Global Journal of Engineering Education

A preliminary study on the certification criteria of professional engineering in Colombia

Oscar A. Vásquez-Bernal† & Félix A. Cortes-Aldana‡

Universidad Nacional Abierta y a Distancia, Bogotá City, Colombia†
Universidad Nacional de Colombia, Bogotá City, Colombia‡

ABSTRACT: Certification of Colombian professional engineering presents a challenge in professional mobility to other countries, which is affected by the fulfilment of the requirements for degrees abroad. Also, the criteria for professional certification differ between certification bodies. The aim of this article is to propose the application of the analytic hierarchy process (AHP) in the context of goal-based selection to determine the weight of criteria (objectives), the preference levels for each alternative (certification models) and identify the most appropriate model for certifying professional engineering in Colombia. This process will contribute to the reviewing of various alternatives and criteria that apply to international professional certification bodies, in order to determine the most appropriate model for Colombia.

Keywords: Professional certification, multi-criteria decision analysis, proactive methods, analytic hierarchy process

INTRODUCTION

Colombian professional engineering is affected by compliance with the requirements for degrees abroad, which presents a challenge to engineers' job mobility to other countries. In addition, the criteria for professional certification differ between certification bodies. The key to improving occupational mobility is the adaptation to the conditions of each country. As professional mobility is desirable, this article examines the criteria and alternatives for professional certification in international engineering and proposes a model to support the professional certification process in Colombia.

Initially, the authors proposed the analysis of alternatives and criteria relating to certification of professional engineering. Several techniques have been used to analyse alternatives and criteria for decision-making. One of the techniques used falls within the framework of selection based on goals (goal based choice), and analysis and decision-making have been undertaken by using the PROACT method (problem, objectives, alternatives, consequences, transactions).

The analytic hierarchy process (AHP) was applied, in order to determine the weight of criteria (targets) and preference levels for each alternative (certification models), and to identify the most appropriate certification professional engineering model in Colombia. To this end, AHP, which is part of the multi-criteria decision analysis, was performed. Multi-criteria decision analysis (MCDA) is a broad term that includes a collection of concepts, methods and techniques that aim to help individuals or groups to make decisions that involve conflicting viewpoints and multiple stakeholders [1]. Although there is an important multi-criterion literature, tools, methods and even self-reflection multi remain largely unknown by technicians and managers at all levels [2].

Moreover, some important implications to be considered are presented, because the models are dependent on the perception of the weights of the criteria provided by the decision makers and the generation of model-based weights may be limited for some organisations' findings. Indeed, in practice, to develop a multi-criteria analysis methodology that results in a constructing professional certification may support more engineering expertise.

The adoption of the PROACT method establishes a methodical and systematic analysis of alternatives and determination of criteria [3]. Similarly, AHP was used because this method has a hierarchical structure that helps prioritise levels of

importance and preference, can deal with a lot of information, different viewpoints, and can ease the comprehension and understanding by people that are not experts in the subject.

STATEMENT OF THE CASE

The engineering profession has taken a major role in social risk that can happen due to the impact of engineering activities on society. Ensuring professional competence and experience is imperative for professionals and vital to the production structure and infrastructure development. Ensuring compliance with the requirements for the suitability of professional engineering is one of the main duties of professional engineering advice in Colombia. Moreover, an external dilemma presented to professional engineering in Colombia is that job mobility to other countries is affected by compliance with the requirements for degrees abroad and that certification bodies and the criteria of each certification body are different in each country [4].

It is important to be aligned with the new demands and requirements requested by certification bodies in other countries where Colombian professional engineering can impact the development of their professional activities. The migration profile of foreigners performing professional activities in Colombia is that 82.3% of the total analysed by the International Organization for Migration came from Venezuela, United States, Ecuador and Spain, while 84.6% of total Colombian highly trained professionals are located in Spain, the USA, Brazil, Argentina, Mexico, Chile, France and Canada [5].

In this regard, it is essential to adapt to the conditions established by each country to professional mobility; thus, it is necessary to identify and define the criteria for the certification of professionally based engineering analysis models of other certification countries and to propose a methodology for multi-criteria analysis to support the certification process of engineering professionals in Colombia.

METHODOLOGY

The analysis of alternatives to establish the important criteria for determining professional qualities of Colombian engineers requires a methodical analysis of secondary data that support common elements with the standards required by professional consortia and international certification organisations. PROACT facilitates this process and guides the decision maker to better analysis of the alternatives and criteria. This activity was developed by an expert who has consulted, researched and analysed secondary data and applied the analytic hierarchy process. The characteristics of the experts who developed the study and performed the implementation process of PROACT method and multi-criteria analysis process is then described.

