Successful Accreditation of the Electrical Engineering Program offered in two campuses at Caribbean University

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***Abstract*— The Electrical Engineering Bachelor Program at Caribbean University, which is offered in two different campuses (Bayamón and Ponce - Puerto Rico), underwent a successful ABET accreditation during cycle 2014-2015, its first time evaluation. During the process it was difficult to find useful information or guidelines for programs offered in more than one location, which represented a challenge for both the EE program and evaluators. This paper presents an overview of our assessment plan, strategies to assess and evaluate the program, and a description of assessment instruments. In addition, a summary of materials for the display room and practices to strengthen continuous improvement of the program to meet accreditation and constituency are included as well, and could be useful information to help other institutions to prepare engineering programs for an eventual on-site ABET visit.**

Keywords*— *ABET, Engineering Accreditation, Assessment Strategies, Continuous Improvement

I. INTRODUCTION

All Engineering programs seeking ABET accreditation must demonstrate compliance with the eight accreditation criteria for baccalaureate level programs, which may change from one accreditation cycle to the next. For our EE program, the student outcomes adopted by the Department of Engineering and Informatics Technology (DEIT) at Caribbean University (CU) are identical to those minimum student outcomes (a-k) established by ABET for Engineering programs [1]. Criterion 3 is the more discussed in the literature because the programs must prepare graduates to attain the Program Educational Objectives (PEOs) and show the relationship of these with the selected student outcomes.

In some cases courses are designed and teaching oriented to satisfy the ABET engineering criteria. For instance, Felder illustrate instructional techniques to prepare students to achieve student outcomes (a-k) [2], but, the institutions typically focus in demonstrating compliance by using direct and indirect assessment methods which lead to triangulation of courses' outcomes results [3-5]. An innovative assessment tool used to evaluate the contributions of a given course, training, or any other item in the curriculum to the design, delivery and achievement of program outcomes, was presented by Gastli [6]. However, information about the strategies to obtain ABET accreditation for a program offered in different cities for a same institution is not available.

With a unique license to offer the program at the main campus in Bayamón and a license extension to offer the same (identical) curricula at Ponce, it was required to submit only one application or request for evaluation. Thus, the program focused on the assessment strategies to ensure compliance with the different criteria. This paper presents an overview of our assessment plan, strategies to assess and evaluate, and a brief of assessment instruments employed by the EE program as part of our successful ABET accreditation experience during cycle 2014-2015. Authors expect to provide a framework to speed up the future re-accreditation process and share experiences that could be useful for programs offering the same curriculum in different campuses.

The approach presented could be adopted for classical one location programs and could be helpful for non US institutions seeking accreditation with other agencies such as Greater Caribbean Regional Engineering Accreditation System (GCREAS) which include continuous improvement as a criterion [7].

II. CURRICULAR REVIEW – PROGRAM CRITERIA

Capstone senior design courses are a critical part for ABET accreditation to meet Major Design Experience (MDE) requirement. Many approaches exist to implementing them, but universities typically include one class in one semester term or two classes in two semester term, with or without the industry involvement [8-9].

During spring 2011 faculty started revising the program criterion as defined by the Engineering Accreditation Commission of ABET. As a result, it was identified that the electrical engineering program did not meet the MDE because students take Electrical Engineering Practice at the end of their curriculum, and it was difficult to control the design scope of the practice centers to ensure MDE compliance for each student.

A curricular review was carried out to replace the Practice course by a Capstone course. The experience with the practice courses helped faculty to recommend two Capstone courses for the two last semesters in the EE curriculum. Two semesters allow students to work in Capstone projects in a higher depth, as well as receive feedback from both faculty and industry engineers through Capstone conferences, which are celebrated at the end of each semester, alternating between both campuses (Bayamón and Ponce). In these conferences, engineers from industry participate as guess evaluators, which serve as a focus group to validate the process. Other curricular changes included the recommendation of the Practice course as a technical elective while the Ethics in Engineering course passed from technical elective to a required socio-humanistic course.

