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Assessing and Evaluating the Course Outcomes of Electrical Circuit Course for Bachelor of Science inElectrical and Electronic Engineering Program

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***Abstract*—** Developing undergraduates' ideas and abilities is a pressing and fascinating issue right now. Teachers should work to improve their pupils' sophisticated and critical thinking skills. However, many of them struggle to accurately evaluate the skills of undergraduate students that enroll in their classes. This study reports the use of the Outcome-Based Education (OBE) framework to the assessment and evaluation of the electrical circuit course in the undergraduate Electrical and Electronic Engineering (EEE) program. For a s tudent-cohort of an electrical circuit course taken in the Spring 2019 Semester at the EEE Department at Southeast University (SEU), the methodology, course contents design, course outcomes (COs) preparation, mapping it with program outcomes (POs), question setting according to Bloom's taxonomy, assessment strategy of the students, CO and PO evaluation records, statistics, and charts have been reported. CO review and assessment reveals that students in this course have met or exceeded the standard set by the course teacher. Teacher suggestions for next-level quality improvement, depending on student CO success, are also provided.

Keywords; Evaluation, assessment, and benchmarking in an electrical circuitry course are all relevant OBE concepts.

INTRODUCTION

On15 November 2009, in the midst of the Fall 2009 Semester, SEU was granted permission by HE University Grants Commission (UGC), Bangladesh to launch a Bachelor of Science in Electrical and Electronic Engineering (BSc in EEE) degree program. In light of this, the Department of EEE launched its Bachelor of Science in EEE degree in the 2010 spring semester. After then, every spring, summer, and autumn semester brings a new crop of students to this division. There have been 19 graduating classes totaling over 500 pupils [1].

The Board of Accreditation for Engineering and Technical Education (BAETE) in Bangladesh grants approval to all engineering degree programs in the country. The Institution of Engineers, Bangladesh (IEB) is a non-profit professional organization open to all BSc engineers in Bangladesh, however it will not admit graduates from unaccredited programs. Engineers need IEBs. membership when he or she has to give the green light to any kind of engineering plan. Therefore, it is thought that the BSc in EEE program has to be recognized by BAETE since our graduates are having difficulty finding employment. However, the essential condition to receive the accreditation is that the program's curriculum is based on OBE [2]. Therefore, beginning with the 2019 Spring Semester (January–April), we have begun implementing OBE in our department by establishing a few courses in accordance with the criteria of an OBE curriculum. The first edition of BAETE's OBE Manual went into effect on July 1, 2017 [2]; the second edition goes into effect on January 1, 2020 [3]. The EEE division has put the first edition of the guide into practice (as of March 2019) [4].

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There are now about 150 universities in Bangladesh, including governmental, private, and foreign institutions [5]. The institution places a strong emphasis on promoting the excellent quality of its programs. It is already common knowledge that the OBE method may be used to provide kids a top-notch education. Since the OBE-based engineering education model has been widely accepted as a benchmark for determining whether or not a program is of sufficient quality, BAETE in Bangladesh has followed suit. As a result of BAETE's adoption of the Outcome-Based Accreditation (OBA) of the engineering program, many programs at various universities in Bangladesh have applied to BAETE for OBA [4], indicating a growing interest in adopting the OBE-based curriculum model. As a result, several of SEU's full-time instructors in the EEE department have begun implementing the OBE-based curriculum. In the first phase, we will use an OBE-based model to execute the electrical circuit course and directly measure its COs. This document details the procedure by which the electrical circuit course is evaluated and graded according to its predetermined assessment plan and its established COs. After that, we map each CO to its matching PO and use it to determine each student's degree of achievement. It's worth noting that BAETE's 12 Prior Learning Outcomes (POs) have been included into the BSc in EEE curriculum [2].

Based on the findings of this assessment, SEU's BSc in EEE program has established OBE protocols for its other upper-level courses. These data and evaluations are useful for the institution as a whole.
management and the relevant academic program in order to enhance the program in terms of quality [6] and future student intake quantity via the creation of strategic frameworks for the long-term success of the department and, by extension, the institution. In addition, it will provide SEU's EEE grads more options for building a successful career and contributing to national growth in the future.

