to complying with certain standards previously defined and agreed upon by the parties.

In summary, evaluation understood as a critical learning activity can be considered as a set of actions that facilitate the information, generate different types of learning, provide timely feedback, spark interest, stimulate creativity, and generate skills to continue learning (Canabal y Margalef, 2010). The present case is important as a contribution in the definition of methodologies for measuring engineering graduation attributes and as a basis for other experiences. At the same time, it is required that these evaluations cease to be seen as a simple instrument for measuring and reporting back to the accrediting agencies (Álvarez Méndez, 2008, cited in García and Canabal 2012), and begin to be seen as real possibilities of improvement of the quality of higher education.

Methodological considerations

Regarding the curricular revision process that intends to use the evaluation of the graduate attributes as input, the first phase was based on an exhaustive documentary analysis, in which all the evaluation reports of the program were thoroughly studied, the resolutions of the program, its study plan and the reports that have been developed over the last 25 years regarding different measurements of the program quality. This revision served as a basis to know the context in which the program has been developed and how the issue of the graduation attributes has gained strength in recent years.

Regarding the background of the current pilot plan for the evaluation of graduate attributes, it should be noted that the EIC has carried out several exercises to design systems for measuring them, which has been a continuous but slow process since 2012. The first measurement of a specific population took place between May 2013 and March 2014, through a consultation tool regarding the educational quality of the courses taught and the attributes (or competences, as they were called at that time) that were being taught. The instrument of the first consultation was handed out to a total population of 60 teachers, out of which only 19 answered fully and validly. The validation process of

the instrument was conducted with three colleagues (civil engineering professors) that taught at other universities. The tool was worked on through an online questionnaire, with weekly reminders inviting them to participate during the two months that the survey was open (May – June 2013). The results were socialized in a workshop with educational representatives and students in October 2013. These shed light on how competences were being addressed in the curriculum, but were not published at that time.

Based on the obtained results, an action plan was presented to conduct a more concrete measurement of the graduate attributes. At the end of 2015, we felt the need to work on a deeper motivational aspect, aimed at the populations directly involved (especially teachers and students). Thus, by August 2015, the work was resumed, with a view to measuring the graduate attributes, and a teaching commission was created, which now leads the process. Simultaneously, the process of comprehensive revision of the program curriculum based on the first concerns, linking the purpose of the graduate attributes being measured result in an update of the already existing profile.

Currently, the major is in a second phase, which follows the fundamental steps of the curricular revision, always maintaining the purpose of establishing the necessary link with the graduate attributes:

- Interpretation of the attributes and their context, what the documentary analysis was considered for (resuming what was seen in the previous phase) and the interviews to experts on the disciplinary field (an interview guide was used as a reminder of relevant topics to be disussed, however, it was an open interview rather than a structured one).

- Mapping of the attributes throughout the courses in the curriculum; a list of the main attributes that are fostered in each course, considering their level of progress. In order to do this, the participation of the professors teaching the course(s) was required.

- Determination of the decadent, emerging and dominant practices of the profession, having as purpose the outline of the activities of a professional civil engineer. This was carried out through semi-structured interviews with outstanding civil engineers. This was done between January and June 2016 and there was a sample of 9 experts that represented the different areas of the discipline. The experts were selected based on the recommendation of the professors in each area. The validation of this instrument was made between the members of the Commission and the Schol Advisory Council.

- Surveys to employers and graduates to complement this first stage of the progress towards the socio-professional profile, along with surveys to professors and students to start enriching the pedagogical framework. We have been working on this phase since October 2016. The instruments were created using mostly closed question schemes with Likert scales of 5 options; surveys to employers and graduates were validated through the support of graduate professionals that did not belong to the area of interest, those of professors among the members of the same commission (12 teachers) and that of students with representatives of the Students Association (10 people). The surveys to the different groups of people were anonymous, with the exception of the group of professors. They were sent to the complete populations and their answer was followed up by telephone; due to the characteristics of the populations and the available resources, a statistical sampling was not pursued but rather, we sought to obtain the maximum number of responses within the considered time (3 months).

