Strategies for Pursuing ABET Accreditation for Civil Engineering Program at ESPOL: A Case Study for Public Universities in Developing Countries.

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***Abstract*– This article describes how the Civil Engineering Program at ESPOL, prepared for the ABET Engineering Commission visit (which occurred in November 2016) under the 2016 – 2017 EAC ABET Accreditation Criteria. The paper depicts the strategies employed to conduct Student Outcome's assessment, describes institutional arrangements to meet EAC Criteria, discusses the preliminary results of the accreditation visit, and concludes with lessons learned, short and long-term issues that our program must address to realize the benefits of accreditation.**

***Keywords*—engineering education, student outcomes, assessment, evaluation, civil engineering, ABET accreditation.**

I. Introduction

At first, Accreditation was created as an assessment tool to measure the quality of university programs. But, its emphasis was redirected to program objectives and learning outcomes from the original established especially to measurable inputs [1].

An accreditation corroborates that the institution/department offers a program that has established good enough processes, practices and resources, to ensure that the required quality and standards are obtained. It has become the fundamental quality assurance mechanism for education over the years.

Accreditation of engineering programs contemplate several aspects of education, focus on the engineering programs contents, but through the years the emphasis has included other areas such as staff, students, resources, curriculum content and design, and content assessment [2].

The improvement engineering education in many ways depends on high-quality assessments, in order to provide educators the needed information to get ahead [3].

A. Learning Outcomes.

The revision of the ABET (formerly known as *Accreditation Board for Engineering and Technology*) engineering criteria has had a remarkable international impact on engineering programs. The program in evaluation must directly demonstrate that it is reaching the student outcomes (among other important criteria) through assessment and evaluation, instead of providing simple numerical information to the educational process [3].

Undergraduate programs seeking accreditation from the Engineering Accreditation Commission of ABET must demonstrate that they satisfy all of the following General and Program (Specific) Criteria for Baccalaureate Level Programs, which have been divided in 9 sections, as follows: [4].

Criteria 1: Students.
Criteria 2: Program Educational Objectives (PEOs).
Criteria 3: Students Outcomes (SOs).
Criteria 4: Continuous improvement.
Criteria 5: Curriculum.
Criteria 6: Faculty/Staff.
Criteria 7: Facilities.
Criteria 8: Institutional Support.
Program Criteria: Specific requirements for the program

ABET Engineering Criterion 3 has been principally challenging for engineering institutions looking for Accreditation. This Criterion is based on Student Outcomes, which describe what students are expected to be, know and be able to do by the time of graduation. These relate to the abilities, knowledge, and behaviors that students obtain as they develop through the program [5].

B. Assessment.

The term assessment is used for the action of collecting data or evidence that can be applied to answer classroom curricular or research questions. Assessment of SOs implies the measuring of attainment of Student Outcomes, by means of a wide range of tools, namely: quizzes, projects, reports, oral presentations, debates, pre-professional internships, etc. [5].

Assessment methodology can be divided into two categories: (1) Descriptive designs, which describe the current state of a phenomenon, and (2) Experimental designs that examine how a phenomenon changes as a result of an intervention. Quantitative techniques are usually used for experimental designs [3].

C. Our experience

The Escuela Superior Politécnica del Litoral (or ESPOL), one of the most prestigious higher education institutions in Latin America, is a public university located in the city of Guayaquil, Ecuador. ESPOL has seven colleges, eight research

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centers and several associated centers, providing thirty-four undergraduate degrees, thirty-seven master's degrees, and two PhD degrees, conducting research in multiple areas of knowledge. Student branches of the IEEE and ASCE are also found at ESPOL.

ABET, currently accredits approximately 3,700 programs at over 750 colleges and universities in 30 countries [6]. In Latin America and the Caribbean, 30 institutions have been accredited, of which only 10 are public. In South America, 11 programs have been evaluated, and no public institution before ESPOL had been given the opportunity to have their undergraduate programs evaluated and receive a positive report [7].

The low number of accredited public institutions reflects the difficulties these institutions face in accessing funds, due to their dependence on the government that regulates them and the costs that accreditation processes involve [8]. Therefore, it is important to increase the number of successful experiences with international accreditation of Latin American public universities. Non-private universities in Latin America represent 35% of universities and receive more than 50% of university students in at least 63% of the region [9].

Latin American public universities play a crucial role in the substantial improvement in living standards of their populations. Improving the quality of their education, they are more likely to achieve well-being, democracy, education, and culture [8], [10].

The ESPOL, has 58 years of academic experience, reaching a great reputation at a national level. Being the first public university in the coastal region that was classified as, "A", the highest category, by the national accreditation agency [11]. Public education in Ecuador has no tuition cost since the Constitutional amendment of 2008, for students pursuing their first graduate degree, as long as they remain in good academic standing and does not fail courses.