Expert profile of the researcher involved: a PhD candidate in engineering - industry and organisations, industrial engineering, project management engineering specialist and Master of Business Administration (MBA), with extensive experience in the productive sector, and also an academic and researcher.

Analysis of Alternatives

For the analysis of the PROACT alternative method, secondary information from professionals and fellow members of international certification bodies was used. Based on the recovered information, selection criteria was established. The selected alternatives are:

A1. Consortium Washington Accord

The International Engineering Alliance (IEA) consists of agreements that include the Consortia Washington Accord, the Sydney Accord, the Dublin Accord, the International Professional Engineers Agreement (IPEA), the International Engineering Technologist Agreement (IETA), the APEC Engineer Agreement, established in a document entitled *Graduate Attributes and Professional Competencies*, Version 3: 21 June 2013.

The guidelines were based on the criteria for programme evaluation, development of competency-based standards for professional registration bodies that educational and professional guilds have developed for mutual recognition of qualifications, resulting in a document that defines the attributes of the graduate and professional skills profiles of three cycles of professions: engineer, engineering technologist and engineering technician. The Washington Accord provides for mutual recognition of engineering programmes: the Sydney Accord provides for mutual recognition of engineering technology programmes; and the Dublin Accord provides for mutual recognition of engineering technicians.

The case study will consider the guidelines associated with the engineer (professional engineering) from the Washington Accord.

A2. Consortium Bologna Process EHEA

The purpose of the Bologna Framework is to provide mechanisms linking qualification frameworks of each of the member countries and the European framework resulting in a rationalisation of common elements.

The Bologna Framework has three cycles that are key to understanding the framework elements. These three cycles are composed of descriptors that determine the characteristics of each cycle. The descriptors have been developed in consultation with stakeholders and interested parties, such as stakeholders in Europe. These descriptors are named the Dublin Descriptors. They are general in nature, but they can engage a wide range of disciplines and profiles, as well as variations of each of the criteria at the national level of the member countries.

In the case of graduate professionals, the descriptors of the first cycle will be considered, as they are applicable to the titles of graduates (Bachelor Degree) and higher education (Higher Diploma). In Europe, these names belong to European levels Qualification Framework 6, 7 and 8 of the Irish Framework Levels.

A3. Professional Councils Engineering in Colombia

The Engineering Professional Councils in Colombia are public entities responsible for the inspection, control and monitoring of the practice of engineers, based on the authority granted by Act 842 of 2003. Professional engineering in all its branches, its related professions and their respective professions auxiliary exercise, should be guided by criteria, concepts and lofty goals; therefore, it must be adjusted to the provisions of the rules that constitute its Code of Professional Ethics. (Act 842 of 2003, Art. 29).

The duties and obligations that professional engineering must meet are set out in the Code of Professional Ethics (Law 842 of 2003).

A4. International Certifying Organisations

National Council of Examiners Guidelines of Engineering and Surveying (NCEES)

NCEES in the United States provides for the licensing of engineers taking into account the impact of the activity performed by the professional.

Guidelines of the European Federation of National Engineering Associations (FEANI)

FEANI provides for the certification of engineers within the EUR-ING title programme established for the free mobility of engineering professionals having this certification to develop their professional activities in the member states of the Federation.

Selection Criteria

The proposed evaluation criteria for the certification of professional engineering are shown in Table 1.

Table 1. Evaluation proposal of the criteria for certification of professional engineering.

Criteria	Sub-criteria
C1. Professional competence	SC11. Knowledge engineering
	SC12. Problem analysis (complexity analysis)
	SC13. Research
C2. Professional skills	SC21. Engineering design
	SC22. Engineering practice
	SC23. Transferable skills
C3. Impact of certification	SC31. Country coverage valid certification
	SC32. Number of Colombian professionals highly rated by country

The selection criteria took into account the information extracted from the alternatives. The analysis, interrelation and interaction of different sources of information resulted in the following criteria.

C1. Professional competence:

Having the skills to pursue a profession. Ability to troubleshoot, act autonomously, be flexible, and to able to contribute to the professional environment and work organisation.

SC11. Knowledge engineering: apply knowledge of mathematics, natural sciences, engineering fundamentals and engineering specialty

SC12. Problem analysis (complexity analysis): identifies, formulates, investigates and analyses relevant literature on complex engineering problems, maintaining findings supported using the first principles of mathematics, natural sciences and engineering sciences.

SC13. Research: awareness of continuous technical change and fostering an attitude of seeking innovation and creativity within the engineering profession.

C2. Professional skills:

Apply knowledge to solve engineering problems, presenting skills in information management, communication and language skills, and professional ethics.

SC21. Engineering design: design solutions for complex engineering problems and design systems, components or processes to meet specific needs with appropriate consideration of impact of public health and safety considerations of cultural impacts on society and the environment.

