Facing the Challenges of Engineering Education: Continuous Improvement at Universidad del Norte

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Abstract *— One of the greatest concerns in the education of engineers, has been, the possibility to ensure society the accomplishment of its professional's graduate profile. Engineering colleges for the past decade, have developed pedagogy formation programs for its teachers, and in a similar manner, have implemented diverse teaching-learning models and approaches, with the objective of reaching the engineering programs' educational objectives. An approach that has been applied for the past decades and which utilizes techniques and models proper of Engineering, is the one related with continuous improvement schemes in the education process. This paper, presents the education model implemented by the College of Engineering at Universidad del Norte for each of the six programs which integrate it. The model's characteristics, the benefits of implementation, the difficulties found during its execution and the lessons learned, which enabled the process of continuous improvement strengthen and consolidate; in the same manner, the paper includes the product results of the implemented approach up to this document´s elaboration date.*

Index term *— Accreditation, assessment, continues improvement process, Engineering Criteria 2000, engineering education.*

INTRODUCTION

The college of engineering at Universidad del Norte (Barranquilla, Colombia), conformed by the programs of civil engineering, electric engineering, industrial engineering, Mechanical Engineering and System's Engineering, considers a central aspect of its mission the integral development of its students, which comprehends the acquisition of knowledge in every discipline of engineering, and the development of skills y capacities to apply such knowledge in an appropriate manner in the solution of problems in their surrounding; the former implicates that formation of the student must be oriented in the development of capacities not only technical-scientific, but also capacities that allow the work with colleagues in diverse professions, in diverse multi cultural contexts and facing challenges that go further beyond the disciplinary knowledge of the engineering profession [1].

In order to offer the required formation the college of engineering periodically revises if its curricula responds society's demands and when required, curricular reforms have been made, accompanied by actions of professor's pedagogical education, updates of didactical resources, acquisition of specialized laboratories and similar others that help in the achievement of the engineering's education profiles.

Particularly, in the last five years, within a given quality frame, the college of engineering, it has been implementing the international accreditation standard EC2000, formulated by ABET (Accreditation Board for Engineering and Technology). The EC2000 is based in a continuous improvement approach, in which the goals of the program educational objectives and the program outcomes are to be determined, and according to the results obtained, strategies for the improvement of the program are developed [2].

This paper presents how the college of engineering has been formulating and developing improvement strategies with the aim of offering quality education for the engineers, and the actual state of the model being implemented and the expectations of its development within de institution's strategic planning frame for the 2008-2010 period is described [3].

CONTINUOUS IMPROVEMENT PROCESS IN HIGHER EDUCATION

The variety and complexity of the higher education offering, together with the challenges that universities face in terms of productivity and competitiveness, makes it necessary that universities assume a complete responsibility for the offered academic programs and furthermore, account to demonstrate that their educational offer is based on national and international quality standards[4].

In order to fulfill these new challenges, the higher education institutions have designed strategies for maintaining high quality standards not only in academic aspects, but also in the administration of institutional resources, infrastructure and of course, professor's education.

The former elements by themselves are not capable of engineering improvements in the academic programs; the existence of a total commitment by the university's board of directors is required, which should transcend the whole institution's community, administrative as well as academic, to highlight the importance of developing strategies for the continuous improvement, and the offer of a quality service.

Once the commitments for the main characters of the continuous improvement model are identified and established (curriculum, administration, infrastructure, professor's education and board responsibility), the next step is planning the model to be implemented for the achievement of the continuous improvement model objectives.

In the named plan, a self-study is initially made, in order to get to know the current state of the model, and to be able to determine the starting point for the strategies to be designed.

With the results of the self-study, the strategies to follow are determined, as well as the responsible group of the aforementioned, the available resources for their execution, and generally, a pilot test is made. A time window for the first expected results is established.

Once the strategies are implemented, the measurement of the results is started and from there, it is determined whether they comply with the initially outlined targets, which conducts to adjustments on the deviations. It is important to constantly monitor the results achieved while changes are made, so that timely corrective actions can be taken, and loss of quality in the model can be avoided.