The ESPOL received over 9,000 students in the 34 undergraduate programs offered by the institution, 22 in Engineering, Science and Technology [12].

The Civil Engineering (CE) program in ESPOL was created on May 1989. In the early 1990s, there were two technical areas in the program: Geotechnical Engineering, and Hydraulics. By 1992, four more areas were incorporated to the program: Structural Engineering, Sanitary and Environmental Engineering, Construction, and Transportation Engineering.

In 1996, academic agreements were signed with the Concrete Technology Center at Guayaquil (now owned by Holcim Ecuador Stock Co.), and with the University of New Orleans (UNO). Those agreements improved the academic standards of our students, allowing them to conduct experiments on concrete technology and special concretes; and, to continue their undergraduate studies abroad, with the possibility of pursuing M.Sc. studies at the UNO.

In 2005, the boom of the construction sector in Ecuador significantly increased the overall number of students in the program, which went from an average of 70 on the early 2000s, to more than 500 in 2014. The program currently has 734 enrolled students and 50 admitted students during the 2016 first term.

Throughout its existence, the program has experienced several academic reviews (1993, 1996, 1999, 2006, and 2009). Currently, ongoing major curricular changes are taking place, running alongside both national and international academic accreditation processes (Higher Education Ministry of Ecuador, and ABET, respectively).

In November of 2016, after a process of more than 3 years, ESPOL received the ABET EAC (Engineering Accreditation Commission) evaluation visit for the Civil Engineering program (and other 3 engineering programs), obtaining positive preliminary reports.

Evaluation results are reported per criteria in a program audit summary, declared either as shortcoming, strength, or observation. Shortcomings can be: deficiencies, when a criterion policy or procedure is currently not satisfied at all; weaknesses, when the program lacks strength of compliance, and need immediate remedial action to comply; or concerns, when the program currently satisfies a criterion, policy or procedure, but the future situation could jeopardize compliance. On the other hand, an observation is a comment or suggestion, not directly related to the accreditation, but offered to the program to assist its continuous improvement efforts [13].

II. Students Outcomes Assessment and Evaluation Plan

A. Program Educational Objectives

Program Educational Objectives (PEO's) are defined as broad statements that describe what the undergraduate students will achieve after 3 to 5 years of academic training [14]. They are aligned to the program's mission statement as well as the institution's mission.

Civil Engineers graduated from the ESPOL, after 3 to 5 years of professional practice, will have:

a. Provided effective civil engineering solutions to society, considering technical, economical, ethical, and environmental issues.

b. Achieved recognition due to excellence in design, construction or infrastructure management.

c. Kept up-to-date with developments in the area of civil engineering throughout their careers, by having undertaken continuous training or graduate studies.

d. Promoted employment or innovation, by means of leading initiatives within their organizations.

B. Students Outcomes Assessment

Aligned to ABET's objective of program assessment, the Civil Engineering program at the ESPOL has defined 13 Student Outcomes (SOs). They describe what the students are expected to be, know, and be able to do by the time of graduation. They constitute a set of skills, knowledge and behaviors that students demonstrate as they progress through the program [14].

Seven out of thirteen of these Student Outcomes are catalogued as "institutional". This means that they are common, and thus assessed in all programs at the ESPOL; these institutional SOs are directly related to the institution's mission and vision. Six Student Outcomes are defined as "disciplinary" and are more related to Civil Engineering abilities and knowledge. The SO's of the program are as follows. The numbering in SOs was referred to match the current EAC ABET SOs.

By the end of their studies at ESPOL, Civil Engineering (CE) graduates are expected to attain the following student outcomes (SOs). Graduates will have:

a) SO8, Disciplinary: ability to apply knowledge of mathematics, sciences, and civil engineering.

b) SO9, Disciplinary: ability to design and conduct experiments, as well as to analyze and interpret data related to civil engineering.

c) SO10, Disciplinary: ability to design systems, components or processes related to civil engineering, in order to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, manufacturability and sustainability considerations.

d) SO6, Institutional: ability to work as a part of a multidisciplinary team.

e) SO11, Disciplinary: ability to identify, formulate and solve problems coming from different areas of civil engineering.

f) SO1, Institutional: understanding of ethical and professional responsibility.

g.1) SO2, Institutional: ability to communicate effectively in Spanish.

g.2) SO3, Institutional: ability to communicate in English.

h) SO12, Disciplinary: ability to understand the impact of civil engineering solutions on a social, environmental, economic and global context.

i) SO4, Institutional: recognition of the need for and ability to engage in life-long learning.

j) SO6, Institutional: knowledge of contemporary issues.

k) SO13, Disciplinary: ability to use the techniques, skills and modern engineering tools, necessary for civil engineering practice.

l) SO7, Institutional: recognition of the need for entrepreneurship and the abilities to become an entrepreneur.

