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Educational Objectives, Outcomes and Competencies Assesment for a Latin American Materials Engineering Program

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Abstract

This work discusses the strategies deployed at the School of Mechanical and Electrical Engineering of the Universidad Autonoma de Nuevo Leon, Mexico, for the assessment of Program Educational Objectives (PEOs), outcomes and competencies of the Materials Engineering Undergraduate program. This program has been reviewed and accredited by two Mexican agencies and recently efforts were made to adapt our procedures to comply with international standards and accreditation processes. Thus we successfully reviewed and evolved our systematic procedure for the assessment of PEOs, outcomes and competencies taking into account our university academic and educational model which is based on six main components: learning-centered education, competencies-based education, curricular flexibility, internationalization and academic innovation. We had to adapt our grading system in order to asses the development of competencies throughout the different courses in the five year (ten semesters) program, passing from a single average grade to a multiple-grading system. The continuous improvement processes were particularly worked in order to integrate the program constituencies inputs, the tutorship and guidance from the faculty members, while at the same time complying with our ISO-certified administrative processes. These good practices are having impact on an steadily increasing enrollment, a high employment rate and high satisfaction of the employers. We firmly believe that one key factor that accounts for the attainment of our PEOs is the strong collaboration with the regional industry which help us to offer a realistic project-based experience to our students which often results in successful research projects and publications. We also believe that our model can be of help for other Latin American engineering programs trying to evolve to international standards.

Introduction

The aim of these paper is to share, in a somewhat colloquial way, our experience in adapting our academic practices and processes to comply with the international standards needed to obtain the ABET accreditation for our Materials Engineering bachelor program. Latin American engineering programs with international accreditation are still not numerous. We believe that our experience can be both interesting and helpful for other Latin American and even for American programs. We are also convinced that it can be interesting for programs and faculty in other countries to know how our program operates. The program is offered at the Faculty of Mechanical and Electrical Engineering (FIME), one of the 26 Faculties of the Universidad Autonoma de Nuevo Leon (UANL), México. Our school is a big faculty, with more than 16,000 bachelor students and approximately 1000 graduate students.

First we would like to point out that, in our experience, American Outcome based education[1,2] is not very different to the Mexican (and Latin American in general) approach, though in recent years many universities and in particular engineering schools have been evolving from a contentcentered model towards a competency-oriented system in which a set of graduate attributes or competencies are mapped to the achievement of attributes that are progressively developed by specific learning activities[3-7].

According to Cahn[8,] university courses in materials engineering started in the US in the late 1950s, evolving from the discipline of metallurgy, the first Materials Science Department was created in Northwestern University, in Illinois M Sc. A similar evolution has been experienced in Mexico, since the first Materials Science and Engineering (MSE) programs have started as Metallurgical Engineering programs. At the present there are 15 MSE/Metallurgy programs nationally accredited in Mexico, including ours, nine of them still include the metallurgical term on their names. Our program was created in 2000 as a result of the evaluation of the former Metallurgical Engineering Program, which was offered from 1975 to 2000, with the last cohort graduating in 2005.

Following international trends in the field[9,10], the program was designed with the aim of graduating engineers that master the understanding and controlling of the four basic elements of Materials Science and Engineering: (1) The structure of materials from the atomic to the macroscopic scales, (2) the relevant properties of the different types of materials, (3) the different synthesis and processing methods, and (4) the performance of materials in components, structures, machines and products, with special emphasis at understanding the relationships among these elements. Besides, the creation of the ME program expanded the original metallurgically oriented curriculum to cover the fields of Ceramics, Polymers and Composites, though in the first years it maintained a very strong emphasis on metallurgy.