A. Electrical Engineering Capstone I

Students are required to work in teams. Multidisciplinary teams are recommended, if there are students from other programs, i.e. Industrial or Civil Engineering, and participation of students from both campuses is open. The project emphasize in a feasibility study for the solution of an engineering problem, which could be proposed by the students or assigned by the major design committee, composed by professors offering the Capstone or Practice courses and the Program Coordinator. Students must consider the realistic constrains such as: economic, social, political, safety, among others. Faculty grade the final report using rubrics defined for the course applicable student outcomes (for reference Appendix A shows an example), which are also used by the external or guess evaluators (focus group) and employed by faculty as a reference to provide student guidance.

B. Electrical Engineering Capstone II

For the second part of the course, students have presented their feasibility report and received feedback from professionals, so they are mentored to implement their design solution or make adjustments, if required. The final deliveries for the course consist of a written report, final presentation, and a poster session. Similarly as in capstone I, the final project is graded using a rubric designed to measure the related student outcomes and the objective of the course.

III. ASSESSMENT PLAN

The assessment plan helps the distribution of faculty duties to ensure that the assessment tasks were met in all locations. The implementation of the plan began with the establishment of an Accreditation Committee to lead the accreditation process. This committee was composed by the Department Director, Program Coordinator, an ABET coordinator, and the VP of Academic Affairs and Accreditation. The committee revised the minimum student outcomes defined by ABET identifying compliance and deciding what outcomes could be adopted according to criterion 3, as a starting point for the assessment process. Faculty participation allows the process improvement, and they were in charge of developing the curricular map and different assessment instruments, which are discussed below.

A. Curricular MAP

The program defined the relation of the student outcomes to the courses in the curriculum or curricular mapping to get assessment data. It was established that each student outcome should be assessed at three levels through the EE curriculum: assessing the outcomes at an introductory level (I), i.e. freshman or sophomore, at an intermediate level where the outcome is reinforced (R), i.e. junior, and at an advance level where the student outcome is emphasized (E), i.e. senior. The EE program divided the curricular map in five parts: (a) Relationship between student outcomes to general courses; (b) Relationship between student outcomes to core courses; (c) Relationship between student outcomes to general engineering courses; (d) Relationship between student outcomes to concentration courses; (e) Relationship between student outcomes to engineering elective courses. Table I shows an example of the relationship between student outcomes to general courses while Table II illustrates an example of the relationship between student outcomes to concentration courses.

TABLE I. Example of relationship between student outcomes and some general courses

RELATIONSHIP OF STUDENT OUTCOMES TO GENERAL COURSES												
Courses		***Student Outcomes***										
		a	***b***	***c***	***d***	***e***	***f***	***g***	***h***	***i***	***j***	***k***
ENGL-1	Basic Course in English I							I				
ENGL-2	Basic Course in English II							I				
ENGL-3	Oral and Written Communication in English							R				
SPAN-1	Basic Course in Spanish I							I				
COSC-1	Intro. Computer Science									I		I

TABLE II. Example of relationship of student outcomes to some concentration courses

RELATIONSHIP OF STUDENT OUTCOMES TO CONCENTRATION COURSES												
Courses		***Student Outcomes***										
		a	***b***	***c***	***d***	***e***	***f***	***g***	***h***	***i***	***j***	***k***
ELEN-1	Electrical Circuits Analysis I	R	R		R							R
ELEN-2	Logic Circuits I	R	R	R		R						
ELEN-3	Elec. Power Transmission	E	E			E					R	R
ELEN-4	Control Engineering	E	E	E	R	E	R	E		E	R	E

B. Assessment Instruments

Tools and instruments that allow gathering information to assess student outcomes were evaluated by the accreditation committee. They decided to use course portfolios instead of student portfolios, because this tool provide information not only about student's work but also on the course teaching techniques and reflections from faculty as well, which is critical to improve teaching and student performance in a program offered in two campuses. Student surveys were also selected as a tool, since with the adequate instruments the EE program get the student perception on the attainment of the student outcomes. Table III shows assessment instruments used in the assessment process.