An example of the items used in the instruments indicated that *"The profile of a graduate Bachelor of Degree in Civil Engineering responds to a set of knowledge, skills and attitudes this person should be able to precisely account at the end of his academic training. For each item below, related to the graduate profile, indicate the degree of relevance that you consider this item possesses when a graduate needs to perform in a professional context. (In this scale: 0 is completely irrelevant and 4 is very relevant)."* Then, 19 attributes or qualites were listed that should be valued (it was considered relevant to break down in detal some of the original attributes in order to have a greater degree of information about possible needs of improvement of the plan).

Subsequently, we will continue to work of the revision of the graduate profile, the associated attributes and the required curricular changes, tasks that are left out of the discussion of this article.

Analysis of results and discussion

Work done so far has shown the first results by providing the major with its own approach to the graduate attributes, within the framework of a curricular revision which constitutes its responsability towards the Costa Rican society and not exclusively towards the accrediting agency. One of the main results has been the partial systematization of the measurement of the graduate attributes process as a methodology of its own and, in a collaborative way, through participation in the aforementioned pilot plan.

Another important aspect provided by the curricular revision process is the discussion of an epistemological framework that allows a consensus on a definition of engineering. According to El-Zein and Hedemann (2016), engineers, both in the academia and in practice, are often defined as problem solvers. Consequently, engineering students are told that their problem solving skills will distinguish them from other areas, and thus they will contribute to society. This makes some sense since it is one of the main tasks that are recognized in all engineers, however, it is certainly not the only one that will be required for their future performance. Thus, problem solving is one of the primary skills in the universty curricula of engineering programmes, not less in the workplace, but not the most important or the only one.

Part of the premises that have been clarified so far with the measurements made is that the educational world of higher education is a complex one and that the training students are receiving depends on many associated variables: some are cognitive, some are social and others more technical and technological. Therefore, it is true that "it is not enough to evaluate what the student knows, defines and remembers, but his cognitive skills should also be evaluated; what he comprehends, relates, integrates, contrasts and transfers" (Canabal and Margalef, 2010, pp.3-4). Garcia and Canabal (2012) argue that from a constructivist perspective, evaluation must be at the service of learning and the person who is learning and, hence, good teaching should lead to good learning, which leads to good evaluation. As students learn, professors must ask new questions, build from mistakes, encourage their reasoning, foster argumentative discussion and tolerance towards those who disagree, undertanding curiosity as an attitude, valuing the implication and trust in the intention to promote learning based on inquiry and ethics. All these teaching practices contribute to the development of the desired attributes throughout the training students receive, and not exclusively at the end of it.

There will always be disagreement among professors and what they want to teach, in opposition to what students and society require. As Kushner (2002) points out, professors stick to what they know and keep distance from that they do not know. That is why training in the evaluation of learning is necessary in order to make professors aware of the fact that uncertainty is intrinsic in the processes of change. The measurements made so far show that this is the reality in which the major is evaluated and that the required pedagogical changes can take several years to occur. Teaching engineering is not an easy task, even more so if we consider that the teaching staff, for the most part, has not received formal education to do so. According to the criterion of Hills and Tedford (2003), the education and training of engineers should be longer and more complete, nevertheless, this is one of the challenges that arise from the evaluations carried out. This leads to the conclusion that not everything can be taught in the university and that a study plan at the undergraduate level cannot be so extensive. Although, not all responsibility lies with professors. Students participation in the evaluation processes influences the development of attributes, enhances reflexive, critical and independent thinking skills, expands the ability to formulate and solve problems, improving the capacity for discussion and negotiation, motivating thinking and increasing learning and trust (Salinas, 2013).

