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A Rubrics Based Quality Improvement Methodology for ABET Accreditation*

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Accreditation is one of the leading techniques used by academic institutions to ensure the delivery of quality educational programs. One of the leaders in providing technical accreditation is ABET. They provide a set of criteria that was developed by technical professionals to ensure the quality of the programs that are accredited. These criteria should be assessed by the institution applying for accreditation. ABET does not specify how the institution should demonstrate its adherence to its criteria. This paper presents an overall framework that uses rubrics that can be systematically applied in a short time frame. This methodology was applied by the computer engineering department at King Saud University. The methodology will highlight where the institution is able to meet the ABET criteria. It provides a set of remedy actions that could satisfy the expected outcomes.

Keywords: ABET; rubrics based methodology; student outcomes; learning objectives; continuous improvement

1. Introduction

Universities strive to provide a quality education to their students. This education should prepare the students with the required knowledge in their field and provide them with the tools so that they can continue their lifelong learning. Pursuing and attaining accreditation is one way for universities to ensure the quality of their education. By gaining accreditation the institute will be able to demonstrate to its students and the public that it is serious about advancing the quality of its programs. Currently there are many well-known international accreditation bodies that perform this task, but ABET (Accreditation Board for Engineering and Technology, Inc.) amongst others has received favorable recognition, particularly in engineering discipline.

ABET accredits higher education programs by outlining criteria towards satisfying the accreditation requirements. ABET however, does not specify how to implement these criteria, yet it recommends guidelines as how to achieve, attain and satisfy these criteria.

Ensuring a quality education is a multifaceted. One has to ascertain that the program is able to achieve its goals at the program and course level. One needs to develop a technique that can monitor and gauge the quality of the program in multiple levels. We have implemented a scheme that is based on rubrics. This methodology requires those institutes that are planning to apply for accreditation to define, evaluate and compare the student's objectives and learning outcomes using rubrics and highlight any continuous improvements together with any remedy actions (if applicable) and finally draw any conclusions based on these findings. This provides a global view of the program. In parallel we maintain a process to measure the quality of instruction at the level of the course to ensure that the course learning outcomes are achieved.

2. An overview of the ABET concepts

The general expectation of any accreditation body including ABET is to assess a set of accreditation criteria. The outcome of this evaluation would determine as whether or not the institution that is applying for accreditation, meets these criteria thereby maintaining the same international standard as those who have already been accredited.

ABET defines some general criteria, in addition to a program specific criterion [1]. The details of these accreditation criteria are freely available on the public domain and can be accessed unreservedly [2]. This paper discusses how to apply a multi-level process to ensure compliance. This paper will show that the process allows the institution to access and apply any necessary remedy action to provide compliance with the ABET criteria within a short time frame. These related criteria include: program educational objectives (PEO), general student outcomes. We will show how a rubrics based methodology is applied in a systematic method to measure the attainment of the global student outcomes.

The following sections provide the methodology used to ensure the compliance of the program to the ABET criteria.

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3. Overall assessment plan

The overall assessment process is illustrated in Fig. 1. As part of this process and based on ABET's definition. We have implemented a multi-stage quality monitoring system.

Initially the Program Educational Objectives are prepared, measured and assessed indirectly every couple of years. This process includes receiving feedbacks from the constituencies such as students, alumni, faculty employers of graduates, industrial advisory council.

Based upon the program educational objectives a set of student outcomes are developed. The references for the Student Outcomes, which are skills and understandings that are achieved by the time a student graduates, are taken as (a–k) are determined by ABET. These student outcomes are assessed using both direct and indirect methods. The direct method is based upon the use of performance indicators and rubrics. This is achieved by expanding the Student Outcomes into appropriate LOs and PIs as will be explained later. The indirect method of assessment is based upon surveys.