TABLE III. Assessment Instruments

Assessment Tool	**Instruments**	**Assess**	**Strengths**	**Limitations**
Course portfolio	Rubrics	Student outcome	Direct, quantitative	None
	Self-Appraisal	Course	Indirect	Indirect, Qualitative
	Other course evidence	Course	Supporting reference	Faculty load
Survey	Graduation survey	Student outcome	At graduation time	Indirect, Qualitative

C. Rubrics

Rubrics permit quantitative analysis of the student outcomes. Therefore, rubric's adaptation and standardization was a critical part of the assessment, and it was essential to calibrate the instruments to collects information in a most accurate way. Rubrics were revised and amended after the completion the first assessment cycle to initialize a process of continuous improvement, which included workshops to orientate faculty regarding the administration and revision of rubrics. Rubrics were available in the display room for the on-site visit, to serve as a reference.

D. Graduation Survey

This instrument helps to collect the students' perceptions of the attainment of the student outcomes. The survey is a questionnaire fills out by the student before graduation ceremony. The data is gathered yearly. The Graduation Surveys and the analysis of results were available for review in the display room for the on-site visit. This survey supports the assessment of the student outcomes.

E. Self-Appraisal Survey

It is an assessment instrument used to collect the student's perceptions of both the knowledge on topics required by a specific course, compiled in the Self-Appraisal Course Initial Survey (SACIS) at the beginning of the course, and the knowledge of the topics covered in class, compiled in the Self-Appraisal Course Exit Survey (SACES) at the end of the current course. Both surveys are a questionnaire fill out by the student before and after a course are taken.

The Self-Appraisal Surveys are part of the course portfolio and allow faculty to follow up the required strategies to improve the student performance. An example of SACIS (on knowledge required by the course) and SACES (topics covered in the class) for the Logic Circuits course is shown in Table IV and Table V, respectively.

TABLE IV. Example of SACIS for Logic Circuits I

Question	Nothing	Little	Good	Very Good
Ohms Law				
Kirchhoff Law				
Circuits Analysis				
First Order RL & RC Circuits				

TABLE V. Example of SACES for Logic Circuits I

Question	Nothing	Little	Good	Very Good
Boolean Algebra				
Base Conversions				
Basic Logic Gates				
Karnaugh Map Usage				
Gate Level Minimization				
Combinational Circuits				
Synchronous Sequential Logic Circuits				

F. Course Portfolio

It is an assessment tool prepared by the professor that compiles all the assessment activities related to the course he or she is teaching. At the end of each academic term, the professor is responsible to turn in the course portfolio as assigned in the sampling cycle. Course portfolios were available in the display room for the on-site visit. Each course portfolio includes:

- Syllabus
- SACIS Evaluation + Copy of SACIS
- Student Outcomes Evaluation + Copy of Rubrics
- Example of Exams
- SACES Evaluation + Copy of SACES
- Grade Book
- Attendance Record
- Appendix (optional) with: Quiz, Assignments, etc.
- General Evaluation

G. Assessment Period

Once instruments were developed by faculty, the assessment process was started. As a pilot program the assessment period was set to one year. The measurement of each of the student outcomes in the major courses was scheduled and the results provided the starting point (base line) of attainment of student outcomes. Being the first time that the student outcomes were evaluated, a performance goal of 60% of students meeting the outcome was set. To ensure a systematic process, the collection of data from courses was focused on the submission of the portfolios as described in the assessment plan. The turn in of portfolios was programmed for the beginning of the next academic term in which the evaluation was conducted.

After the first year, the length of the assessment cycle was modified to 2 years. Two or three student outcomes were measured per academic term. Table VI show an example of data collection for student outcomes, including the two first subsequent cycle. The periodic cycle of assessment begins and finish before one student graduates, which allow the EE program to evaluate the results of the first cycle and implement the improvement actions during the second cycle.

TABLE VI. Example of schedule for data collection of student outcomes

Student Outcome	2011-2012		2012-2013		2013-2014	
	Fall	Spring	Fall	Spring	Fall	Spring
a	x		x			
b		x		x		
c	x				x	
d		x				x
e	x		x			
f		x		x		
g	x				x	
h		x				x
i	x		x			
j		x		x		
k	x				x	

The assessment period allow a continuous improvement process where faculty evaluate the assessment data and provide suggestions, which are studied by a steering committee, composed by the Department Director and Program Coordinators, which establishes complementary action to be implemented through the program. For reference, Fig. 1 illustrates a continuous improvement process for the EE program.