In addition to the recommended student outcomes by ABET under the 2016-2017 Criteria for Accrediting Engineering Programs [14], the ESPOL has decided to include two SOs. Student Outcome g.2 relates to communication in English, as the majority of the program is being thought in Spanish, a goal of the institution is that CE graduates are able to communicate effectively in English. Also, in alignment with the ESPOL's mission, to form professionals, leaders and entrepreneurs [15], SO7 (l) has been included for assessment and evaluation purposes.

Through a macro-curricular plan, the program is designed for educational objectives, in order to contribute to the institution mission statement. In a similar way, student outcomes contribute to students' attainment of program educational objectives (PEOs). A systematic way of assessing and evaluating student outcomes along the 5-year program, together with a strong link between SOs and PEOs, enables to know if students are meeting, at each stage, student outcomes performance.

The Civil Engineering program carries out several area meetings during the year. In those meetings faculty members discuss the data collection processes, review the rubrics used to keep-up the forming process and measure the student outcomes (SOs), and define the expected level of attainment for each SO.

Three assessment strategies used for data collection regarding SOs in the program are: (i) Course Assessment (direct for all SOs), (ii) Senior Students Survey (direct for SO_i), and (iii) Comprehensive Examination (indirect for SO: SO_a, SO_b, SO_c and SO_e).

(i) Course Assessment thru portfolios

During plenary sessions, faculty members define which courses are selected to conduct SO assessment. In 2014 and 2015, each CE student outcome was assessed in two or three levels of the program (initial, intermediate, and advanced), representing students from junior, sophomore and senior level respectively, as depicted in Table III and Table IV. For each student outcome, the Accreditation Program Coordinator selects among faculty, a Student Outcome Coordinator, who leads the process of data collection. This process consists of selecting appropriate assessment tools, defining rubrics (when not at institutional level), collection periods and reporting the findings to the Program Coordinator and to the Accreditation Coordinator.

For this purpose, courses have been classified into three groups: Initial for courses offered between levels 200 and 300; Intermediate for courses at the 400 level; and Advanced for courses at the 500 level. The level ###-1 indicates that the course is taught during the first semester (May to September), whereas the level ###-2 is during the second semester (October to March). The table also shows the total number of courses contributing to the SO assessment process. This ensures data collection (for every SO) is done at least twice across the academic flowchart.

(ii) Survey to Assess SO_i:

A questionnaire applied to senior students was utilized as an assessment tool to measure Key Performance Indicators for SO_i. This survey asks students questions related to their study habits, where they usually look for information and, how frequently they take continuous education and development courses. Without being explicit, the responses are compared to the SO rubric performance indicators.

(iii) Comprehensive Examination to Assess SO_a, SO_b, SO_c and SO_e.

By the end of the second term during 2015, a comprehensive pilot examination was applied to Senior Students. This examination was taken by 62 students and consisted of 60 questions related to 28 Civil Engineering courses. A match between each question and 4 SOs was determined for the purpose of assessing the attainment of each of these SOs.

Due to the format of the examination, which consisted of multiple choice questions, with a single correct answer, the level of attainment of the SO could not be assessed thru institutionalized rubrics, but rather provide a holistic view of the percentage of students solving problems or responding to questions related to Civil Engineering courses and their respective SO.

The full assessment cycle for the CE program takes one academic year, and is carried out every two years, with the exception of the interval 2014-2016 which has been yearly due to the ABET accreditation candidacy process. Since in the Geosciences College (where the CE program is located) most courses are taught once a year (I or II term), each SO is measured only once during the designated assessment year. At the end of each semester, all faculty members, who were assigned to conduct an SO assessment during that semester, must submit a portfolio with the results, an evaluation, and proposed improvement actions.

C. Students Outcomes Evaluation

Within an assessment course, each student stands in one of four levels for each Key Performance Indicator (KPI), as follows:

a) Unsatisfactory: he/she does not understand the concept being presented, or his/her performance is null. b) Developing: he/she partially understands the concept, but does not apply it properly, and thus fails to meet expectations. c) Developed: he/she understands the concept and applies it properly thereby meeting minimum expectations or requirements. d) Exemplary: he/she exceeds expectations about understanding and application.

As student performances are quantified, CE faculty have established (in meetings) as a threshold that at least 70% of all students in a course should be either in the satisfactory or the exemplary levels. In general, this assessment has been performed in a direct way, by means of program rubrics per SO.

The results of assessment (detected problems or situations) are discussed among faculty members in order to produce an evaluation report (one per SO), and continuous improvement strategies for the next assessment/evaluation period.

III. Preparing the CE Program for the AEC Accreditation

The CE program scheduled a three year plan to be prepared for the ABET accreditation visit, and several tasks and institutional arrangements were undertaken during this timeline.

Being the year 0 (2016) the moment in which the program received the accreditation visit, the plan began on year -2 (2014).

On this first year of preparation, a top-down approach was followed. One of the first things to do was to review the institutional vision and mission, and check how the program's mission contributes to it.