LITERATURE REVIEW

In OBE-based engineering education, evaluating POs requires evaluating COs [7], [8]. The coursework offered to a given semester's cohort serves as the basis for the CO evaluation. This is a crucial instrument for understanding the course's intended learning goals and, by extension, the students' perspectives [9], [10]. Different approaches may be discovered in the literature for determining COs, all of which include tallying up each student's successes relative to some standard. Assessment is a continuous, systematic procedure aimed at identifying, collecting, analyzing, and interpreting data on students' achievements in order to quantify the accomplishment of each CO, determine how well attainment matches between expectations and standards, and take appropriate measures to improve student learning and ensure and propel quality engineering education at the tertiary level. Therefore, a long-term evaluation strategy should be created for each program [12]. Depending on the desired goal, an effective evaluation may use quantitative, qualitative, direct, or indirect techniques [13].

In order to gain accreditation, engineering programs must demonstrate that they are providing students with the necessary resources to succeed in the course material and the Professional Obligations (POs) that are expected of them upon graduation [1], and that they have developed an evaluation procedure to determine to what extent these POs have been achieved effectively. The logical, interactive, and collaborative growth of students is a primary concern for COs since it contributes to students' academic performance. After completing a course in the curriculum, students are expected to demonstrate their acquisition of the course's learning goals in terms of knowledge, abilities, and attitudes [15], [16]. The engineering program's QA strategy and curriculum design are both directly impacted by COs [17].

To measure progress toward objectives, several different evaluation frameworks are being employed. The two most common kinds of evaluation procedures are direct and indirect [18]. However, direct evaluation systems [19] are often employed for CO monitoring. By using the CO evaluation methods, a program may show how a certain PO is being taught. Therefore, calculating CO levels has become a very laborious endeavor. In a direct method of evaluation, paper is shredded on the spot. verification of the course's intended results. The degree to which a student's topic knowledge, skill sets, and other qualities are interrelated may be inferred from these shards of data. While this kind of evaluation is most often used at the seminar or program level, it is equally applicable at the school or university level. Direct assessment may be done using a variety of instruments. The exam is the most typical method used. Writing samples, presentations, etc., are also useful [20]. It's worth noting that, although direct evaluations are an important part of any assessment system, they can't offer enough assessment analysis on their own. Achievement in learning may be reported, but not the means by which or the ends for which the learning was accomplished. Indirect evaluation, on the other hand, is a crucial instrument that may offer a sense of the learning environment in order to improve the learning process [18].

Indirect evaluation puts more weight on proximal factors of learning than on the learning itself. Most often, this is done via a survey that collects information from many stakeholders including but not limited to current and former students, program professors, industry experts, curriculum designers, and employers of program graduates. The surveys provide us insight into how committed students are to studying and how effective certain program activities are for certain classes [18].

Students' progress toward meeting the COs and, by extension, the POs, as defined by a set of evaluable, course-related performance indicators, was proposed as a means of direct evaluation [14]. These PIs should have quantifiable characteristics differentiating the degree of performance required to meet the broader program level objectives or POs [21].

The study of electrical circuits is a cornerstone of every engineering education. Many people have tried to explain DC and AC circuits to pupils [22] for a long time. This course is more like a cross-disciplinary

engineering curriculum based on Physics and Mathematics, however it is required for the BSc in EEE degree. This makes it more difficult for course instructors in the BSc in EEE program to ensure that their students achieve the goals of this course [23], and therefore teachers in this field need to provide extra encouragement to their students [24].

Assessment methods and performance indicators have been established to monitor students' progress toward the goals of the electrical circuit course for the EEE program. Indicative criteria for course outcomes can only give limited information about what students could have learned and accomplished, thus a more detailed description of course content is required. Nonetheless, these guidelines have the potential to identical each time an electrical circuits course was made available to pupils. When we combine this extensive collection of criteria with the results of our analyses of the most important prerequisites for undergraduates and our other assessment data, we get a true depiction of the results of the BSc in EEE program. The course's electrical circuits instructors should make an effort to establish a connection between the standards and program objectives and the questions on the course's quizzes, tests, assignments, midterms, and final examinations. A course-based evaluation is to be utilized for grading student responses and assessing their success, and students' scores are to be tallied separately [25].