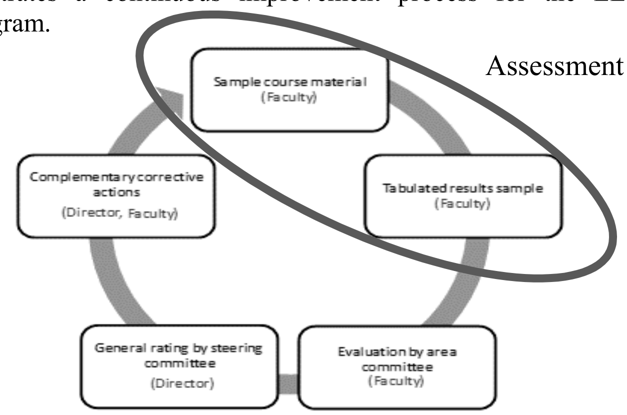

Fig. 1 Continuous Improvement Process.

IV. ASSESSMENT STRATEGIES

With only one application or request for evaluation, the program focused on the assessment strategies to ensure compliance with the different criteria. For example, share a material storage, standardize processes, capstone conferences and disseminate the results across the community served at both campuses. Moreover, the department carries out a Mock Visit in order to get feedback from an experimented Program Evaluator (PEV). For reference, authors provide a brief description of the assessment strategies implemented by the program.

A. Mock Visit

A request for evaluation in order to accredit engineering programs for a first time always requires a lot of work on assessment and investment from institutions. Actually, a deficiency in any of the criteria is enough for the EAC to deny accreditation of a program. Therefore, one of the implemented strategies was a mock visit, which works as a simulation of an on-site visit evaluation, where a specialist served as a PEV. The PEV worked in the revision of the self-study draft prepared by faculty from both campuses. The mock visit followed a schedule similar to an evaluation visit, interviewing students, faculty, and administrative staff as well. One evaluator covered both campuses, which required a four days visit. At the end, the specialist summarized the findings in a report to the program. Then, the department worked to resolve any issue to assure compliance.

B. Digital collection of assessment data

The educational platform was used as a tool to share information, standardize the process to access and store the assessment data. The EE program prepared a space, available only for faculty and administration, where assessment documentation was organized. Thus, faculty from both campuses could access the information and instruments available within. For example, a folder for a course in the platform could storage information such as: student outcomes evidences, rubrics, syllabus, surveys, portfolios, among other resources. For reference, Fig. 2 shows an example of the program space in the educational platform.

C. Design project guide

Since the same program is offered in two campuses, including identical textbooks, laboratory assignments, and different faculty teaching the same courses, even using the same syllabus, assignments and projects could result in different levels of complexity or depth due to the faculty's perspective. To ensure that the same level of complexity and depth is attained at both sites, faculty was exhorted to work together to develop project guides.

For those courses including design, faculty from both campuses developed a design project guide to guarantee the same level of depth rigor for the project's scope in both campuses, which support ensuring the attainment of related student outcomes. These guides describe the objectives, problem identification, scope of work, requirements, related course learning outcomes and student outcomes. Each professor participates on the development of the project design guides and communicates with colleagues of the same technical area (i.e. Controls). Faculty guidance and follow up of the student's work allows us to ensure success, by promoting interdisciplinary work and by allowing us to track the tasks into the project to evaluate the individual contribution of each student.