One of the reasons to expand our program from Metallurgy to Materials Science was that metallurgical programs were experiencing a decrease in enrollment. Even nowadays, Materials Engineering programs in Mexico, as well as in other countries, normally are not very numerous in their enrollment, in Mexico these programs typically have a steady enrollment ranging between 100-200 students. We believe that ours is a particularly successful program in this respect, because as a result of good promotion and diffusion practices, the enrollment, Fig. 1, has more than doubled in recent years, passing from 152 students in 2006 to 354 in 2014, it is probably one of the largest Materials Engineering programs in Latin America and certainly compares very well with similarly named American programs. Graduates of our program are highly sought by local companies and typically are hired before their graduation, with very competitive starting salaries. Students are also frequently sought for industrial internships.

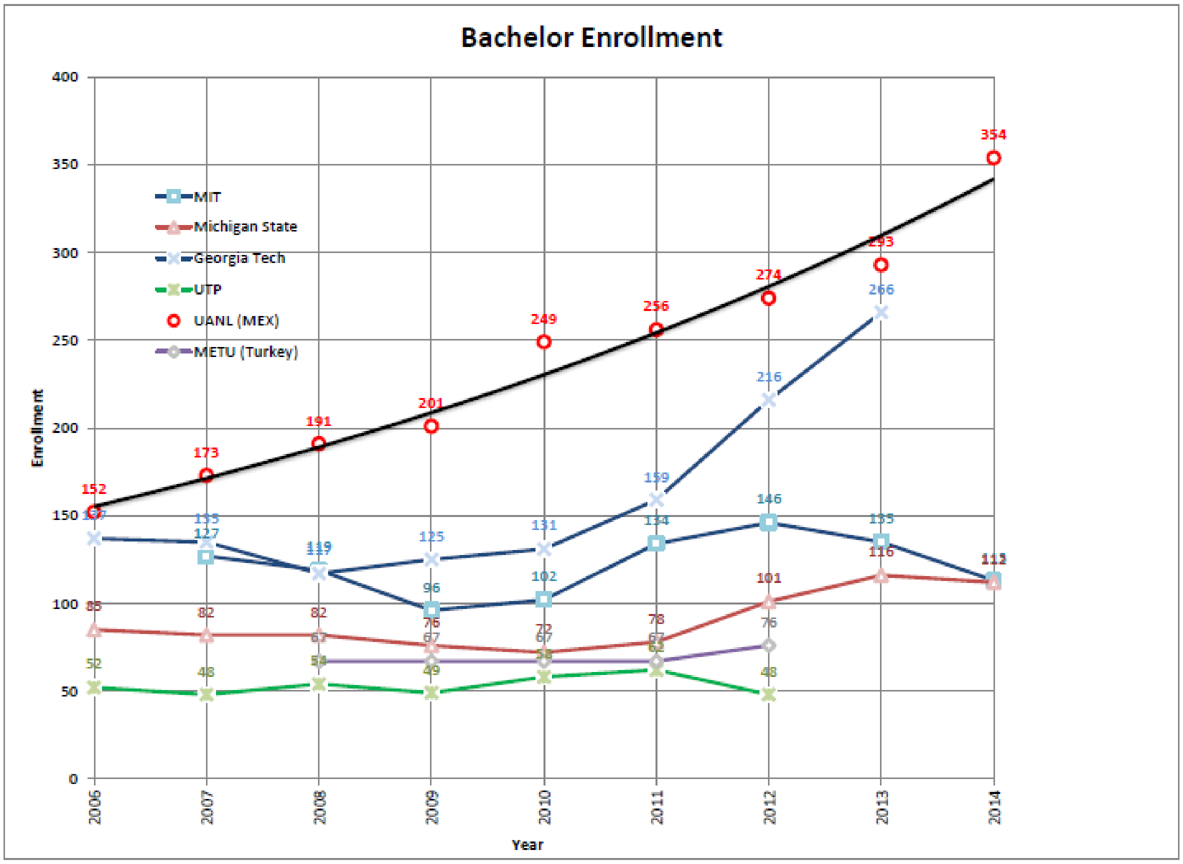

Fig.1.- Evolution of the enrollment of our ME program between 2006 and 2014, compared with similar representative international accredited programs (Source: Information published on the respective webpages).