Additionally each course has its course assessment report (CAR) that measures the attainment of the course outcomes. The CAR is prepared by the faculty at the end of each semester for every course that is taught during that semester. These CARs in addition to the faculty stating the course outcomes covered in the course, have the student perception on the level of attainment of the course outcomes. The CAR also contains a section about the overall observations of the professor on whether students have some learning barriers that should me mentioned. This way, once a summary of all course assessment reports are discussed in the department council, appropriate measures may be taken to make the necessary adjustments.

4. The Program Educational Objectives (PEO) review process

ABET in a broad statement defines PEO as being 'the career and professional accomplishments that the program is preparing graduates to achieve [1].

Consequently, the PEOs can be considered as an evaluation of the graduate's achievement a few years after his/her completion of the program. The PEOs have to be consistent with the mission of the institution, school and department [3, 6, 7]. To be highly effective periodic revision, and assessment of the PEOs, by the various program constituencies including students, alumni, faculty, employers of graduates, and External Advisory Board (EAB) need to be involved and constantly consulted [4].

The PEO review process is illustrated in Fig. 2. This process utilizes surveys from program constituencies. After collecting the surveys, they are analyzed by the Department ABET Committee (DAC) according to the ABET guidelines [5]. If there are no changes in the PEO, they are sent for the approval by the department council. Otherwise, they are directed to the EAB for consideration. If there are some suggestions made, they are referred to the DAC for further discussion; otherwise they are submitted to the department council for processing purpose. The overall process will continue until the changes in the PEO are finally approved and implemented. This will reflect on the academic curriculum of the exit students (graduates).

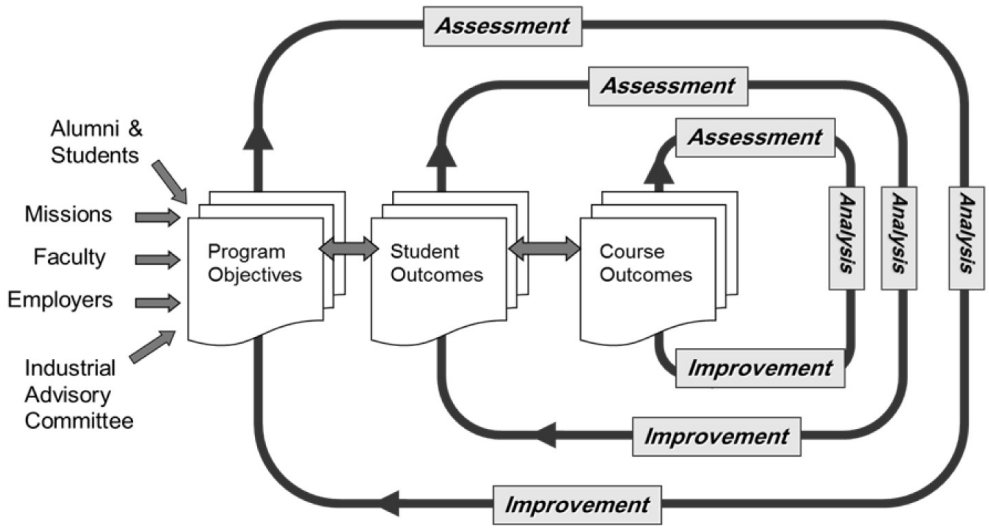

Fig. 1. Overall assessment plan.