Another relevant result obtained so far is part of the suggestions made by the experts who have been working on this area for many years, who were asked about the changes that have occurred, what should be taught and the roles that have changed in society in the light of professional practice in civil engineering. Table 1 shows a synthesis of these results and those marked with (*) are related to some of the attributes being measured:

Table 1
Results synthesis of the qualitative consultation to the experts in civil engineering in Costa Rica

Aspect	Contribtions of the interviewees
Changes in civil engeneering in the last 10 years	More technological development (*) Analysis of complex projects Gap between working practices in the public and private sector Optimizatoin necesities and rationing of resources Multidisciplinary work (*) Specialization that restricts a global approach Environmental and social responsibility (*)
Changes in civil engineering that should be promoted from UCR	More analytical and planning skills (*) Technological and computational tools (*) Development of critical and integral thinking Leadership and staff management Ethical approach to the career (*) Incorporation of specialties when addressing a project (interaction with other disciplines) (*) Infrastructural adaptability towards climate change and "resiliency" (*) Professional rigurosity and retrieval of work thematics Creativity and conceptualization of solutions Betterment of risk management (environmental and anthropogenic) (*) Mapping of the social actors to which the project serves (*) Decision making without dependency in specialized tools or models
Features of UCR graduates	Analytical and conceptual strength (*) More comprehensive training Able to fulfill objectives Able to work under pressure Proactively search solutions Impractical Lack of communication skills (*) Less adaptable employment Low innovations
What should be taught in the major	Engineering of added value Accounting and finances Work sustainability (*) Development of cities with an interdisciplinary perspective (*) Conceptual design and planning (*) Tools for Project management Professional ethics (*) Integration and complement among disciplines (*) Development and assessment of projects Understanding of the national reality (*) Modeling and simulations Use, reuse and treatment of resources and waste Role in decision making at a national level Analysis of effects and risks (*)
The profession in 20 years	Engineers able to pose a project comprehensively Knowledge of national and international regulations (*) Being able to work in an interdisciplinary setting (*) Involvement in national politics Cost analysts, repercussions and alternatives Adaptability to changing conditions in the labour market and society Complex thinking applied to projects Capacity to engage and realice international profesional exchanges Openness to work in new areas of knowledge User guidance Analysis of the cycle of live and environmental benchmarks (*) Learn to work with less resources when resolving complex problems

Source: synthesis made from interviews conducted with experts, 2016.

When analyzing the results presented by the experts, one of the most remarkable points is the need to carry out in-depth analyzes of the environmental and social implication of the projects. This is consistent with what is being developed in the most avant-garde universities in the discipline, which were studied as part of the major references. The most significant change in engineering curricula in the last two decades is the introduction, in various forms, of competences related to the environment and social sustainability (El-Zein and Hedemann, 2016). This seeks to expand a vision that goes beyond individual projects, to identify environmental externalities and effects on the society that surrounds them.

Comparing the results that have been obtained in the EIC until today with what has been reported by Gutierrez, Kikut, Rodríguez, Navarro and Azofeifa (2016) as a result of the study of employers of civil engineering graduates in state universities, great similarities were found. The surveys carried out in this study corresponded to 69 employers, out of which 56 belonged to companies with more than 101 workers. This study the most considered aspects in the process of selecting graduates are personality, entrepreneurial spirit, academic degree and availability. The competences that they valued as the most important ones were ethical commitment, the commitment to quality, the ability to work and organize time and the ability to work in teams (Gutiérrez et al, 2016). All these aspects agree with the soft attributes of graduation that are also observed in the measurement of graduates made by the School.

The ability to work and organize time are, according to the perception of employers, some of the most significant gaps between the importance of the attribute and the performance that is reflected (Gutiérrez et al, 2016). These soft attributes also appeared as aspects to improve in the training that students are receiving. By agreeing with the results of the interviews with experts, the importance of reinforcing the teaching approach and the way of dealing with problems in a systemic way is highlighted. El-Zein and Hedemann (2016) state that education based exclusively on problem solving prevents engineers from thinking outside the technical box and reduces their ability to address "ill-structured problems" where they face uncertainty, contradictory and incomplete information, diversity of opinions, among others. If we go back to the results presented by Gutiérrez et al (2016), there is coherence when it is stated that the only hard attribute that showed a significant gap between the importance and the performance, was the ability to analyze and synthesize.