Our admission process: Admission to UANL requires a national exam, which has the purpose of measuring the basic skills and knowledge of aspiring students, providing information about which students have the highest possibilities to successfully pursue bachelor studies. The exam assesses the logical-mathematical reasoning and verbal skills as well as the knowledge on Spanish, Mathematics, and Information Technologies. As a preparation for an international accreditation, in 2012 it was decided to adopt the practices of the admission procedure in our graduate programs, were student are interviewed and assigned a tutor or advisor once it is admitted. The result of the admission exam is analyzed and individual remedial actions are put in place where needed.

Program constituencies: The principal constituencies of the Materials Engineering program are: the current students, materials engineering faculty, alumni, a Program Committee, the Program Advisory Council and employers. In general, Mexican and Latin American engineering programs at the bachelor level in public universities does not have an external advisory council, so this practice is highly recommended for programs that envision an international accreditation.

The Program Committee is integrated by the program coordinator, the head of the Materials Engineering Division and three full time faculty members of the program, this collegiate body work as a team and plans and monitors all the academic aspects of the program, this team is responsible for the outcomes and competencies assessment processes and collect and analyze all the necessary materials. The Program Advisory Council was created, among other reasons, in order to reinforce the periodic revision of the program educational objectives. It is integrated by expert active practitioners and employers in the regional industry and includes several alumni.

I addition, our School has a General Advisory Council, which is integrated by distinguished professionals of the region, though this council have traditionally concentrated on the graduate programs, is now also monitoring our ten bachelor programs, providing input about the needs in the local industry, as well as pointing out future needs by analyzing current trends in industry, technology and science development.

Employers are a very important constituency of our program; we receive their input in different ways. One of the strengths of our School is the dynamic relationship that it has with a great variety of local, regional and national companies. Our school is part of the different clusters that the government of the state of Nuevo Leon has organized in sectors such as the automotive, aerospace, home appliances and nanotechnology, among others. These clusters integrates many companies which have strong relationship with Materials Engineering, thus we receive their feedback directly from them. Although this a well established international practice, it is not, in our experience, the general case for Latin American programs, at least at the bachelor level.

Curriculum and its evolution.

After its creation in 2000, the program has been revised in 2004 and 2011. In the 2004 revision the General Education module was reinforced. The revision in 2011 aligned the program with the current educative model of the UANL[11], which is based on: (a) Learning-centered education (b) Competencies-based education, (c) Flexibility, (d) Internationalization and (e) Academic innovation. This model aims at promoting the transition from a traditional knowledge-oriented approach to a methodology that seeks the development of skills and competencies, the curriculum flexibility is reinforced, the internationalization processes are taken into account as well as the student exchange and mobility. The current version of the program consist of a total of 220 credits distributed in 10 semesters. According to both the Educative and Academic Model of the UANL, one credit is equivalent to 30 hours of student work. Our curriculum prepares our students to apply advanced science through a series on Basic Science (Physics, Chemistry and Organic Chemistry, Mathematics, Materials Science and Engineering) and Basic Engineering Courses mainly in the first two years. We make sure that the Chemistry, Organic Chemistry and Materials Science and Engineering courses are taught by FT faculty of our program. The principles learned on these courses are then applied in subsequent courses covering the Ceramics, Metals, Polymers and Composites, these courses are invariably taught by our experts on each field, the Project Based Learning strategy is encouraged on these courses. Courses added in the 2011 revision include: Introduction to Solid State Physics, Nanostructured Materials, Nanotechnology. With the Materials Science and Engineering course, offered in the second semester, our students begin to integrate the scientific and engineering principles underlying the structure, properties, processing and performance of the different materials systems, we strongly emphasize the understanding of the relationships between structure and properties, how the synthesis/processing methods depend on and modify the structure and properties and how all of these influences the performance of a material, component or product. This focus is maintained throughout the rest of the specific courses covering topics on each of these materials. The program is designed to provide a balanced formation on materials in general, while being flexible through elective courses so that the student can concentrate at his/her choice on Metals, Ceramics, Polymers and Nanotechnology, these concentrations are specialized in the fifth year where the students are expected to develop a project on one of these fields under the direction of one of our full time researchers. The professional internship is mandatory, it is included in the official transcripts and given credits.