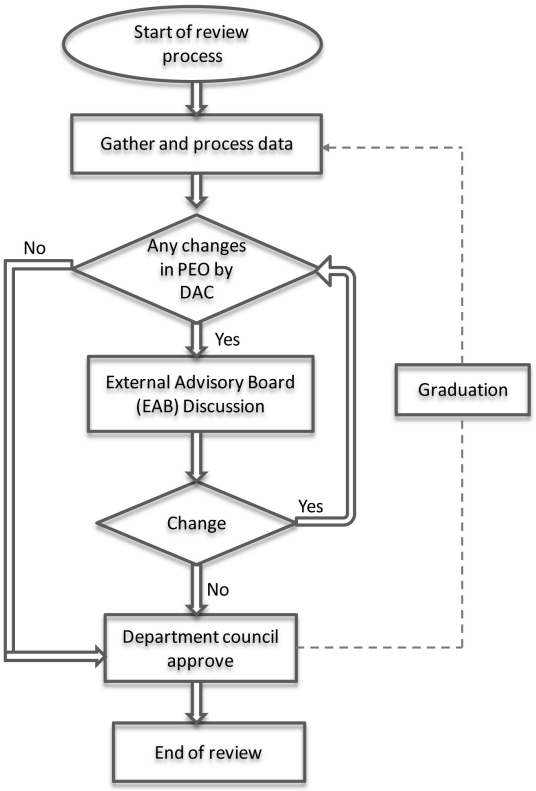

Fig. 2. PEO review process.

5. Student Outcomes Attainment Evaluation and Improvement Process (SOAEIP)

The overall flow of the SOAEIP model is illustrated in Fig. 3. Based upon the evaluation of the current PEOs, the existing SOs which are based on a-k criteria set by ABET can be updated (added) if need arises. These Student Outcomes which are skills and understandings that are achieved by the time a student graduates, are expanded into appropriate LOs (LO(a)1, . . . , n_a; LO(b)1, . . . , n_b, . . . , LO(k)1, . . . , n_k) and PIs (PI(a)1-A,B,C; PI(b)1-A,B,C; . . . , PI(k)1-A,B,C). These SOs are assessed using both directly through exams, tests and quizzes and indirectly through questionnaires and surveys.

The major thrust of this methodology is how to measure the attainment of the student outcomes (SO). We have defined a model that systematically allows an institution to measure the level of attainment. This model addresses the question: How to ensure and improve the attainment of ABET's Student outcomes (a–k)? The SOAEIP model is based on the following integrated components:

Learning Objectives: To evaluate the attainment of ABET's student outcomes (SOs) a set of Learning Objectives (LOs) were developed based on ABETs SOs (a-k). These LOs are articulated in such a way that results in specific statements indicating clear characteristics students should exhibit in order to demonstrate attainment of the compound statement of each SO.

Performance Indicators: Each LO is refined further into Performance Indicators (PIs) which are articulated to be more specific and measurable than LOs. Carefully selected courses are mapped to these PIs. The selection of courses is based on the relevance to the PI statement and should, where possible, represent the culminating learning experience for each PI. Thus, the selected courses are mostly advanced compulsory courses within the three different CEN (Computer ENgineering) tracks; namely: Computer Architecture, Computer Networks and Signal Processing. This tracking scheme can be extended to cover all possible variation that a department may have.

Direct Assessment Action: Direct Assessment Actions are used in relation to assessing student's performance in each PI. These actions are carefully selected to enable students demonstrate the attainment of the corresponding PI. Actions include homework, projects, exam questions, quizzes, etc. The direct assessment activity is thus a course-based assessment approach where the faculty member

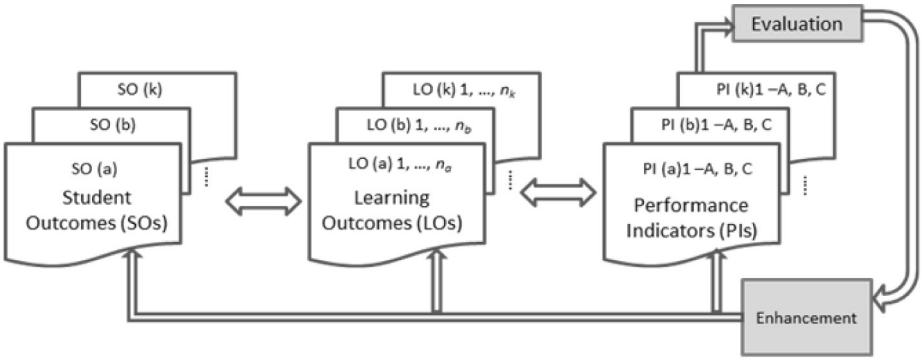

Fig. 3. SOAEIP Attainment flow.

makes sure that the direct assessment action relates well to the corresponding PI, LO and SO.