As a part of activities of the first year, an Engineering Advisory Board (consultative committee) was created. The board is composed by representatives of employers from the public and private sectors, engineering local association (CE, and Construction Chamber), free-lancer civil engineers, and graduates. This committee followed recent institutional guidelines for its conformation, representing the program constituents and serving to validate that the program was meeting their needs. A major revision of the PEOs was carried out together with all the constituents of the program (advisory board, faculty, graduates).

Also on the first year, the Program Accreditation Coordinator, together with the Program Coordinator, worked on defining the SOs. Student Outcomes suggested by ABET were the start point, although CE faculty members had to demonstrate that the undergraduates possess other abilities defined as institutional such as communication in a foreign language and the ability to become an entrepreneur, as aforementioned. During the elaboration of the SOs, the Bloom's taxonomy [16]and the collaboration of a writing center inside our institution became useful tools to define clear and measurable outcomes. Another task developing along with the definition of SOs, was the elaboration of standardized rubrics. Analytic rubrics were developed in order to facilitate the assessment process of the SOs.

Once all of the SOs were defined, a process for evaluating and collecting evidence of SOs assessment was created. This process is summarized in Section II. It was essential to have in

place this process, at least two years before the accreditation visit, in order to demonstrate that one full evaluation cycle was finished. This means that the results of evaluation from year -2, produced improvement actions that were implemented on year -1, and evidence of evaluation from year -1 demonstrated improvement coming from the actions taken.

During year -2, institutional arrangements were undertaken in order to meet some of the Program Criteria for CE, updated for the 2016-2017 review cycle, where it was found the program was not strong enough. Course syllabi for courses were revised to meet the specific curriculum requirement to "design a system, component, or process in at least two civil engineering contexts: including principles of sustainability in design; explain the basic concepts in project management, business, public policy, and leadership; analyze issues in professional ethics; and explain the importance of professional licensure" [14]. Courses that required content modifications to meet these requirements are shown on Table I.

TABLE I
COURSES THAT REQUIRED CHANGES TO MEET ABET PROGRAM CRITERIA FOR CIVIL ENGINEERING

Course	ABET Criteria
Construction (FICT02998)	principles of sustainability in design
Construction Cost Analysis (FICT03335)	explain the basic concepts in project management
Construction Cost Analysis (FICT03335)	explain the basic concepts in business
Professional Legislation (FICT03293)	explain the basic concepts in public policy
Construction (FICT02998)	explain the basic concepts in leadership
Professional Legislation (FICT03293)	analyze issues in professional ethics
Professional Legislation (FICT03293)	explain the importance of professional licensure

Other institutional arrangements included a revision of the program laboratories. Part of the curriculum criteria for ABET accreditations for CE programs is to "conduct experiments in at least two technical areas of CE". This lead to upgrade the Soils Mechanics and Concrete Technology laboratories. In addition, it was needed to plan the acquisition and procurement of equipment and infrastructure for two laboratories for Hydraulics, and Sanitary Engineering. Noteworthy is, the program also frequently utilizes a Fluid Mechanics laboratory located in another college inside our main campus. This served to demonstrate compliance with this criterion.

Students' involvement in preparation of the accreditation played a key role for a successful accreditation visit. Meetings with student leaders were kept to inform them about the accreditation process, ensuring they understood the program educational objectives and student outcomes, as well as they have the understanding of their needs and opinions on their overall education experience. This strategy was to complement what students already experience in all their courses across the curricular plan.

The second year (year -1) occurred during 2015. This year the program prepared a draft of the Self-Study (SS) report, being a critical document for evaluation of the CE program. Also, the faculty members in charge of the process decided to have a mock visit, which occurred approximately a year before the official accreditation visit. Preparation of this SS report required significant time and effort, resulting in a document that could be easily updated for the official visit. Furthermore on this year, improvement actions identified in 2014 were implemented for both the formative and assessment activities. The Mock Visit occurred from Sunday, August 30, 2015 through Tuesday September 1, 2015, following the usual protocol for evaluation visits. On Sunday the evaluator visited laboratories, infrastructure and reviewed displayed material prepared with sample of students work and evidence of SOs assessment process. On Monday, interviews to students, faculty members, staff, and authorities were conducted. Finally on Tuesday, the evaluator delivered his exit statement with the findings of his visit.

The conclusion from the Mock Visit was that the CE program could be, by the end of the academic year, ready for an ABET visit. Nonetheless, the Mock Visit reported 2 strengths, 1 observation, 4 concerns, and 3 weaknesses in the program. This report showed that the accreditation team and faculty members could prepare themselves and set the basis for improvement in the upcoming year before the official visit.