SC22. Engineering practice: general knowledge of good engineering practice in their field of engineering and the properties, behaviour, fabrication and use of materials, components and software.

SC23. Transferable skills: understanding the engineering profession and its obligation to serve society, the profession and the environment, through the commitment to implement the appropriate code of professional conduct. A skill in economic engineering, quality assurance, ease of maintenance (maintainability), and the use of technical and statistical information. The ability to work with others in multidisciplinary projects. The ability to provide leadership covering managerial, technical, financial and human considerations. Communication skills and the obligation to maintain competence by continuous professional development. Language proficiency.

C3. Impact of certification:

Incidence of certification in the region where it is valid, considering country coverage and the number of beneficiaries of professional certification.

SC31. Country coverage valid certification: the granting of certification covers a large number of countries that promote international mobility of professional engineering.

SC32. Number of Colombian professionals highly rated by country: the number of highly qualified professionals who are in the country where the profession is being exercised.

Weighting of Criteria

The criteria weights are determined by the level of importance that the decision maker will give to each of them. There are heated discussions about the granting of weights to each of the criteria and the meaning impacts of the MCDA and of obtaining it. In the analytic hierarchy process (AHP), representation by means of a hierarchy of levels, one to one comparisons between the upper level and the next levels are made.

This binary comparison gives some results of priority. To calculate the weights of the criteria, it is necessary to make a comparison and opt for an approach that is better than others; for this, the rating scale used by Saaty was performed [6].

Based the evaluation of index weights of the criteria for certification of professional engineering, the results are shown in Table 2.

Table 2. Evaluation of index weights of the criteria for certification of professional engineering.

First level index		Second level index	
Criteria	Criteria weights	Sub-criteria	Sub-criteria weights
C1. Professional competence	0.370	SC11. Knowledge engineering	0.570
		SC12. Problem analysis (complexity analysis)	0.321
		SC13. Research	0.109
C2. Professional skills	0.493	SC21. Engineering design	0.529
		SC22. Engineering practice	0.308
		SC23. Transferable skills	0.161
C3. Impact of certification	0.137	SC31. Country coverage valid certification	0.250
		SC32. Number of Colombian professionals highly rated by country	0.750

Note: Rating alternatives and criteria

For this case study, the expert performed iterations of the criteria, sub-criteria and alternatives. Figure 1 shows the hierarchical structure of criteria and alternatives.