Rubrics: The department council members could decide on the number of the scale for rubric system which CEN department has decided to use a four scale rubric system (unsatisfactory, satisfactory, good and exemplary) where the description of anticipated student's performance is carefully written in a task-specific way. Some PIs statements required having multi-dimension rubrics; hence, analytical rubric method was adopted to enable staff suggest a suitable remedy action (when the results of students performance in a particular PI are below a particular threshold (the Meeting Expectation ME threshold)).

Meeting Expectation and Remedy Action: The CEN department council selected a Meeting Expectation (ME) threshold as follows; for each PI (or rubric dimension within a PI), at least 70% who took the Direct Assessment Action should have scored good or exemplary in the corresponding four level rubric statements. When the threshold is not met, the staff member who writes the PI report should suggest a remedy action to be implemented to improve students' performance in subsequent terms. The set of remedy actions are discussed in a CEN council meeting and approved. An action plan is compiled based on the remedy actions for follow-up. It is worth noting that the threshold value of 70% is flexible and can be decided by the department council members to best serve, the needs of the department in question.

PI Report: Faculty members responsible for courses related to selected PIs need to write a PI report, where students' performance is reflected upon and a tangible remedy action is recommended if the Meeting Expectation threshold is not met. Once the relevant PI assessment activity is conducted in the subsequent term, another PI report is generated with reflection on the improvement/non-improvement caused by the remedy action and a conclusion statement is produced.

LO Report: A report summarizing the results per LO is produced with suggestions for improvement if ME threshold is not met at the LO level. In addition, a follow-up plan is devised to make sure that suggested actions take place and improvement is achieved.

SO Report: A report summarizing the results per ABETs SO (a–k) is produced with suggestions for improvement if ME threshold is not met at the SO level. In addition, a follow-up plan is devised to make sure that suggested actions take place and improvement is achieved.

5.1 Illustrative example implementing the SOAEIP model

In the sub-section below, the authors shall illustrate the above model using an example considering two of ABET's SOs, namely, SO (b) and SO (g).

Table 1 and Table 2 depict how SO (b) and SO (g) are developed into LOs and PIs. The two SOs were selected to illustrate the model on two types of SO; technical and soft-skills.

As stated above when presenting the SOAEIP model, direct assessment actions (e.g. exam question, quiz, homework, lab report, etc) were carefully selected at the course level to evaluate the attainment of the particular PI within the selected course. Hence, these direct assessment actions acted tools to enable students demonstrate their attainment of the stated PI. When grading students' works, rubrics were used as a scoring tool that lists the criteria for a piece of work (the direct assessment action). It also illustrates the degree of quality for each criterion, from unsatisfactory to exemplary. The use of rubrics proved to be helpful for assessors as they become more focused during teaching and assessing. Also, it acts as a clear guide

Table 1. Development of LOs and PIs from SO (b) 'an ability to design and conduct experiments, as well as to analyze and interpret data'

LO	LO Statement	PI	PI statement	Course
(b)1	Design and conduct an experiment	PI(b)1-A	Design and perform an experiment in Digital Logic Design Laboratory	Digital systems Lab
		PI(b)1-B	Design and conduct an experiment in Digital control	Digital Control Lab
		PI(b)1-C	Conduct an experiment in Computer Networks Laboratory	Digital Communications
(b)2	Analyze and interpret the results of an experiment	PI(b)2-A	Evaluate and analyze the results of an experiment in Logic Lab	Digital Systems Lab
		PI(b)2-B	Analyze and interpret the results of an experiment in Digital Control	Digital Control Lab
		PI(b)2-C	Examine and interpret the results of an experiment in Network laboratory	Computer Network Lab