Faculty: In our experience, Mexican engineering programs in general, as it is probably the case in other countries in Latin America, are still far from integrating a faculty with international level[12]. One of the main reasons to decide to apply for an international accreditation for our program was that the program faculty is highly specialized and covers all the curricular areas of the program with a possible shortness in the field of Composite Materials (an issue that is being getting attention). Our FT faculty has very strong credentials, with the vast majority of the professors holding a PhD and having been educated overseas in highly recognized institutions such as INSA (France), ONERA (France), University of Sheffield (UK), University of Texas (USA), etc. Besides, the majority of the faculty are also members of the Mexican Research System, which is highly demanding and appoints researchers a national distinction in different levels according to the researchers scientific quality and productivity through a peer review process. Several members of our Faculty are also members of the Mexican Academy of Sciences and/or the Mexican Academy of Engineering. Compared with national and Latin American standards for Bachelor Engineering Program[12], ours has an exceptionally qualified faculty. These full time faculty is complemented with successful expert practitioners which at least hold a M.Sc. degree and have relevant experience and responsibilities in local companies. Taking into account the enrollment of the Materials Engineering Program of 352 students, the current FT Faculty of 19 professors is adequate and sufficient, with a ratio of about 19 students per FT active professor. The faculty is sufficient to provide advising and career guidance to the students throughout their studies

Internships as a strategy to gain professional experience and promote competency development**:** Since its creation, the program awards credits for a mandatory one-semester industrial internship. Students can apply when they have completed the fourth semester. Normally, our students pass their industrial internships at companies in the fields of steelmaking and forming, aluminum foundry, metal and polymer extrusion, ceramics products, among others. Exchange students typically go to Europe for an academic semester and an industrial semester which is also awarded credits. Due to the strong collaboration with the industries through our graduates, companies often seek candidates according to their needs by contacting directly one of the members of the faculty. There is also the so-called *Social Service*, which is a mandatory legal requisite for all Mexican higher education students. This consists in an internship either in the private or social sector, one of its objectives is to be “an act of reciprocity with society through the plans and programs of the public sector”, it also aims at “contribute to the academic and professional development of higher education students”. At our school it is a one-semester internship which is also granted credits. A high percentage, about 50 %, of our students are hired by the companies immediately after finishing their internships.

Capstone projects and bachelor thesis: The possibility of interacting with industrial and professional practitioners is a strength at our school, and this is particularly true in the Materials Engineering program, since faculty members often develop a number of projects and collaborations with locally based companies such as Nemak (the global leader in aluminum machine heads for cars), Ternium (steelworks), Vitro (glass manufacture), CEMEX (cement), Frisa (Superalloy components), among many others. These kind of projects, whose success in other programs have been reported in the literature[13], involve faculty and both undergraduate and graduate students. Taking advantage of this, students in the ME program can have a major experience both on design and research, under this context, in their fifth year they have project-based courses with the proposal, execution and reporting phases being nominally divided up into the two semesters. A member of the ME faculty is assigned as advisor and often the project results in a bachelor thesis, several of this projects have also resulted in journal publications and/or patent applications. We are strongly promoting this option, since it greatly benefits the students and allows us to detect talents to pursue graduate studies.