TABLE II
CIVIL ENGINEERING AT ESPOL PROGRAM EVALUATION FOUND DURING THE MOCK VISIT AND THE OFFICIAL VISIT

Criteria	Mock Visit	Official Visit
1) Students	Strength	Strength
2) Program Educational Objectives	Observation	
3) Student Outcomes	Weakness	
4) Continuous Improvement	Concern	Concern
5) Curriculum	Concern	Strength
6) Faculty	Concern	Concern
7) Facilities	Concern	
8) Institutional Support	Weakness	
Program Criteria	Strength	Concern
Accreditation Policies and Procedures	Weakness	

Year 0, named the evaluation year, or the year in which the official accreditation visit occurred, was mainly to update the Self-Study report with the last available information. A lot of time and effort were devoted to the logistics of the visit and having the infrastructure ready for the visit. Following ABET's calendar, the Self-Study report was sent on June 2016, and communication was kept via email with the Program Evaluator

attempting to clarify or expand into the SS review. The official visit occurred on November 2016, and findings from the Official Visit and the Mock Visit are summarized on Table II.

IV. Program Assessment Results

Although Continuous Improvement is one of the criteria evaluated by ABET, it constitutes in our opinion the core of the evaluation process. SOs assessment results are described in this section.

Fig. **1** shows the overall average of the percentage of students performing at the Developed and Exemplary levels combined from years 2014, 2015, and 2016. Some SOs assessment results from the 2016 II term were not yet reported at the time of preparation of this document. As previously mentioned, the expected goal established by the program is that 70 percent of students perform at this level. As part of a continuous improvement process, the percentage of students meeting the goal in each SOs is expected to increase over the years (due to the continuous improvement process). This occurred for SOs A, B, D, E, I, and J.

Figures Fig. **2** and Fig. **4** show a shortcoming in meeting the desired goal with SO "L" ("Recognition of the need for entrepreneurship and the abilities to become an entrepreneur"), in which the percentage of the students in exemplary and developed level could not reach the expected goal during the years assessed; the highest percentage was 60% in 2016.

Understanding education as a cumulative process for acquiring knowledge and abilities, the percentage of the students in the Exemplary and Developed category are expected to increase as the students' progress in the academic flow, as Figure Fig. **2** shows for SO "G1". For instance, in the Technical Drawings and Plans (FICT03210) course, that belongs to the level 300 (3rd year) of the program, 50 percent of the students performed at the expected level. However the percentage improves in the following courses, Road Design I (level 400) and Hydraulics (level 500), increasing to 90 and 100 percent, respectively.

A comparison of performance and the effect of improvement actions from one year to another are represented on Figure Fig. **2** (2015-1) and Figure Fig. **4** (2016-1). For example, assessment results of SO "F" ("Ability to comprehend ethical and professional responsibility") and SO "G1" ("Ability to communicate effectively in Spanish") show consistent improvement on students' performance.

SOs assessed during the second term of 2015 academic year (2015-2) depicted on Figure Fig. **3** show that students met the performance goal. In particular for SO "H" ("Ability to understand the impact of civil engineering solutions on a social, environmental, economic and global context") it can be appreciated that performance increases from CE Materials (FICT03392), a second year course, to Road Design II (FICT03426) and Professional Legislation (FICT03293); fourth and fifth year respectively.

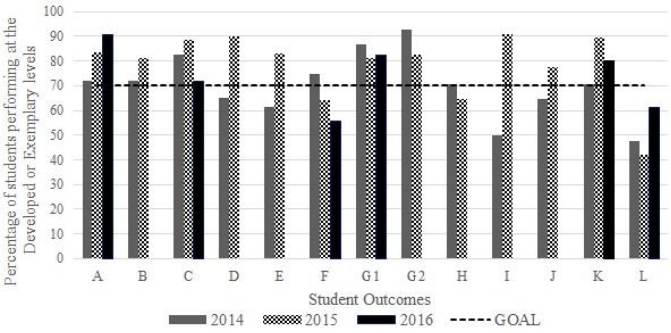

Fig. 1 SOs assessment overall averages.

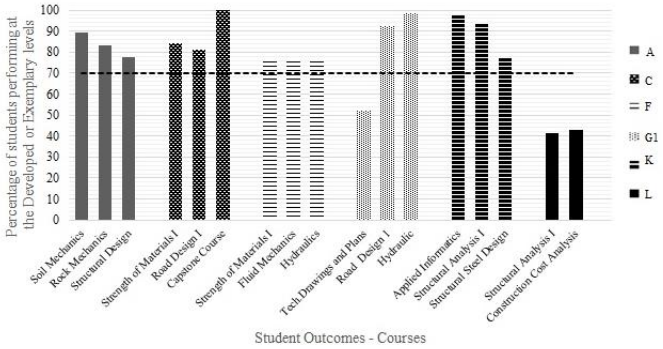

Fig. 2 Student Outcomes assessment by course, I Term 2015.