When the pilot test of the model is finished, the final corrective actions are taken and the validation of the results takes place. In this stage, it is verified whether the planned strategies complied with the expectations. Being so, the planning process is started once again, in order to determine new opportunities of improvement. If not, the critical points of the model are determined (in which the targets were no met) and the necessary corrective strategies are determined.

GLOBAL ASSESSMENT MODEL

Background

The college of engineering has had as main objective to educate professionals that are capable of formulating solutions to real life problems within a technical, economical, political and social frame. Guaranteeing the highest quality in every educational project and working in the constant continuous improvement of such are then the main objectives of the division. For the achievement of these objectives, the quality assurance is assumed as a responsibility that requires permanent exercises of self evaluation and improvement, expecting to guarantee excellence in the offered educational service [5].

In the years 1996 and 1997, ABET (Accreditation Board of Engineering and Technology) granted the programs of industrial engineering and mechanical engineering substantial equivalence; during the 2002 period, the industrial engineering and mechanical engineering programs developed a self evaluation process for the renovation of the substantial equivalence, however, the continuity of the evaluation was interrupted because of the security problems the country was facing at the time. At the same time, the programs of civil engineering and system's engineering applied for the first time to ABET for the accreditation process, but the visit was not carried out given the aforementioned reasons.

In the decade of 2000, the university established the curricular modernization guidelines, and in the year 2004, the college of engineering, within the frame of the given guidelines, implemented the curricula of the six programs, with the objective of guaranteeing the achievement of the educational objectives of each program within de high quality standards and under the same continuous improvement approach; following, the model here described was designed.

In the model's description, the aspects of administration, infrastructure, professor's education and board responsibilities will not be approached, for it is not the purpose of this paper their development, even though they are embedded in the model.

The model is conceptually based on the proposed continuous improvement scheme in item II and was developed under the engineering criteria 2000, formulated by ABET, adopting the proper terminology of the EC 2000, and in accordance to the former, it was denominated "Global assessment model".

The concept of assessment comprehends the measurement process of a performance, a product or learning skill, but also feedback, documentation and respective decision making oriented to the improvement of the given measures [6]; in the designed model, the definition given by ABET for assessment and evaluation was adopted [7]; the model was designed under a global concept which implicates the assessment in the different levels proposed by ABET; the processes and tools were defined, and the targets for each model level were established.

Timeline

In the year 2004, the college of engineering formulated the global assessment model to be implemented in the six programs; this model was based on EC2000, and took into account the national and international engineer's education tendencies, as well as the institutional guidelines for modernizing the curricula; in the year 2005, a pilot test of the model was designed, consisting in assessment of core courses of each engineering program. The pilot test allowed the quick

determination of relevant aspects in terms of design, measurement and evaluation of the core courses outcomes for each program.

Starting 2005, the model has been strengthened through progressive refinements; in 2009, the complete application of the aforementioned model is reached. The model in its first phase (pilot test phase) considered the assessment of the courses outcomes, CO, and in the current year (2010) includes the complete assessment process of program outcomes, PO; these were formulated in accordance with the established guidelines by ABET PO from a) to k), plus some additional PO defined for each program, and the program educational objectives, PEO, of every one of the six engineering programs. The CO, PO and PEO constitute the key elements in the continuous improvement process of the college of engineering. The fulfillment of each one of them, as well as the evaluation of their pertinence, is the anchor of the global assessment model.

Description of the model

The global assessment model core is conformed by three loops, as shown on figure 1 below.