Accreditation: Engineering programs accreditation agencies in Mexico started in the middle 1990´s. Our ME program was accredited by the Mexican Council CACEI in 2007 and re-accredited in 2013. In general, in these evaluations we received relatively minor observations oriented to reinforce the admission and tutoring programs so that the graduation rates were enhanced and the failures rates on Basic Science courses were reduced. In particular, we have weaknesses in the field of Mathematics, this a common problem in Latin American engineering programs[12] that in our opinion does not receives enough attention. In our case, since 2005 we have put in place a collaboration with a French University (INSA-Lyon), oriented at reinforcing teaching and learning practices on Engineering Mathematics. Another important recommendation was to establish a program to update and renew the laboratory equipment as well as put in place a maintenance program. Through a better integration with our graduate program on Materials Engineering (Master and PhD) our bachelor students have access to state-of-the art equipment. At the present the program benefits with the equipment located at our well-equipped research labs at our facilities, as well as those located at the Center for Innovation, Research and Development in Engineering and Technology (*Centro de Innovación, Investigación y Desarrollo en Ingeniería y Tecnología*, CIIDIT) and the Center for Innovation and Research in Aeronautical Engineering (*Centro de Investigación e Innovación en Ingeniería Aeronáutica*, CIIIA), which is well-equipped and has an Aerospace Materials Lab, specialized on Polymer-Matrix Fiber-Reinforced Composite. Having been nationally accredited and re-accredited and fulfilling the observations received, in 2012 it was decided that our program was prepared to face the challenge of obtaining an international accreditation, specifically the ABET accreditation, so it is pertinent to discuss and compare the Mexican accreditation criteria[14] with respect to those of ABET[15].

The current Mexican criteria for accrediting engineering programs[14] include ten categories: Faculty, students, curriculum, learning evaluation, general education, learning support services, *liaison* (vinculación in Spanish), research and development, facilities and administrative-financial support. These criteria are general for all engineering programs and there are no additional specific criteria for particular engineering fields. On the other hand, the ABET criteria are divided in the following eight general categories: Program Educational Objectives (PEOs), Student Outcomes, Continuous Improvement, Curriculum, Faculty, Facilities, and Institutional Support. Additionally there are specific criteria for particular programs according to the technical field, in the case of Materials and Metallurgy programs there are two specific criteria, one specifies requirements of the curriculum and other requires that the program faculty expertise must encompass the metals, polymers, ceramics and composites fields. From this very rough comparison it is evident that the main differences in the ABET criteria that are not explicitly included in the Mexican ones are: the Program Educational Objectives, Student Outcomes and Continuous improvement. In our case, satisfactions of these criteria required a set of actions and strategies. One of the general strategies was to integrate the Program Committee which includes five people, i.e., the Program Coordinator and four members of the Faculty. To enrich the process and following a practice that have proved to work well in our graduate programs, we also integrated an External Advisory Council specific to the program. In the following, we describe with certain detail the Program Educational Objectives, Student Outcomes and the Continuous Improvement process along with some actions that we have put in place.

Program Educational Objectives

As is the case, in our experience, of typical Mexican and Latin American engineering programs, the Program Educational Objectives traditionally did not receive particular or constant attention once they were defined at the creation. They were typically reviewed only every five years or so. The strategy to comply with this criteria was to establish a process, integrated to our Quality System (described below), for the periodic review of the PEOs. We formalized the Program Committee and created the external Advisory Council specific to the program. As part of the process, the Program Committee held periodic (weekly, normally) meetings and discusses all the relevant affairs of the program. At the end of each semester, the Program Committee and the Advisory Council hold a session to review the PEOs, they also analyze and integrate the observations emitted by the General External Advisory Council.