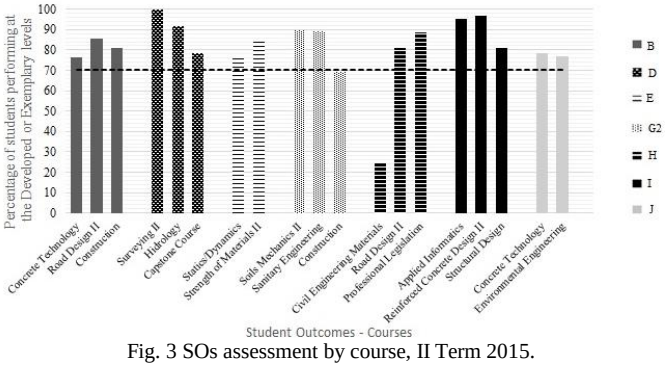

Fig. 3 SOs assessment by course, II Term 2015.

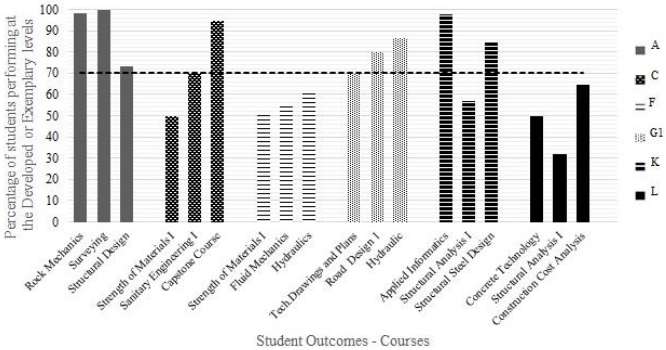

Fig. 4 SOs assessment by course, I Term 2016.

V. Discussion

A more detailed evaluation provided focuses on the accreditation visit results summarized on Table II, as well as their causes and implications.

A. Students

The student body remained as a strength during both the mock visit and the official visit. Students were well informed about accreditation objectives and program assessment, in all the courses and presentations. Student associations were key for having a good standing on this criterion, specifically the conformation of the first Student Chapter of the American Society for Civil Engineering (ASCE) in Ecuador, during the visit year, together with the participation of students belonging to the American Concrete Institute (ACI) Student Chapter at the ESPOL, in an international ACI contest. The overall student satisfaction from the program was positive, and this was corroborated from the evaluator during personal interviews.

B. Program Educational Objectives (PEO's)

An initial observation on this criterion made during the mock visit, was cleared during the official visit. Reasons for clearing this observation were showing evidence of periodic review and documentation from findings, as well as documentation from the process itself. Other evidence that supported the compliance was keeping minutes from the Engineering Advisory Board meetings and having our PEO's visible to the public in various places, and also at the institutional website.

C. Student Outcomes

During the mock visit this criterion was evaluated as a weakness. Specific comments from the evaluator addressed the assessment of SO "D" (ability to work on multidisciplinary teams) about lack of multidisciplinary characteristics, although courses assessed required work on teams. This weakness was cleared, by providing stronger evidence of multidisciplinary work on course assessed. Excellent evidence of this was the Capstone course project, in which a solution for a given real-life civil engineering problem, related to various fields of the program, is proposed (and selected among other options) considering social, technical, environmental, ethical, and economic aspects and contraints.

D. Continuous Improvement

Continuous Improvement remained as a concern during both the mock visit and the official visit. Initial evaluation from the mock visit required demonstrating that identified improvement actions had been incorporated into the program. Until the official visit, the program was able to "close the loop" and satisfying this criterion. However, during the official visit, the evaluator was not entirely satisfied in the approach employed to assess SO "L" ("recognition of the need for entrepreneurship and the abilities to become an entrepreneur"). In that respect,

specific changes where implemented, in the way the faculty members in charge of the process assessed this SO, time for completing a full evaluation and effectively assessment was short, considering this is an additional SO, not required by ABET, but aligned to the institutional mission.

E. Curriculum

From being an initial concern after the mock visit, the curriculum was evaluated as a strength after the official visit. A major change in the program consisted of rethinking and clarifiying the graduation requirements. Before the accreditation process, most of the CE students graduate, after taking the required courses, by completing a *thesis*, consisting of a document with relevant scientific contribution to the field of acknowledge, but lacking of multidisciplinary and engineering design concepts. Beginning the accreditation process, all the students were required to take a capstone course, which culminates with a project involving a major design experience. Capstone course, together with a 5-year curriculum that covers design in six technical areas of Civil Engineering, makes the CE program at the ESPOL exceed ABET requirements, in a way no other institution can compare with. Actually, the latter issue was labelled as a strength for the program.

F. Faculty

This is the second criterion that remained a concern in both the mock visit and the official visit, yet it was expected. Although the program demonstrated the faculty members were in sufficient number and had the competencies to cover all six of the curricular areas, a concern was raised about the few faculty members with a Ph.D. degree, as well as the high number of FTE (full time equivalent) non-tenure track faculty members. This assertion was based on the fact that the ratio of non-tenure and tenure-track faculty is below the average of ESPOL. A short-term faculty retention plan was prepared for the accreditation visit, defining a number of 25 tenure-track positions that should be filled in the following 5 years, to assure a sufficient number of faculty members.