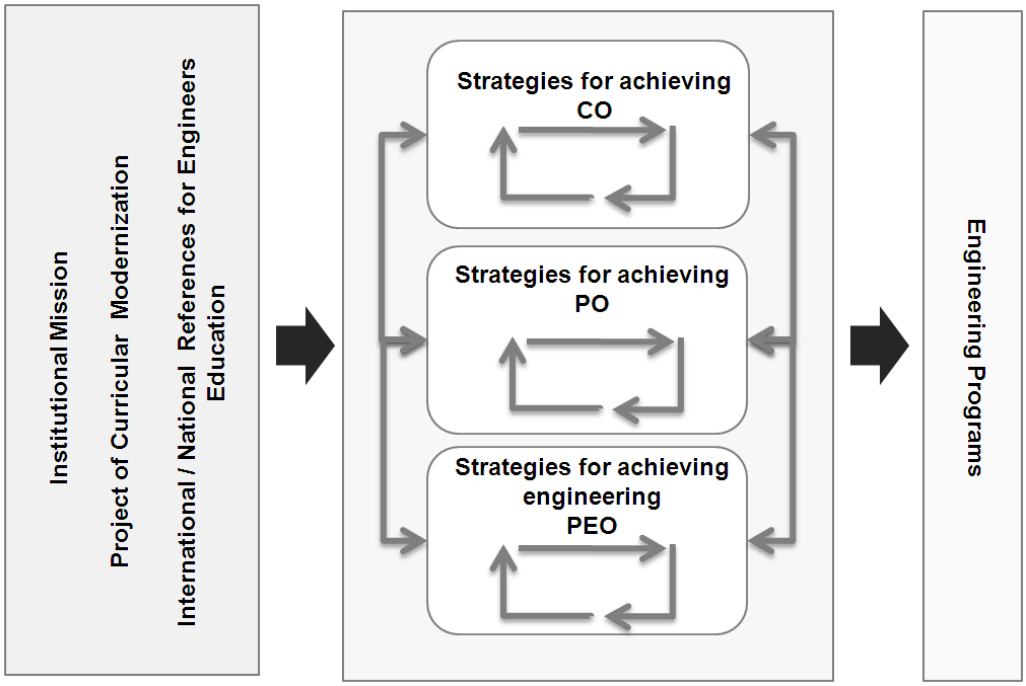

FIGURE 1
GLOBAL ASSESSMENT MODEL

The initial loop is related to the course outcomes assessment, CO; the middle loop with the assessment of program outcomes, PO, and finally, the last loop is related with the assessment of the program educational objectives, PEO. For each loop, the targets are defined, as well as processes of definition, measurement, evaluation and mechanisms that carry out the improvement actions.

Course Outcomes Assessment

Started as a pilot test in 2005, the assessment of the CO is considered the global assessment model core; it was consolidated in 2008 as monitoring mechanism for the curricular reformation project, implemented in the second semester of 2008 for the six engineering programs. From that year on, the process of assessment for all the core courses has been standardized. Figure 2 below shows the processes carried out in this loop.

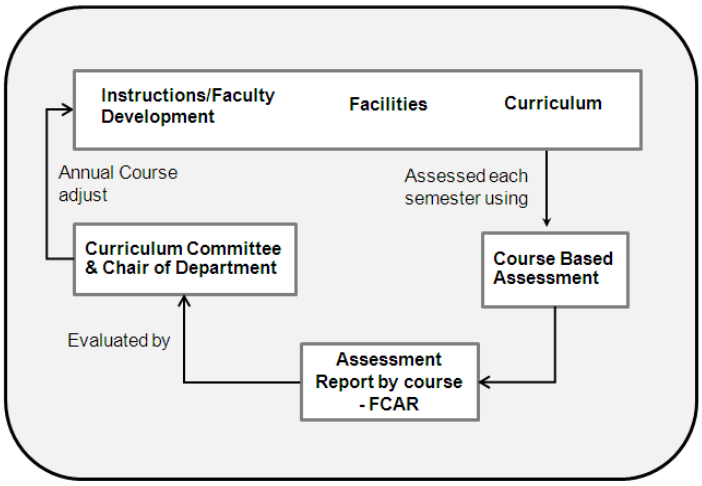

FIGURE 2
COURSE OUTCOMES ASSESSMENT

For means of establishing improvement actions that are easily applicable and measurable, the continuous improvement process established for the CO is implemented every semester, whereby the impact of the actions taken when a semester finishes are evaluated at the end of the next academic period.

The measurement in this loop is done through the FCAR (Final Course Assessment Report), elaborated for each course and which constitutes the main tool for impact verification of the improvement actions implemented, and the definition of the pertinent strategies for the achievement of the targets. This way, the structure changes that are necessary for the improvement of a course, will be implemented formally one year later of being identified, this with the goal of validating if the proposed changes really respond to the improvement opportunity initially detected.