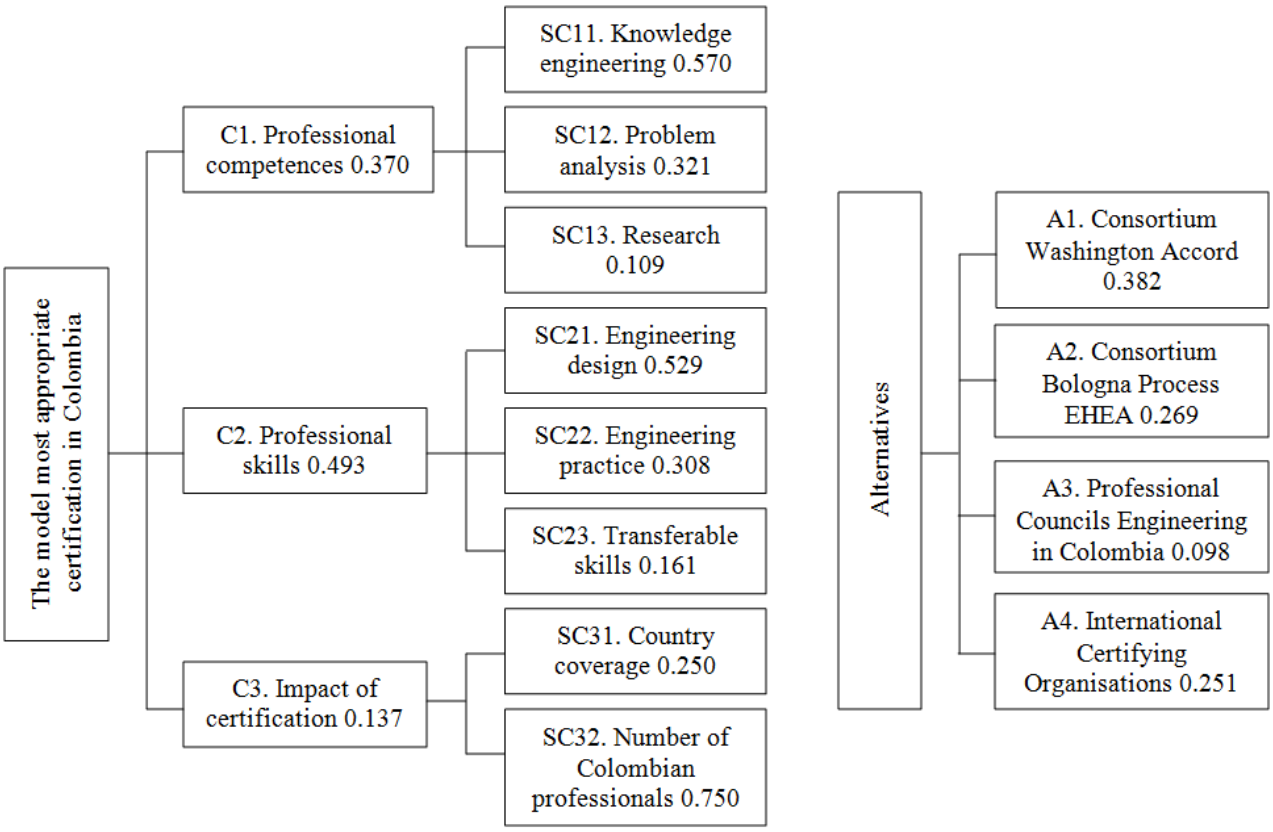

Figure 1 Hierarchical structure of criteria and alternatives.

CONCLUSIONS

When analysing respective results from the analysis of decisions reached according to the PROACT method, the method of assigning weights and hierarchical analysis process can generate several discussions.

First, it is essential to have clear decision variables i.e. alternatives and decision criteria, through which a thorough analysis from the decision makers generate reliable methods for implementing elements of assigning weights.

Second, the methods of assigning weights depend directly on advice from the decision makers. The method is simple and it will be setting the trend according to the rating given by the decision maker. This is of great importance in terms of the choice of decision makers and impartiality and objectivity thereof.

Third, the grouping of the criteria is critical, but it is necessary to consider a good group in terms of consistency and impact against each sub-criterion presented.

Given the importance of decision analysis and accompanying methods, and the analytic hierarchy process, it is important to further analyse the results presented in order to improve and/or refine the information and generate constructs that contribute to decisions.

REFERENCES

1. Belton, V. and Stewart, T., *Multiple Criteria Decision Analysis. An Integrated Apporach*. Kluwer Academic Publisher (2002).
2. Barba-Romero, S. and Pomerol, J-C., *Decisiones Multicriterio. Fundamentos Teóricos y Utilización Práctica, Alcalá, España*. Universidad de Alcalá de Henares (1997).
3. Carlson, K.A., Janiszewski, C., Keeney, R.L., Krantz, D.H., Kunreuther, H.C., Luce, M.F., Russo, J.E., van Osselaer, S.M.J. and von Winterfeldt, D., A Theoretical Framework for Goal-Based Choice and for Prescriptive Analysis. The Wharton School, University of Pennsylvania, Pennsylvania (2007).
4. Vásquez-Bernal, O.A., Unification and certification and recertification criteria to the professional engineers. Case study in Colombia, United States, Canada, Guatemala, Honduras, El Salvador. *Proc. 2011 IEEE Inter. Conf. on Quality and Reliability*, Bangkok, Thailand (2011).
5. Ramirez, C. and Mendoza, L., Perfil Migratorio de Colombia 2012. OIM Organisación Internacional para las Migraciones, Bogotá (2013).
6. Saaty, T.L., *The Analytic Hierarchy Process*. McGraw Hill International (1980).

BIOGRAPHIES

Oscar A. Vásquez-Bernal is an Assistant Professor in the School of Basic Sciences, Technology and Engineering at Universidad Nacional Abierta y a Distancia, Bogotá Colombia. He earned his BS in Industrial Engineering from Universidad Antonio Nariño, Colombia, Masters in Business Administration from UNAD Florida USA, and is a PhD candidate in engineering at Universdad Nacional de Colombia. He has published several journal articles and conference papers. Professor Vásquez-Bernal has been involved in projects with manufacturing and engineering companies. He is a management consultant in quality assurance, project management and safety management. He has taught courses in entrepreneurship, strategy and corporate logistic and innovation for engineers. His research interests include certification, accreditation, multi-criteria decision analysis and optimisation. He is member of NFPA and IEEE.

Félix A. Cortés-Aldana is an Associate Professor in the Faculty of Engineering at Universidad Nacional de Colombia, Bogotá Colombia. He earned his BS in Systems Engineering from Universidad Nacional de Colombia, Master of Economic Sciences from Universidad Santo Tomas, Bogotá, Colombia and PhD in engineering at Universidad Politécnica de Valencia, Spain. He has published several journal articles and conference papers. Professor Aldana-Cortes has focused on projects in decision-making, implementation of multi-criteria analysis methodology.