The Work's Primary Goals

Finding a concrete approach for evaluating the COs and, by extension, its contribution to the POs of SEU's BSc in EEE program is the primary focus of this research. However, the work's other goals are to: i. examine several works on the OBE-based assessment and evaluation process and design an assessment plan for determining whether or not the COs of the electrical circuit course have been met; ii. teach students essential skills in circuit design and problem-solving that are central to the undergraduate EEE curriculum.

ii. Determine each student's individual performance level.

iii) Assess how well PO achievement is correlated with electrical circuit course outcomes.

iii. Assess the course's strengths and weaknesses and advise the EEE Department on how to fix the problems identified as part of CQI.

VII. METHODOLOGY

Three engineering programs at SEU have been approved by the Bangladesh Accreditation and Evaluation of Training Establishment (BAETE). It's common knowledge that certification is a useful tool for ensuring a high standard of learning [1, 26]. Therefore, in 2017, SEU administration decided to submit accreditation applications to BAETE for all three of the university's engineering programs (Computer Science and Engineering (CSE), Electrical and Electronics Engineering (EEE), and Textile Engineering (TE)) [1]. The fundamental goal of this risky move was to provide these engineering programs with the money and facilities they needed to flourish and become the centers of excellence in engineering education at the university level in Bangladesh. Specifically, it was up to these three divisions to identify the key performance indicators for monitoring the COs and, by extension, the POs [1]. The development of an OBE-based curriculum, the implementation of a required laboratory setup, the acquisition of the most essential machines, equipment, test, and measurement instrument, the creation, testing, and demonstration to students of new laboratory experiments in accordance with the revised undergraduate curriculum, the creation of appropriate laboratory experiment manuals, the hiring of competent as w

A. teaching pupils the fundamentals of OBE methodology, etc [1]. In January of 2019, the BSc in EEE program implemented the OBE-based curriculum after a meeting of the curriculum revision committee [1]. At that gathering, a methodology was agreed upon to monitor progress toward the POs in a variety of ways. Every CC in every required BSc in EEE course was connected to some program objective (PO). Each instructor makes these changes and submits them for approval to the EEE Department's Academic Committee. Once approved by the Academic Committee, the many ways in which each course's instructors will determine whether or not their students have fulfilled the COs will be implemented. Then, based on the course's COs and the desired degree of learning outcomes as determined by Bloom's taxonomy, each instructor will craft an assessment strategy and question sets. The Chairman of the EEE Department's OBE committee will need to see the results of his or her review and assessment. The OBE committee evaluates the program's success based on the cumulative objectives (COs) and performance outcomes (POs) data supplied by each faculty member. The committee also ensures that no student's PO has been overlooked. In such case, the CO-PO matrix is recalculated for that group of students. In addition, each student's performance on the PO is assessed using information gathered from course exams, course instructors, current students, alumni, research and internship mentors, and employers of graduates [27]. After looking into the precision of the findings, it was discovered that they were incorrect because of the equal importance placed on the many measuring procedures that all lead to the same PO [1].

Course Outcomes, Part B A course objective (CO) is a set of learning outcomes that describe the knowledge, abilities, and dispositions that students should have after completing the course. While more advanced COs may be encountered later on, the electrical circuit course is a cornerstone of the undergraduate EEE curriculum. This course is crucial to the comprehension of many others that need familiarity with electrical circuits. As a result, the electrical circuit course's COs should help students get a firm grasp of the nuances of building a wide range of electrical circuits. Both theoretical and practical concepts related to electrical circuits are covered in this course. Each CO was prepared with a suitable set of action verbs. After that, we began our four-Os for the electrical circuit class with the following statement.-

Students who complete this program will have the skills to: Provide an overview of the many theories and rules that govern DC electrical circuits (CO1)

[CO2] Apply a variety of principles to the

computation of electrical signals and parameters in different kinds of DC electrical circuits. formulasDC electrical circuits: [CO3] address issues using rules and network theories

[CO4] Find answers to DC electrical circuits' transient difficulties [CO5] Determine the values of the magnetic circuit's parameters using the B-H diagram and Ampere's law.