The evaluation is performed once per semester by the chair of the department and the curricular committee of each program, consisting of the program coordinator, one professor's representative, and one alumni representative; an employer is invited optionally, when required.

Program Outcomes Assessment

The main target of this loop is to be able to identify the aspects that have to be improved and those that need to be potentiated, in order to reach the levels of achievement associated with the program outcomes for each program.

The main input in this loop are the results obtained in the course assessment reported via the curricular committee report assessment and the FCAR.

The scheme for the assessment of the program outcomes behaves similarly to that of the course outcomes, as seen on figure 3 below [8-13].

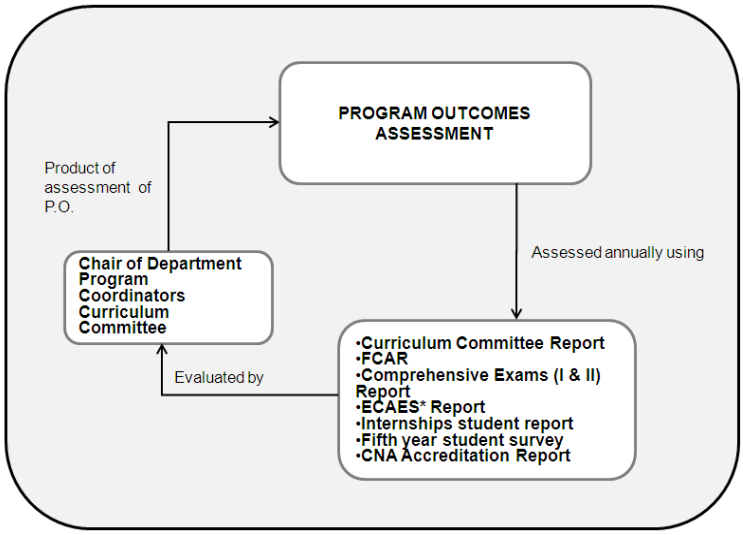

FIGURE 3
PROGRAM OUTCOMES ASSESSMENT

The tools used for the measurement are:

- Curricular committee report:
  Report that presents the global results of the course assessment for each program.
  Periodicity: Once per semester.
- Comprehensive tests I and II
  These exams were designed during the first semester of 2008 and applied for the first time during the second semester of 2008. They are administered in two different stages in the curriculum. Comprehensive exam I tests the basic education component in science and mathematics, physics, chemistry and communication courses; the comprehensive exam II includes the professional education of each engineering program.
  Periodicity: Twice every semester.
- ECAES (Quality Exam of Higher Education).
  This exam is required by the Colombian Ministry of Education for all college seniors. The exam is part of a series of instruments through which the national government evaluates the quality of the education service. The following is the objective of ECAES:
  "To evaluate the degree of competences development of the students in the last year of an undergraduate academic program offered by institutions of higher education" [14]
  Periodicity: once per year (annual)
- Internship student report:
  These are the evaluations of a student's performance given by their immediate superiors at the end of his/her internship. The results of these evaluations have been used since 2006 for the evaluation of the program outcomes.
  Periodicity: Once per semester
- Fifth year student survey:
  This survey was designed and applied by the college of engineering and is aimed to senior students (students who have finished their academic courses). It was applied for the first time in the first semester of 2009.
  Periodicity: One per semester
- National Accreditation Report, CNA
  This report is elaborated by the national evaluators delegated by the Consejo Nacional de Acreditación – CNA (National Council of Accreditation) to determine if the program complies with high quality standards.
  The criteria taken into account for the evaluation are faculty, students, alumni, academic processes, mission and institutional projects, physical and financial resources, organization, management and university well-being.
  All the engineering programs currently count with the national accreditation given by the CAN.
  Periodicity: defined by the CNA.

The evaluation process in this loop is done annually by the curricular committee, the chair of the department and the program coordinator. The improvement actions are applied the next academic year.

Program Educational Objectives Assessment

Figure 4 [8-13] below shows the mentioned process.