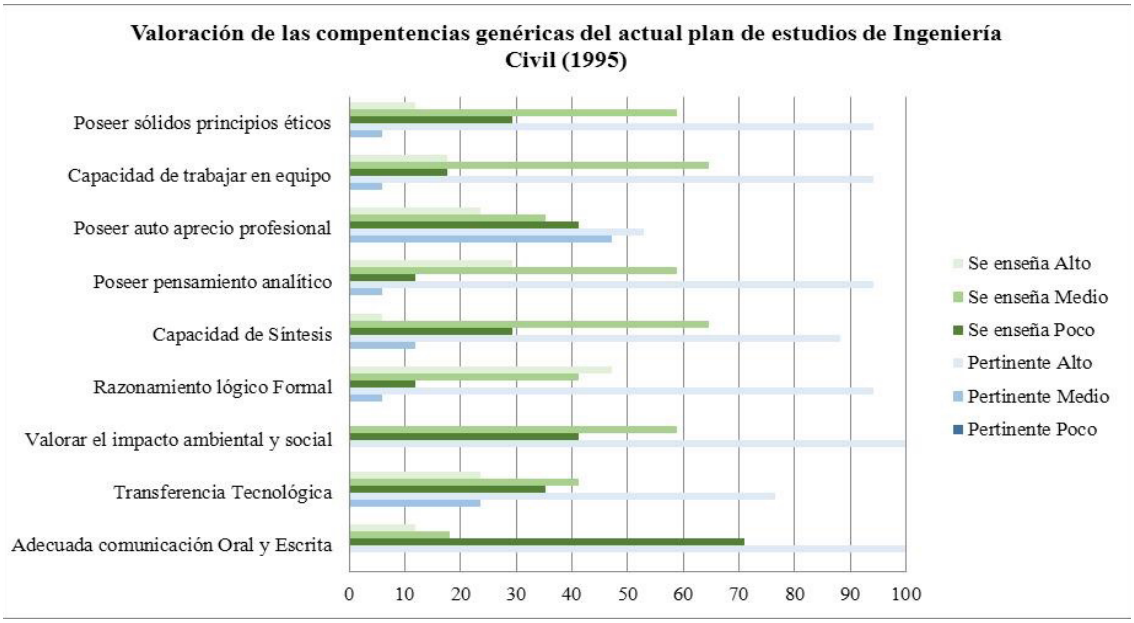

Figure 2. Results of the consultation with professors regarding the existent competences in the curriculum of the Civil Engineering major at the University of Costa Rica.

If we additionally analyze the results of the professor surveys of 2014, where the competences of the current curriculum (1995) were evaluated, we can observe once again how some of these aspects are reiterative. Figure 2 shows the results obtained in this measurement, where it was asked about how much was taught and how relevant each of this aspects were.

Additionally, among the results of the measurement made in 2014, an opinion was stated by the professors about the main knowledge, skills and attitudes that were provided in the current graduate profile. The results are presented in figure 3.

These results are being compared with the attributes that are being adapted to the graduate profile. In fact, part of the results that the work team has achieved in the pilot plan is to define the specific indicators that will be measured in each graduate profile. Table 2 presents these indicators, which were collectively constructed in several participative workshops between 2015 and 2016. It stared with a brainstorm that provided more than 120 indicators, wich were then summarized, considering the real possibility of measuring them and the most complete representation of the attribute.

The specific rubrics are currently being defined to measure each of these indicators in the three performance levels and in the courses selected for this purpose. This measurement will be made in 2017.