Table 2. Development of LOs and PIs from SO (g) 'an ability to communicate effectively'

LO	LO Statement	PI	PI statement	Course
(g)1	Demonstrate effective oral communication in discussions and technical presentations	PI(g)1-A1	Deliver oral presentations with professional clarity and presence	Senior Design Project I
		PI(g)1-A2	Deliver oral presentations with professional clarity and presence	Senior Design Project II
		PI(g)1-B1	Effective discussion during or after a formal presentation	Senior Design Project I
		PI(g)1-B2	Effective discussion during or after a formal presentation	Senior Design Project II
(g)2	Demonstrate effective communication in writing and presenting technical work	PI(g)2-A	Write a high quality laboratory report in engineering	Digital Systems Lab
		PI(g)2-B	Write a high quality dissertation	Senior Design Project II

to students to be aware of what they are expected to demonstrate with regard to the PI assessment; they make assessors expectations clear and guide students on how to meet these expectations. Consequently, rubrics can help students be more considerate juries of the quality of their own work, thus making them more reflective learners. In some cases (soft skills in particular), we concluded that multi-dimension rubrics should be used to cater for a genuine assessment of the PI statement. Table 3 illustrates the selected direct assessment action and rubrics used to assess the attainment of a PI within SO (b). If the number of students achieving exemplary or satisfactory is less that 70% of the total number of students who took the direct assessment action, a corrective action (remedy action) should be suggested by the assessor then discussed and approved during a departmental meeting where all non-meeting expectation PIs are presented and discussed. This is monitored carefully in subsequent semesters to validate the appropriateness of the suggested remedy action.

Here the expectation is to demonstrate a statistical presentation for the SO direct assessments for all a–k criteria namely SO (a), SO(b), ... SO (k) during a nominated semester to LOs and then to respective PIs such as PI(a)1 –A,B,C, PI(b)1 –A,B,C, PI(c)1 –A,B,C , ... PI (k) 1 –A, B, C for a number of nominated subjects. Nevertheless due to the space limitation the authors have illustrated the SO for all possible cases of a-to-k and amongst these have nominated the SO (b) and highlighted the PIs PI (b) 1 and PI (b) 2 respectively. As it can be seen some of the sub dimensions of PIs namely PI (b) 1-A, PI (b) 1-B, PI (b) 1-C, PI (b) 2-B and PI (b) 2-C do not meet the threshold of 70% or above. This necessitates launching a remedy action so that it can be implemented in the following semester, aiming at improving the students' performance and meeting the expectation threshold.

At this stage it is beneficial to include an overall assessment plane to summarize our procedure and final comments.

Figure 4 illustrates sample attainment of SO(b) using LO(b)1 and LO(b)2 with three PIs: PI(b)1-A, B, C and PI(b)2-A, B, C. However, LO(b)1 is divided into three PIs, namely, PI(b)1-A, PI(b)1-B, and PI(b)1-C. These are in relation to three different courses such as Digital systems, Digital control laboratory, and Digital Communications, respectively, as indicated in Table 1. The numbers of students in these courses are 17, 18, and 16, respectively. In case of LO(b)1, 55% of students enrolled in

Table 3. A sample of assessment activity and rubrics

PI(b)1-B: Design and conduct an experiment in Digital control				
Assessment Rubrics				
Performance Indicator		Direct Assessment Action		
PI(b)1-B: Design and conduct an experiment in Digital control		Include a problem that determines stability test of a system using Routh Table. Then, evaluate students' works through carefully selected rubrics and provide the number of students attaining different scores.		
Category	Exemplary	Satisfactory	Developing	Unsatisfactory
Capability of designing Routh table (Final, Q.4)	Having an outstanding mathematical knowledge and skill to apply them to design Routh table	Competent in mathematical knowledge to design Routh table	Moderate knowledge in mathematics to design Routh table	Unable to apply mathematical knowledge to design Routh table
Number of students	3	8	4	3