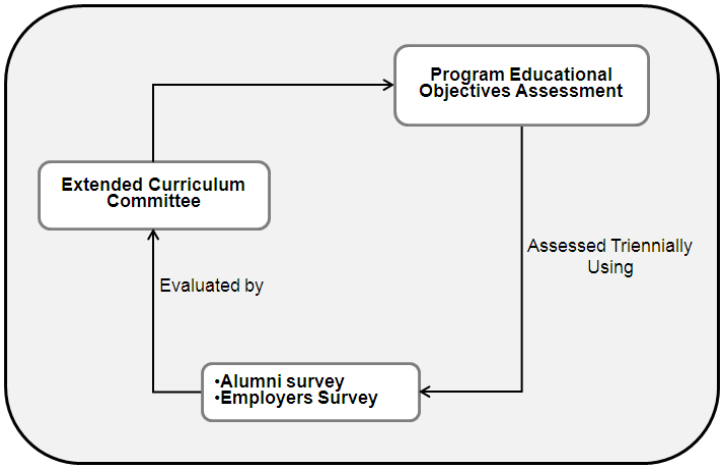

FIGURE 4
PROGRAM EDUCATIONAL OBJECTIVES ASSESSMENT

The process of definition [15], measurement and evaluation of the PEO is formulated and implemented. The evaluation is implemented through a set of tools, previously validated, through which it is possible to identify the key aspects that show the compliance of the educational objectives for each program.

As with the two former loops, the assessment of the program educational objectives is implemented in three processes (measurement, evaluation and improvement). The measurement tools used are the following:

- Employer's survey
  The objective of the survey is to evaluate the satisfaction level of the employers based upon the performance of the alumni in the social and business sector in which they come across.
  Periodicity: Every three years.
- Alumni survey:
  The objective of the survey is to evaluate the development of both professional and personal skills of the alumni from the moment of their graduation and until five years after.
  Periodicity: Every three years.

The evaluation process is implemented by the extended curricular committee (employers included) under the coordination of the chair of the department. The improvement actions are applied within the period next to the established cycle.

RESULTS

The global assessment model is clearly defined, as well as its processes and tools, and it is known and applied by the entire faculty of the engineering programs.

The measurement tools and the evaluation processes have evolved and to date, year 2010, the complete model is being revised in order to improve the processes and standardize some tools, with the objective of simplifying it and making it more efficient and fluid in its application.

In terms of loops that make up the model, the following results have been taken into account:

- Course assessment: The assessment has already contributed to the improvement of the course contents and the teaching and evaluation methodologies, and in reaching the program outcomes. It has permitted the identification, proposal and implementation of improvement actions for specific courses and complete areas of the curriculum.
- Program outcomes assessment: It has permitted the identification of difficulties in the development of some professional skills required in the engineer's education; it has permitted the articulation of the evaluation from different courses, and the innovation in form of evaluation.
- Program educational objectives assessment: It has permitted the clear identification of the performance levels of the alumni and the recognition that the alumni and employers have of the college of engineering. The engineering alumni profiles have been revised and in some programs, improvement actions towards the complete achievement of PEO have been formulated.

The development of the global assessment model permitted the college of engineering to be subject of the self evaluation process with the six programs, for the ABET accreditation; the program evaluator visit was held on 2009 and the official response is expected for July 2010.

CONCLUSIONS

The implementation of this approach in the education of engineers becomes a significant contribution for higher education in Colombia, regarding the development of contemporary approaches for the education; since, even though the Colombian engineering colleges are currently incorporating in their analysis and curricular adjustments the concept of continuous improvement, the implementation of such is not being done under the parameters established in the current quality administration and continuous improvement schemes.

The model applied intends to take into consideration the regional and colombian higher education's proper contextual characteristics, together with international references for the engineer's education. It has been integrally developed, considering the qualitative as well as quantitative dimensions in order to ensure a global approach, and by this, obtaining better results in the education of alumni.

The next step will consist in the complete standardization of the model, supported with the software development to speed up the information processing; as well, some processes will be redefined and some tools will be adjusted, with the objective of facilitating the application of the aforementioned, incorporating it in the normal routine of the engineer's education.

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