G. Facilities

The CE program was able to demonstrate that the facilities are adequate for the needs of faculty and students. As an ABET requirement to conduct experiments in at least two areas of civil engineering, the students were able to perform tests regularly for Soils Mechanics, Concrete Technology, Fluid Mechanics and Road Design, by using available laboratories. A plan to procure and build two new laboratories (Hydraulics and Sanitary Engineering) was in action at the moment of the visit, and is currently under execution.

H. Institutional Support

This criterion was evaluated as a weakness during the mock visit but did not received observations after the official visit. Perhaps this might happen in the way information was

presented during the mock visit, because ESPOL is organized at the institutional level through various service and support units. During the official visit, evaluators had a chance to meet these support units, considering them a strength for all university programs.

I. Program Criteria

Although not identified in the mock visit, compliance with recent changes to ABET's 2016-2017 Criteria for Accrediting Engineering Programs, specifically for CE Program, could not be completely fulfilled, and thus, a concern was raised. Changes to the civil engineering courses, to comply with these requirements, are summarized on Table I. Evaluation results evidenced that covering these topics were not clearly or explicitly documented in standard course syllabi and description.

J. Accreditation Policies and Procedures

No findings or observations where found neither during the mock visit nor the official visit.

VI. Conclusions

The ABET accreditation model is performance-based. It is not a prescriptive model, as there are not metrics that have to be met, being more focused in results and qualitative evaluation. In this matter, a phrase that relates is that "it is not what you have, but what you do with what you have". "You do not have to belong to a big institution or to be a resourceful program to be successful". Also, the evaluation process may become somehow subjective to the evaluator, as results from the mock visit to the official visit can differ in some criteria.

The adversarial nature expected to the ABET visit was diluted by a PEV (Program Evaluator) that empathized with the evaluation process. As intended by the PEV, much of the issues identified in the Self-Study procedure were answered prior to the visit, by keeping an open communication with the program's accreditation coordinator, during the 4 months between the submission of the Self-Study report and the official visit. Having a mock visit is highly recommended to properly prepare a program for official evaluation.

Five-year engineering programs, which are usual in Latin America, exceed the curriculum requirements for ABET Engineering Accreditation Commission. In particular, the CE program at the ESPOL possess a curriculum that no other institution in the US can compare with, having two first years of study in basic sciences and then a strong education in five technical areas of Civil Engineering. Thus, the CE curricular plan is, able to couple applied sciences, engineering courses, professional internships, outreach hours and a Capstone course during the five-year program.

It is essential for an initial accreditation to "close the loop", by completion of one full assessment and evaluation cycle (2 measurement periods), demonstrating that improvement actions, identified from a first evaluation process, have been implemented, and their effect on the program assessed can be evidenced.

Preparing for an ABET accreditation visit should not be an effort that takes place every six years. It should be a continuous process that requires constant effort from faculty members, students, staff, and authorities. The ESPOL is constantly implementing processes that assure periodic report of assessment results (every 2 years) and improvement actions (in the meantime). These reports aid to provide comprehensive reviews for all programs at the institution.

From a broad perspective, it can be concluded from the accreditation process for the CE program, that the performance-based approach allows for diverse programs to seek for accreditation, emphasizing on results rather than on resources. This brings an opportunity for public higher education institutions on developing countries, to continuously improve their programs and position themselves at a global education level.

References

[1] John W. Prados, G. D. Peterson, and L. R. Lattuca, "Quality Assurance of Engineering Education through Accreditation: The Impact of Engineering Criteria 2000 and Its Global Influence," *J. Eng. Educ.*, vol. 94, no. 1, pp. 165–184, Jan. 2005.

[2] L. R. Lattuca and J. S. Stark, *Shaping the college curriculum: academic plans in context*, 2. ed. San Francisco, Calif: Jossey-Bass, 2009.

[3] B. M. Olds, B. M. Moskal, and R. L. Miller, "Assessment in Engineering Education: Evolution, Approaches and Future Collaborations," *J. Eng. Educ.*, vol. 94, no. 1, pp. 13–25, Jan. 2005.

[4] "EAC Criteria - E001-15-16-EAC-Criteria-03-10-15.pdf." [Online]. Available: http://www.abet.org/wp-content/uploads/2015/05/E001-15-16-EAC-Criteria-03-10-15.pdf. [Accessed: 13-Jan-2017].

[5] M. Ogot, G. Elliott, and N. Glumac, "An Assessment of In-Person and Remotely Operated Laboratories," *J. Eng. Educ.*, vol. 92, no. 1, pp. 57–64, Jan. 2003.