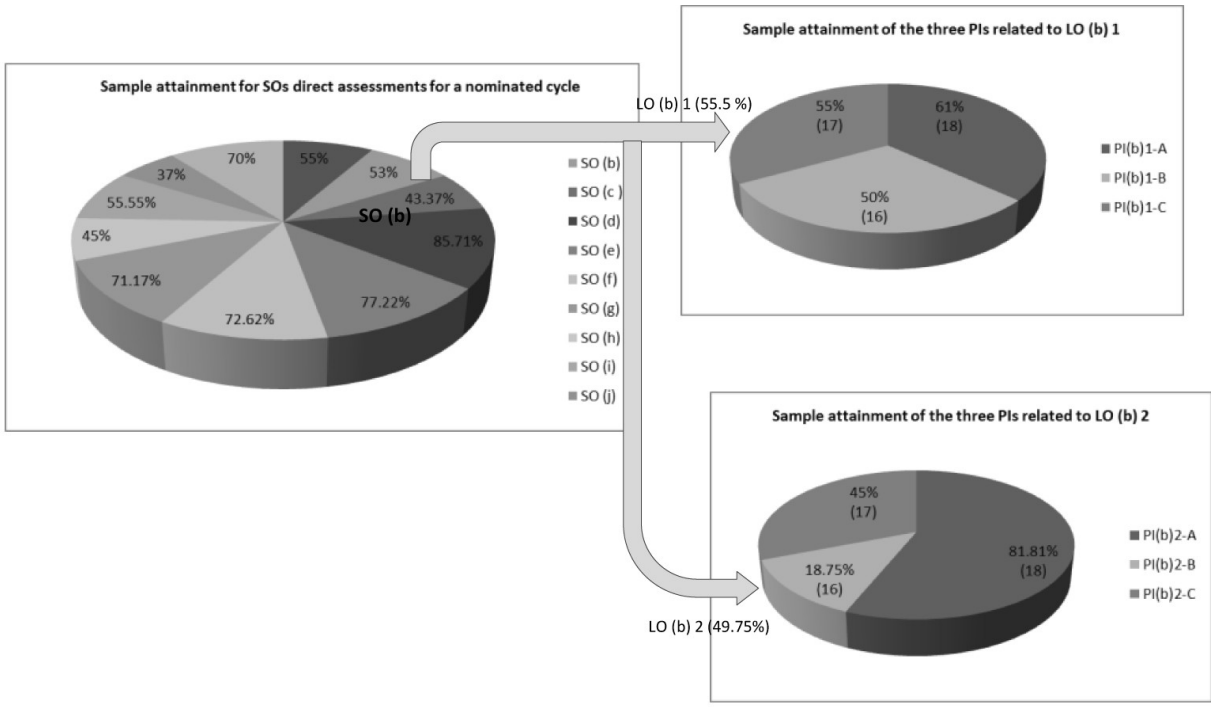

Fig. 4. Sample attainment for SO direct assessment and its relationships to three PIs related to LO(b)1 and LO(b)2.

Digital System course have fulfilled the two categories (exemplary and satisfactory, see Table 3) in the rubrics. The same argument can be applied to the remaining courses for related to PI(b)1-B and PI(b)1-C.

As far as LO(b)2 is concerned, the same concept is applied. However, we find that 81.81% of students in Digital Control Laboratory, which is related to PI(b)2-B, have comfortably satisfied the meeting expectation of exemplary and satisfactory. The same analogy equally applies to the remaining two PI(b)2s.

In order to calculate the SO(b), one has to obtain the overall attainment result which can be drawn by multiplying the percentage by the number of students in each course. This can be repeated for the all courses in question, and then averaged. This procedure results to the value of 53%, as indicated in SO(b) in the left-hand pie chart.