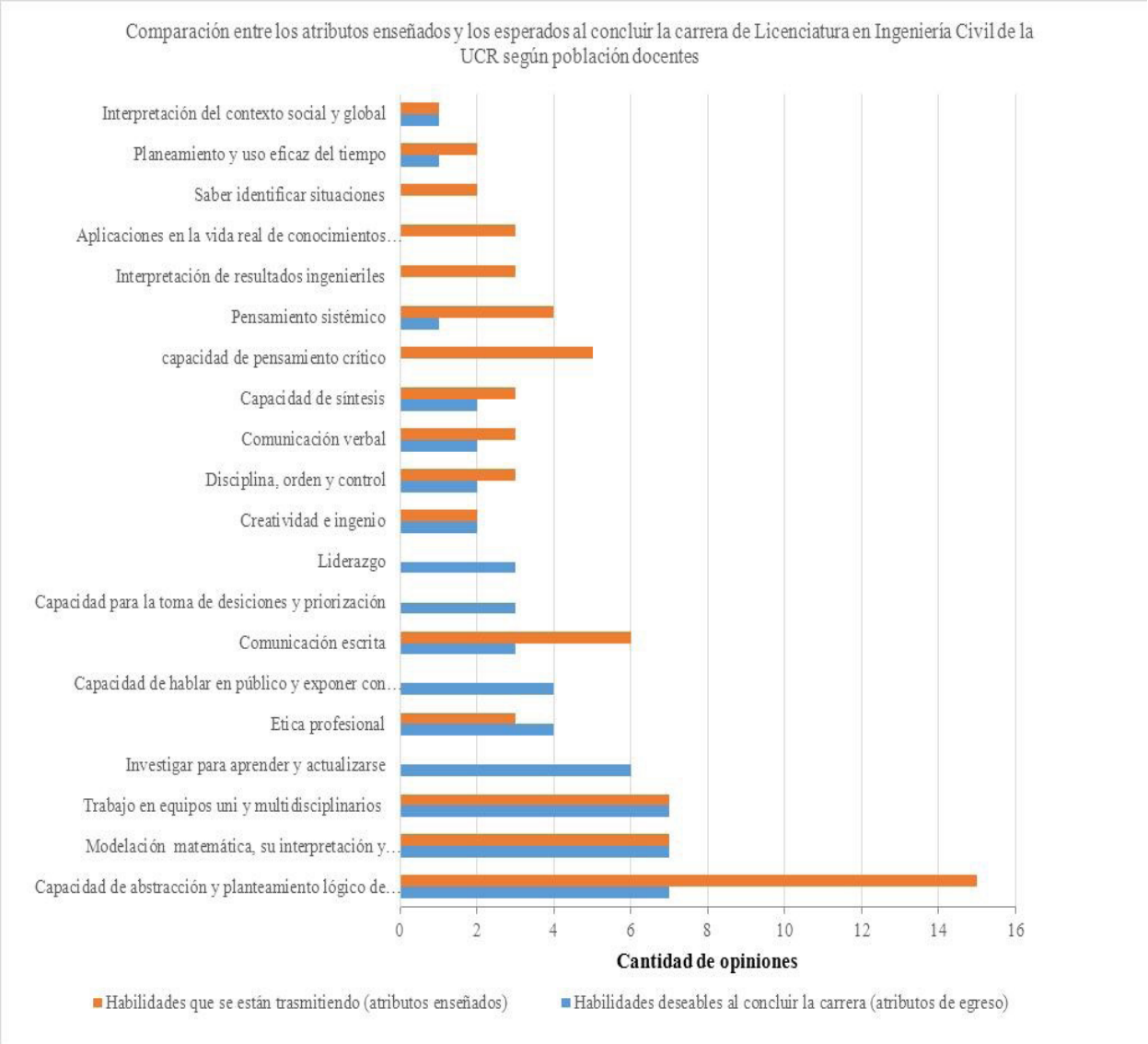

Figure 3. Results of the consultation with professors regarding the attributes taught and expected for the graduate of the Civil Engineering major from the University of Costa Rica.