Student Outcomes and Competencies

We had to analyze the *a* through *k* ABET outcomes and map them to the 22 competencies in our program, Table I. The UANL academic model[11] requires a set of fifteen competencies in different categories which are applicable to all the bachelor programs, we considered they are of interest and we proceed to list them fully: There are eight instrumental competencies, three personal and social interaction competencies and four integrating competencies. The instrumental competencies are: (1) Apply autonomous learning strategies on the different levels and knowledge fields that allow appropriate decision making. (2) Uses the logical, formal, mathematical, iconic, verbal and no-verbal languages, in accordance to his stage of life, to understand, interpret and express ideas, feelings, theories and trends of thoughts with an ecumenical focus. (3) Handle the information and communication technologies as a tool to the information access and its transformation on the knowledge, such as for the collaborative work and learning with the new technologies that allow its constructive participation on the society. (4) Masters his native language in oral and written form with correction, relevancy, opportunity and ethics, adapting his message to the situation or context for the transmission of ideas and scientific findings. (5) Use the logic, critical, creative and proactive thinking to analyze natural and social phenomena that allow making appropriate decisions in its influence field with responsibility. (6) Uses a second language, preferably English, with clarity and correction to communicate on daily, academic, professional and scientific contexts. (7) Make academic and professional inter, multi and transdisciplinary proposals in accordance with the best global practices to foster and consolidate the collaborative work. (8) Uses the new and traditional methods and research techniques for the development of their academic work, practice of his profession and the generation of knowledge.

The personal and social interaction competencies are: (9) The student maintains an attitude of compromise and respect towards the diversity of the social and cultural practices that reassure the principle of integration on the local, national and international context, with the aim of promoting environments of peaceful coexistence. (10) Takes part on the problems of the contemporary society on the local and global level with a critical attitude and human compromise with the academic and professional areas to contribute to help consolidate the general welfare and sustainable development. (11) Practice the promoted values of the UANL: truth, equality, honesty, freedom, solidarity, respect for life and others, respect for nature, integrity, professional ethics, justice and responsibility in its personal and professional field to contribute to build a sustainable society.

The integrating competencies are: (12) Builds innovative proposals based on the holistic understanding of the reality to contribute to overcome the struggles of the independent global environment. (13) Assume the leadership committed to social and professional needs to promote a pertinent social change. (14) Solve personal and social conflicts in accordance to specific techniques in the academic and professional field to the adequate decision making. (15) Achieves the adaptability required by the social and professional environment of uncertainty of our time to create better living conditions.

There are four competencies applicable to all engineering programs: (16) Analyses the parts of a device, equipment, system or process, establishing the relations between them, documenting the information on a structured, organized, coherent manner, including their own conclusions. (17) Generates models using the mathematical language to describe the behavior of a system, phenomenon or process, generating hypothesis that are validated through analytical methods or computational tools. (18) Solve engineering problems selecting the appropriate methodology, applying established models, based on the basic sciences, checking the obtained results with an analytic model or with the support of a technological tool, so that the solution can be pertinent and feasible meeting the quality standards and security policies. (19) Apply methods and techniques of scientific and technological research to the development of engineering projects.

We have added three specific competencies for our Materials Engineering program: (20) The Materials Engineering Program student applies the appropriate experimental techniques for the characterization of materials, generating a technical report. (21) The Materials Engineering Program student establishes the relationship between materials structure and properties, with the purpose of emitting statements and reports related to the many applications of materials. (22) The Materials Engineering Program student optimizes processes for the synthesis and processing of metallic, ceramic and polymeric materials that will lead to problem solutions and that will favor the production of high-quality materials, according to the requirements established and taking special care of the social, economic and technological impact.

Table I.
Mapping of ABET outcomes and ME program competencies

(a) An ability to apply their knowledge of mathematics, science, and engineering.	1, 2, 8, 17.
(b) An ability to design and conduct experiments, as well as to analyze and interpret data.	16, 17, 20.
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	16, 17.
(d) An ability to function on multi-disciplinary teams.	7
(e) An ability to identify, formulates, and solves engineering problems.	18, 19, 20.
(f) An understanding of professional and ethical responsibilities.	9, 10, 14.
(g) An ability to communicate effectively.	2, 4, 6.
(h) To understand the impact of engineering solutions in a global, economic, environmental, and societal context.	11, 12, 13, 15. .
(i) A recognition of the need for, and an ability to engage in life-long learning.	5, 9, 10.
(j) A knowledge of contemporary issues.	3, 6, 8.
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	21, 22.