B. Results of the Program

The BSc in EEE program at SEU follows the standards established by the UGC, Bangladesh [28] and the BAETE, Bangladesh, and requires students to complete a minimum of 153 credits to graduate. The BSc in EEE program's course curricula have been developed by the faculty and then submitted to the department's academic and curriculum committee. However, prior to that, the IAP (Industry Advisory Panel) was consulted. The EEE Department at SEU [1] has implemented the updated curriculum beginning with the Spring 2019 Semester, following the proposal of the curriculum committee, the academic council, and the syndicate meeting. The BAETE Manual [2] has 12 P.O.s, all of which have been included into the BSc in EEE curriculum at SEU [29]. It is expected that graduates of this program will also be able to achieve the 12 POs required by BAETE's manual [29]. In addition to holding in-person sessions in traditional lecture halls, professors at SEU's EEE department also use online tools like Google Classroom and Google Meet to hold virtual lectures and student meetings. They also provide students with course syllabi on the first day of class for each semester. The curriculum parameters indicate the students' ability to perform at the point of their completion of the EEE program.

The anticipated knowledge, skills, and attitude essential to accomplish any of the 12 program outcomes mentioned in theBAETE manual [2], and adopted by the BSc in EEE curriculum of SEU [29] to define the various performance indicating parameters with relevant teaching domains and levels of Bloom's taxonomy, teaching-learning approaches, and assessment apparatuses of electrical circuit course are shown in Table I with the CO-PO mapping. To provide students with the necessary knowledge of electrical circuits, various levels of the cognitive domain in the teaching-learningstrategies (from 'remember' to 'create' level) have been chartedfor the electrical circuit course. The reason is that it has already been observed that this method is more effective than that observed in the traditional method of teaching-learning strategies in several studies

B. CO-PO Performance Indicators (PI) are quantitative criteria that each student must meet to certify the accomplishment of the numerous COs of his or her program [1, 13]. Students' understanding of electrical circuits is gathered by direct evaluation against observable and measurable course outcomes (COs). This should provide a picture of each student's progress toward achieving each CO. Every student's grades for the whole semester must be kept in a permanent file by the 'electrical circuits' professor. Students will get their letter grades at the conclusion of the semester, upon completion of the course. Nonetheless, for each CO, students will be given a "score" between 0 and 5 (the maximum) or a percentage indicating their level of performance [1, 29, 30]. These

Provide an overview of the many theories and rules that govern DC electrical circuits (CO1)
[CO2] Apply rules and formulae to the computation of electrical signals and characteristics in a variety of direct current (DC) electrical circuit configurations [CO3] Problems in DC electrical circuits may be solved by using rules and network theory.

The percentage of question distribution in the assessment plan as per various levels of Bloom's taxonomy in terms of thenumber of questions and amount of allotted marks is shown inTable III. From this table, it is seen that no questions are set from level one of the cognitive domain. Most of the questions (50%) are set from level three and the marks allotted to this type of question are 48.5%. Since this is the electrical circuit course, it is expected that the students should be able to solve mostly the application-level problems. Besides, a fewquestions have been set from levels 4, 5, and 6 with 6.25%,
12.5%, and 6.25% questions with 7.5%, 16.7%, and 9.1% of allotted marks respectively.

TABLE III
PERCENTAGE DISTRIBUTION OF QUESTIONS AS PER LEVELS OF BLOOM'STAXONOMY IN THE COGNITIVE DOMAIN

Cognitive Levels		**Questions**			
Level #	**Level Name**	**Number of Questions**		**Marks of Questions**	
		In Count	**In %**	**In Number**	**In %**
C2	Understand	4	25%	12	18.2%
C3	Apply	8	50%	32	48.5%
C4	Analyze	1	6.25%	5	7.5%
C5	Evaluate	2	12.5%	11	16.7%
C6	Create	1	6.25%	6	9.1%
Total		**16**	**100.00%**	**66.0**	**100.00%**

TABLE IV
PERFORMANCE SCALE BASED ON THE PERCENTAGE OF MARKS OBTAINED

Performance Level	**Numerical Scale**Excellent	80% and Above Very Good	70-79%
Good	60-69%		
Satisfactory	50-59%		
Developing	40-49%		
Unsatisfactory	Below 40%		

A performance scale is also developed (as shown in Table IV) based on the percentage of marks obtained in each COcontributed from different direct assessment tools discussed inTable II. Initially, the CO achievement target has been set to 50%; that means, 50% of students of the cohort of this courseshould be at the satisfactory or above

level, because, in a satisfactory level, the numerical scale is also 50%.