Table 2

Indicadores seleccionados en la Universidad de Costa Rica para la medición de atributos de egreso de las carreras de Ingeniería

Atributes	Selected indicators
Basic knowledge in engineering	pplies scientifical concepts, tecnologycal and instrumental that sustain theorically the process of conception, proposal, design, implementation and evaluation of projects. Tests physical phenomena by means of experimentation for the compression of laws
	Uses models for the analysis of reality and formation of methodologies that allow problem solving in the field Identifies the necessary information, influence variables and theoretical principles associated to with the resolving of a problem
Research	Raises concerns relevant to the profession for the development of research Uses data pertinent for the development of research
Design	Selects, between diferent design proposals in engineering, solutions for engineering problems, considering health risks and public security, legal aspects, regulations and other considerations of economic, environmental, cultural and social nature Applies codes, standards and parameters charactericstics of the discipline in a design proposal
Use of tools	Uses modern and relevant tools for the different phases of development of a project Uses new techniques, tools or applications depending on the necessities and opportunities presented in the development of a project
Individual and group work	Contributes ideas and input for individual and team decision making Plays a role in the work in accordance with the expectations stablished by the team and the demands of the work or project
Communication skills	Correctly employs orthography, grammar and syntax of verbal language and graphic design codes relevant in the elaboration of documents Exposes in a clear and effective way a topic that talks about engineering to a diverse audience
Professionalism	Applies norms, guidelines and standards relevant to their discipline in projects Develops consciousness about problems in a national scale
Impact in society and the environment	Applies engineering solutions considering their possible impact in society, the environment and economy Proposes actions to mitigate the effects of solutions given about culture, society, the environment and the economy
Ethics and equity	Recognizes the limits of professional performance and prevents their infringement Promotes equal opportunities and a culture of respect towards ideological and personal differences, as well the erasure of any form of discrimination towards sexual orientation and gender identity, physical or mental disability, religious belief, political tendency, ideologies, ethnicity and culture.
Economy and Project administration	Selects the resources to complete tasks and projects from the economic impact of the design choices Distinguishes the basic principles of management suitable for the development of projects
Lifelong learning	Explores, through pertinent information sources, scientifical, technological and academic advances that are generated in the discipline to expand the area of knowledge. Exchanges knowledge with professionals of other disciplines that enrich and diversify their own learning

Source: Adapted from CEAB (2014), Issacson (2016) and CEA (2016) so it could then be collectively developed with representatives of seveal schools from the Engineering Faculty from the UCR.

Conclusions

The process of measuring attributes and general educational evaluation carried out to date shows some significant conclusions, which have a clear theoretical basis, a documentary analysis and a process of consultation with diverse groups of people. The most prominent conclusions are the following:

Nowadays, the civil engineer requires a holistic training, with a focus on the national reality and a commitment to society that is stronger than the one that has been developing in the major during the last 20 years. The teaching of civil engineering has been specialized and technified to a large extent, which has negatively made an impact on the acquisition and development of some graduation attributes, especially the soft ones. The training of these major graduates is solid in terms of skills and hard knowledge (theoretical); however, the lack of soft skills hinders their performance when it comes to expressing their ideas and conceptualizing practical solutions that convince different audiences.

The transversal axes considered as fundamental in the training of graduates, such as environmental awareness, comprehensive planning, respect for diversity or gender equality, have not been present enough in the major curriculum. This directly affects the lack of skills of graduates when it comes to wanting to incorporate these aspects in their professional performance. Different studies, both within the UCR and the program and at the level of external bodies, including the Consejo Nacional de Rectores (CONARE) through the professions Observatory, agree that the level reached in some graduate attributes, associated with subsequent professional performance, must be reinforced. The measuring processes of graduate attributes are complex and, until this day, there are no standardized methodologies that can be replicable in any reality. Each university must develop its own process, considering its reality and possibility.

The methodological results in erms of the measurement of attributes have contributed to make decisions for the improvement of the quality of the program, and this will be reflected in the curricular changes to be proposed. The changes in the way of teaching and the exposure of students to the already existing information demand a teaching-learning strategy different from the traditional one. Finally, as indicated by Hills and Tedford (2003), it must be taken into account that the nature of engineering education also needs to consider another context: that of global problems, human values and techonologies. Therefore, the soft attributes become relevant, both for those who employ engineers and for those who already have many years of professional experience.

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