Evaluating Student Performance and Assessing Outcomes: Before the 2011 revision, student performance was evaluated in the traditional way through the scores obtained on each course, so that in general the performance of the student was formally documented by the set of scores obtained on each course and concentrated of the Average Score. This methodology is clearly not consistent with today international standards and best practices. On September 2011 the UANL published a new General Regulation for Evaluations (*Reglamento General de Evaluaciones*), which considers the development of competencies through the different courses of each program and requires the use of modern methods and practices, indicating that the evaluation for each course cannot be specified using only a single method or score and has to be both formative and summative through a series of specific and properly designed activities and their evidences. To comply with this regulation and at the same time satisfying ABET criterion 1 (relative to students and that specifies that "student progress must be monitored to foster success in attaining student outcomes..") a new informatics system has been developed. This is aimed at monitoring the degree to which each course contributes to develop of program competencies. Each course is evaluated through a series of properly documented evidences (typically ten) derived from activities designed to contribute to one or more of the ABET outcomes and program competencies. For example, the Physics I course provides eleven activities that contribute to the 5,8,16,17,18, and 22 competencies, the Materials Science course provides seven activities (including a project) which contribute to competencies 1,5,8,16,18,21 and 22. As a result, for competency 22, for example, there will be at least fifty activities with documented evidence to asses it development. The system calculates the degree to which each competency is being developed for each student at any time, it also can provide traditional average scores for each course.

Continuous improvement.

In the last decade, Mexican universities started to establish Quality Assessment Systems and pursuing ISO Certifications, though this is a topic of controversy, it is undeniable that the adoption of standards has improved the administrative systems of universities, in particular Mexican public universities. In this trend, our school was among the firsts in Latin America to develop a System of Quality Management (SAC) under ISO 9001 standards, that was first certified in 2002. Our now consolidated Quality Management System has been evolving from an administrative approach to an academic-centered one. This systems consists of a total of 83 academic administrative processes, aligned with both the ISO standards and reference frames and criteria of the Mexican accreditation agencies. These processes are audited every six months to demonstrate continuous improvement. The system has proven to be of great helped in order to prepare the evaluation visits of the national accreditation agencies, both for our bachelor and graduate programs. However, these systems, which are the subject of debate, tend to focus mainly on the administrative part of education. One of the undeniable positive aspects is that they help to develop a culture of continuous improvement. With regard to ABET accreditation, we had to reinforce our existing processes to include the periodic outcome assessment and the revision of PEOS. It appears that demonstrating compliance with the Continuous Improvement criteria poses challenges for engineering programs around the world in general[16-20].

Impact on students

The described practices have demonstrated a positive impact on our students through the recent years. We have successfully and steadily increased the enrollment (Fig. 1) since our program is now more attractive to prospect Mexican students. The employment rate is high, with more than 50 % of our students hired before finishing the program, more than 80 % of those than do not pursue graduate studies are hired within the first six months after graduation, mostly by the companies where they have passed their internships.

Conclusions and lessons learned.

The Mexican Materials Engineering described evolved from a Metallurgical Engineering program, in accordance with international trends in the field. Its curriculum can be considered typical and has experienced a particularly positive evolution in is enrollment. One of the successful strategies that can be recommended to similar Latin American programs seeking international accreditation is the existence of a Program Committee and an external Advisory Council, as well as a dynamic interaction with industry representatives and employers in general. A highly specialized faculty is vital and we believe that in general Latin American engineering programs should make efforts to integrate the best researchers in the bachelor level education. Project based learning, industrial internships, capstone projects and the elaboration of bachelor thesis have proven to be successful strategies that we strongly recommend. The main differences that we identified in Mexican and ABET international process were the criteria related to Program Educational Objectives, Student Outcomes and Continuous Improvement aspects, which are not explicitly included in the Mexican criteria. The quality systems that are being implemented in higher education can be of help to establish successful continuous improvement processes in the educational practice, but this requires to focus the attention more on the educational aspects and less on the merely administrative tasks.