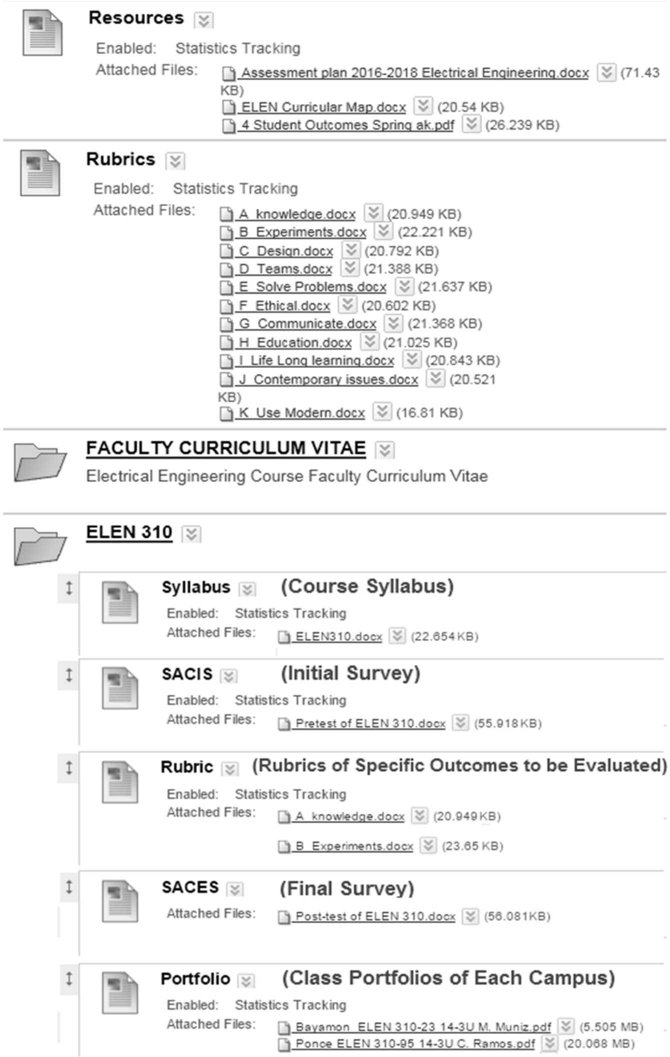

Fig. 2 Program Space on Educational Platform and Course Folder Resources

D. Capstone Evaluation and Assessment

Assessment of capstone projects is critical to evidence the attainment of the engineering student outcomes. Actually, institutions seeking ABET accreditation emphasize in the strategies to ensure a major design experience and its corresponding assessment.

A capstone design project requires creative activity and thinking, and provides a picture of the attainment of the student outcomes. Therefore, all student outcomes at the program level are mostly mapped in the learning outcomes of capstone projects. The assessments of student outcomes add faculty work, making laborious the evaluations of student performance and project qualities. Literature suggests that instruments for this course must be developed to provide a systematic mechanism of quantitative evaluation of these outcomes [10].

Faculty selected to measure the students outcomes c, e, f, g, i, and k, in both capstone courses with different evaluation criteria. For reference, the evaluation criteria for Capstone I, is presented in Table VII and each criterion is discussed below.

TABLE VII. Evaluation criteria for Capstone I

Component/Criterion	Weight
Company Presentation	10%
General Methodology	15%
Feasibility Draft	25%
Final Presentation	20%
Weekly Reports	15%
Evaluation of Individual Contribution	15%

- Company presentation: The students form a mock company and must select at least three (3) real projects and present them as being made by their mock company.
- General methodology: The students must present all the methodology, formulas, codes and standards that might be used on the design of the project. Schedule of design activities, including a fair distribution of workload between the group's members must be included.
- Feasibility Draft: The students must show at least three feasible alternatives to solve the problem. Comparison of these alternatives and schedule of design activities to be used on Capstone II must be presented.
- Final Presentation: The students must adjust (i.e. correct) the feasibility draft as indicated by faculty. A poster and the final written report must be delivered.
- Weekly Reports: The students will describe the targets achieved during the reporting period and must provide any deliverable of the project.
- Evaluation of individual contribution: Capstone professor evaluates the individual contribution to the project from each group member.

For all oral presentations, students should show: effective use of visual aids, individual oral skills, and individual non-verbal communication. Beside the evaluation from the professor in charge of the course, members from the industry and government are invited to evaluate the students' works during the final presentation and poster presentation on Capstone I and II. The evaluation criteria used in Capstone II is presented in Table VIII and discussed below.

TABLE VIII. Evaluation criteria for Capstone II

Criteria	Weight
Conceptual Design	20%
Preliminary Design	20%
Final Design	25%
Weekly Reports	20%
Evaluation of Individual Contribution	15%

- Company presentation: Based on the problem and feasibility report done in capstone I, the student must demonstrate the limits of their project and identify the product delivered as a final project.
- Preliminary Design: The students would have designed most of the project, except the details.
- Final Design: The students must have finished the whole design integrating all the corrections and faculty recommendations. A poster and the final written report must be delivered as well.