[6] "Accreditation | ABET." .

[7] "Find an ABET-Accredited Program | ABET," 13-Jan-2017. [Online]. Available: http://main.abet.org/aps/accreditedprogramsearch.aspx. [Accessed: 13-Jan-2017].

[8] M. M. Larrondo, G. Méndez, and V. Medina, "Modelo de Registro y Acreditación de Instituciones de Educación Superior basado en el Modelo CMMI," *7 Th Lat. Am. Caribb. Conf. Eng. Technol.*, Jun. 2009.

[9] A. L. Gazzola, A. Didriksson Takayanaqui, and International Institute for Higher Education in Latin America and the Caribbean, Eds., *Tendencias de la educación superior en América Latina y el Caribe*. Caracas: Instituto Internacional de la UNESCO para la Educación Superior en América Latina y el Caribe, 2008.

[10] E. Forcael, V. González, F. Orozco, A. Opazo, S. V. Tejeda, and A. Sandoval, "Towards a methodology for assessing the Human Development Index in the Chilean construction industry.," *Obras Proy. Rev. Ing. Civ.*, no. 19, pp. 50–60, 2016.

[11] "Resultados de la acreditación y categorización vigentes | CEAACES," 13-Jan-2017. [Online]. Available: http://www.ceaaces.gob.ec/sitio/acreditacion-y-categorizacion/. [Accessed: 13-Jan-2017].

[12] "ESPOL - Vida Estudiantil," 13-Jan-2017. [Online]. Available: http://www.espol.edu.ec/es/vida-estudiantil. [Accessed: 13-Jan-2017].

[13] "Accreditation Policy and Procedure Manual (APPM), 2017 – 2018 | ABET." .

[14] "Criteria for Accrediting Engineering Programs, 2016 – 2017 | ABET." .

[15] "ESPOL - Vision and Mission." [Online]. Available: http://www.espol.edu.ec/en/vision-and-mission. [Accessed: 31-Jan-2017].
[16] B. S. Bloom, *Taxonomy of educational objectives: the classification of educational goals: by a Committee of College and University Examiners: handbook 1*. David McKay, 1969.

APPENDIX 1

TABLE III
ESPOL - CIVIL ENGINEERING – INSTITUTIONAL STUDENTS OUTCOMES
ASSESSMENT PLAN - 2016 ACADEMIC YEAR

Course	INTITUTIONAL						
	SO1	SO2	SO3	SO4	SO5	SO6	SO7
ABET Equivalence	f	g.1	g.2	i	J	d	l
Intro. to Geotech. Eng.					Ini.		
Statics/Dynamics							
Civil Eng. Materials			Ini.				
Soil Mechanics I							Ini.
Applied Inf.				Ini.			
Tech. Drawing and Plans		Ini.					
Strength of Materials I	Ini.						
Soil Mech. II							
Surveying II						Ini.	
Strength of Materials II							
Fluid Mechanics	Int.						
Sanitary Eng. I							
Rock Mechanics							
Road Design I		Int.					
Structural Analysis I							Int.
Reinforced Concrete II				Int.			
Hydrology						Int.	
Sanitary Eng. II			Int.				
Road Design II							
Structural Analysis II					Int.		
Hydraulics	Adv.	Adv.					
Construction Cost Analysis							Adv.
Structural Design				Adv.			
Structural Steel Design							
Professional Legislation							
Environmental Engineering					Adv.		
Construction			Adv.				
Capstone Course						Adv.	
Assessment Total per Student Outcome	3	3	3	3	3	3	3

APPENDIX 2

TABLE IV
ESPOL - CIVIL ENGINEERING – DISCIPLINARY STUDENTS OUTCOMES
ASSESSMENT PLAN - 2016 ACADEMIC YEAR

Course	DISCIPLINARY					
	SO8	SO9	SO10	SO11	SO12	SO13
ABET Equivalence	a	b	c	e	h	k
Intro. to Geotech. Eng.				.		
Statics/Dynamics				Ini.		
Civil Eng. Materials					Ini.	
Soil Mechanics I						
Applied Inf.						Ini.
Tech. Drawing and Plans						
Strength of Materials I			Ini.			
Soil Mech. II	Ini.					
Surveying II		Ini.				
Strength of Materials II				Int.		
Fluid Mechanics						
Sanitary Eng. I			Int.			
Rock Mechanics	Int.					
Road Design I						
Structural Analysis I						Int.
Reinforced Concrete II						
Hydrology						
Sanitary Eng. II						
Road Design II		Int.			Int.	
Structural Analysis II						
Hydraulics						
Construction Cost Analysis						
Structural Design	Adv.					
Structural Steel Design						Adv.
Professional Legislation					Adv.	
Environmental Engineering						
Construction		Adv.				
Capstone Course			Adv.	Adv.		
Assessment Total per Student Outcome	3	3	3	3	3	3