6. Course sssessment

To ensure that each course is able to provide students with quality education, whereby the students in each course are taught what has been specified in the course specifications, we have implemented a course portfolio. The course portfolio contains both direct and indirect assessments of the course. The course portfolio is prepared by the faculty at the end of each semester and for every course taught during the semester. The portfolio contains six sections with the following information:

Section 1: Textbook and Other Required Material.
Section 2: Syllabus with Course Policies, and CARs.
Section 3: A complete Listing of Assignments and Tests.
Section 4: Samples of Graded Student Work.
Section 5: Other Relevant Material: A Sample of Lecture Notes.
Section 6: Location of Online Documentation, if any.

In the syllabus, we present a mapping of the course learning outcomes to student outcomes. A course assessment report (CAR) is written by each faculty for every course taught during the semester. There are 8 subsections in CAR. We observe that in addition to the faculty stating the course outcomes covered in the course, a student perception survey on the level of attainment of the course outcomes is also conducted just before the final exam, and the results are part of the faculty course assessment report. In subsection 3, grade distribution of the students is given. This grade distribution is important to the program level as well as the university level to assess a course in terms of students' performance. In general circumstances, the distribution should follow normal distribution. Subsection 4 maps assignments and exams to course learning

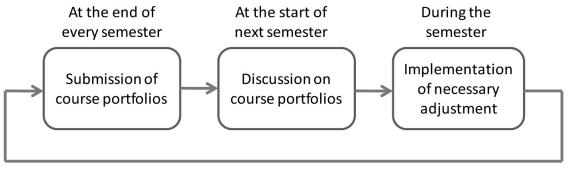

Fig. 5. Continuous improvement process on course portfolio level.

outcomes with attainment level. The percentage of students who get exemplary or good corresponds to the attainment level for a particular assignment or exam. Subsections 5 and 6 give brief mappings of course learning outcomes to student outcomes and assignments to student outcomes. The CAR also contains a section about the overall observations of the professor on whether students have some learning barriers that should me mentioned. This way, once a summary of all course assessment reports are discussed in the department council, appropriate measures may be taken to make the necessary adjustments. Sections 3 of the portfolio contains a complete listing of the assignments and tests with instructor′s solutions, while in Section 4 we give a detailed mapping of those listing to the course learning outcomes and to student outcomes. Recall that in the two-page syllabus we only had a mapping of the course to student outcomes, but now we are doing a more specific and detailed mapping from all assignments and tests given during the semester to course outcomes and to students outcomes to make sure that all ABET student outcomes are satisfied through all curricular components offered in the computer engineering program as claimed. In Section 5, we have samples of graded student work on assignments, written reports and tests. Examples of excellent, satisfactory, and poor student work are included and identified. Samples of the class notes given to the students are given in Section 6 of the portfolio. Then, in Section 7, links to any information made available to students on line are given.

Figure 5 shows the process used to monitor the level of attainment in a course. At the end of every semester, all the faculty members submit their corresponding course portfolios to the department. During the first week of the next semester, these course portfolios are discussed in a department council meeting. Necessary adjustments or remedy actions on courses are then implemented during the whole semester.

7. Conclusions

One of the main outcomes of any accreditation activity is to ensure the delivery and attainment of quality educational programs. As indicated earlier, there are many well known international accreditation bodies that perform this task, but ABET amongst others has received favorable recognition, particularly in engineering discipline. In this paper, the authors have tried to detail the principle aspects of the main methodology that has proven to be a successful model in assessing the Student Outcomes Attainment Evaluation and Improvement Process (SOAEIP). In doing so, we have implemented the rubrics methodology and illustrated continuous improvement on the attainment of ABET's Student outcomes (a–k). To this effect, we have highlighted the required steps in order to achieve this outcome.

In view of the authors, one the most important outcomes of this study is that the duration of our successful accreditation process has been taken approximately 2 years to complete. This was only attainable when true teamwork activities together with joint collaboration among the team members were honored.

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