Weekly reports and Evaluation of individual contribution is the same as described before for capstone I.

In general, in order to set systematic process for evaluation and assessment of the capstone projects in the EE program at CU, we include the use of grading rubrics. These are employed by faculty and industry or external evaluators (focus group) during oral final presentation, which are organized by the engineering department in a conference model, where students from both campuses expose their work. Such conferences are open to the community and are alternated between campuses each academic semester.

E. Summary portfolio for students outcomes

Regardless of the way the assessment data is organized and stored, it's recommended to follow the instructions of the evaluator's team chair to exhibit the evidences through the materials room. In our case one PEV covered both campuses in a four days visit and the materials room was located in the main campus. A useful way to organize the materials room was to prepare a summary or portfolio for each of the student outcomes. This summary facilitates the program evaluators to review the assessment documentation in support to actions taken by the program in order to improve.

Thus, all relevant information supporting the attainment of the student outcomes is available in the student outcome portfolio. These portfolios were available both, digital and in hard copy for exhibition in the materials room. The structure we use for these portfolios included the student outcome and corresponding performance indicators, rubric evaluation and evidences following the assessment plan.

V. CONCLUSIONS

Communication is a key point to obtain accreditation. The collected information in the course portfolios could be analyzed during term break (i.e. summer), and dissemination of assessment results through faculty meetings, in the educational platform, general presentations, and in institutional bulletin boards. Meetings of faculty from both campuses allow sharing impressions on the assessment of the student outcomes (closing the loop) to make recommendation and promote equivalence for the different campuses, setting the base for continuous improvement. On the other hand, bulletin boards facilitate sharing of assessment results with the community as required by ABET guidelines.

The use of an educational platform to store and share digitalized documentation facilitate to structure and organize the assessment data and it was helpful to provide access 24/7 to faculty from both campuses. Since most institutions today use an educational platform, the authors recommend taking advantage of this, without incurring additional costs.

Capstone conferences allow sharing student experiences from both campuses and students presenting Capstone I might receive feedback on their design projects from the community, including faculty and guess evaluators.

Strategies presented in this work showed to be effective since they provide not only the support to ensure compliance with criterion four, but also allow the improvement of the program through a clear and agile information management. In general, authors expect that this experience allow speeding up a joint accreditation process for the next cycle.

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APPENDIX A

Table A-1: Rubrics used to evaluate EE Capstone Projects
OUTCOME K: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

PERFORMANCE INDICATORS	**DOES NOT MEET (1)**	**MUST IMPROVE (2)**	**MEETS (3)**	**EXCEEDS (4)**	**SCORE**
Ability and experience using a software	Does not know nor have any experience using specialized software.	Knows specialized software but does not have any experience using it.	Knows specialized software and has some experience using it.	Is an advanced user of specialized software and knows various related programs.	
Apply Programming and program language	Does not have any idea about programming or a specific programming language.	Has an idea about programming but does not know a specific programming language.	Can program and knows a specific programming language.	Is an advanced programmer and knows various programming languages.	
Ability and experience using high-tech or state-of-the-art specialized equipment	Does not have any experience using high-tech equipment (ex. Matlab, AutoCAD, Labview, GPS equipment).	Has some experience using high-tech equipment (ex. Matlab, AutoCAD, Labview, GPS equipment).	Has some experience using high-tech or new specialized equipment (ex. Matlab, AutoCAD, Labview, GPS equipment).	Is an advanced user of high-tech or new specialized equipment and shows a great ability (ex. Matlab, AutoCAD, Labview, GPS equipment).	

(Note: This is just part of a table that include outcomes c, e, f, g, and i as well)

Table A-2: Evaluation using Score of Student Outcome Rubrics

Student Outcomes		**Score**	**Weight**	**Weighted Score**
(c)	an ability to design a system, component, or process to meet desired need within realistic constrains such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability		50%	
(e)	an ability to identify, formulate, and solve engineering problems		15%	
(f)	an understanding of professional and ethical responsibility		5%	
(g)	an ability to communicate effectively		10%	
(i)	a recognition of the need for, and an ability to engage in life-long learning		10%	
(k)	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice		10%	
		Total	100%	