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References

1. J. Kearney, Outcome-Based Education. Final Report. Kearney College of Education University of Idaho, 1994.
2. Spady, W. (1994) Choosing outcomes of significance. Educational Leadership 51 (6), 18–22.
3. V. Sriraman, W. Stapleton, Lessons learned in first time accreditation of engineering programmes, Global Journal of Engineering Education, Volume 15, Number 2, 2013
4. Outcome-based Education – The Assessment of Programme Educational Objectives for an Engineering Undergraduate Degree, K.Y. Tshai, J.-H. Ho, E.H. Yap & H.K. Ng, Engineering Education, Vol 9, Issue 1 (July 2014).
5. J. Walther and D.F. Radcliffe, The competence dilemma in engineering education: Moving beyond simple graduate attribute mapping, Australasian Association of Engineering Education 2007, Vol 13 No 1, 41-51
6. Nusche, D. (2008), "Assessment of Learning Outcomes in Higher Education: a comparative review of selected practices", OECD Education Working Papers, No. 15, OECD Publishing.
7. Masni-Azian, A.1 , Rahimah, A.H. 1 and M.S., Othman, Towards OBE: A Case Study of Course Outcome (CO) and Programme Outcome (PO) Attainment for Product Design and Development Course, IOSR Journal of Research & Method in Education (IOSR-JRME), Volume 4, Issue 2 Ver. III (Mar-Apr. 2014), pp 55-61
8. R.W. Cahn, The coming of Materials Science, Pergamon, 2001
9. Materials Science and Engineering for the 1990s. Report of the Committee on Materials Science and Engineering, National Research Council. National Academy Press, Washington, DC, 1989.
10. M. C. Flemings, R. W. CAHN, Organization and Trends in Materials Science and Engineering Education In the US and Europe, Acta mater. 48 (2000) 371-383
11. Academic Bachelor Model (Modelo Académico de Licenciatura, document in Spanish), Universidad Autónoma de Nuevo León, Mexico, 2011.
12. Jeffrey Puryear and Tamara Ortega Goodspeed, Building Human Capital: Is Latin American Education Competitive?, in Can Latin America Compete?: confronting the challenges of globalization, edited by Jerry Haar and John Price, Palgrave 2008.
13. Todd, R.H. and Magleby, S.P. (2005) Elements of a successful capstone course considering the needs of stakeholders. European Journal of Engineering Education 30 (2), 203–214.
14. Reference Frame for Accrediting Engineering Programs (Marco de referencia para la acreditación de los programas de licenciatura, document in Spanish, CACEI, Mexico, D.F, Mexico, 2014.
15. Accreditation Board for Engineering and Technology (ABET) (2012) Criteria for accrediting engineering programs 2013–2014. Baltimore, MD
16. M. F. Mat Tahir, N. K. Khamis, Z. Wahid, A. K. Ihsan, J. A. Ghani, M. A. M. Sabri, Z. Sajuri, S. Abdullah & A. B. Sulong, Direct Measurement and Evaluation for Mechanical Engineering Programme Outcomes: Impact on Continuous Improvement, International Education Studies; Vol. 6, No. 6; 2013
17. K. J. Min, J. Jackman, D. Gemmill, Assessment and Evaluation of Objectives and Outcomes for Continuous Improvement of an Industrial Engineering Program, International Journal of Engineering Education Vol. 29, No. 2, pp. 520–532, 2013
18. Shekar, C.R., Farook, O. and Bouktache, E. (2008) Continuous improvement process based on outcome based education. Nashville, TN: IAJC-IJME
19. Chandra R. Sekhar, Omer Farook and Essaid Bouktache, Continuous Improvement Process Based on Outcome Based Education, Proceedings of The 2008 IAJC-IJME International Conference, Paper 031, ENG107
20. Anuar, N. H. Shuaib, K. S. M. Sahari, I. Z. Abidin, Continual Improvement and Assessment Plan for Mechanical Engineering Programme in UNITEN, 2009 International Conference on Engineering Education (lCEED 2009), December 7-8, 2009, Kuala Lumpur, Malaysia, pp 19-24, IEEE