B. PO Assessment

To measure the attainment echelons of POs for each student of the electrical circuit course, each CO of this course is assigned to at least one PO out of the 12 POs of the BSc in EEE program at SEU. The attainment status of each PO is calculated as per the following steps [1]:

i. Contributions of each CO to the corresponding PO is thesame for the electrical circuit course.
ii. From Table I, we observe that CO1 helps to achieve PO1, CO2 and CO3 jointly help to achieve PO2, CO4 helps toachieve PO4 and CO5 helps to achieve PO3.
iii. The percentage of scores is calculated and is assigned to the PO contribution for each student.
iv. The percentages of students in each CO and PO are computed as well.
v. A PO is said to be attained if the combined percentage of students in the "Excellent", "Very Good", "Good" and "Satisfactory" groups is equal to or greater than 50%. This is corresponding to 50% of the students scoring grade C+ (50%) and above. Because SEU follows the UGC grading scale [1], [24].
vi. The PO status is calculated as per the following criteria of the percentage score contributed to each PO [1]-

a. Score ≥ 50% → achieved
b. Score < 50% → not achieved
c. Score ≥ 50% but < 59% → marginally achieved
d. Score ≥ 60% but < 69% → achieved but need improvements in knowledge and skills.
e. Score ≥ 70% but < 79% → achieved with very good status but still need improvements in a few areas ofknowledge and skills.
f. Score ≥ 80% → achieved with an excellent status
g. Score ≥ 40% but < 49% → unachieved and in the developing stage and require additional care for the attainment of COs and POs.
h. Score < 40% → unachieved and in the unsatisfactory stage and require retaking the course for the attainment ofCOs and POs.

C. Data Collection

The sample of 18 students used in the study was chosen from the pool of undergraduate students enrolled in the electrical circuits course offered in the spring 2019 Semester of the academic year 2019 at the EEE Department of SEU. Data were collected from direct assessment tools of the 'Electrical Circuits' course offered during the first semester ofthe EEE Department for one cohort of students. It is to be mentioned that the EEE Department of SEU started OBE curriculum implementation from the spring 2019 Semester with the fresh students admitted in that particular semester. To evaluate the students' CO and POs attainment based on direct

assessment tools, we have used data only from the course offered in the Spring 2019 Semester as we started to implement OBE Beginning with the 2019 Spring Semester, the OBE curriculum will be implemented at the Electrical and Electronics Engineering Department at Southeastern. The pupils were not provided with any kind of indirect evaluation this semester.

Chapter Seven: Findings and Discussions

A. Assessment of the CO-PO

Tables V and VI summarize the percentage of pupils that met the CO and PO benchmarks, respectively. The data in Tables V and VI reveal that Sixteen out of eighteen pupils were able to get CO4 and, by extension, PO4 at the end of the course. The outcomes for CO and its related PO are identical since only CO4 of this course maps directly to PO4. CO5 and PO3 are quite similar, with 17 out of 18 students in the cohort of electrical circuit courses achieving CO5, that is, successfully determining the magnetic circuit parameters using ampere's circuital equation and B-H curves.

Progressing Well - Reasonably Satisfying Fifteen of the eighteen students in the cohort met or exceeded their expectations for learning the course's laws, rules, and theorems; this represents more than half of the class and means that the course and POs through this course have been achieved by this cohort of students according to the first-CO of the electrical circuit course. The remaining three classmates need special attention. These two tables also display the results of applying different rules to the

calculation of electrical signals and parameters in many different kinds of DC electrical circuits.

CO1	5	2	5	3	1	2
CO2	4	5	3	2	3	1
CO3	3	4	7	3	0	1
CO4	4	5	4	3	2	0
CO5	3	5	4	5	1	0

TABLE VI
NUMBER OF STUDENTS ACHIEVING THE PERFORMANCE LEVELS FOR VARIOUS POS THROUGH THE ELECTRICAL CIRCUIT COURSE OF EEE DEPARTMENT

and formulas as well as the solution of DC electrical circuits

	Excellent	**Very Good**				
PO1	5	2	5	3	1	2
PO2	0	9	6	3	0	0
PO3	3	5	4	5	1	0
PO4	4	5	4	3	2	0

problems by applying rules, laws, and network theorems have been achieved by them, 14 and 17 in number for CO2 and CO3 respectively. Thus, the contribution to PO2 has been achieved by all the students in the cohort. On the other hand, it is observed that the skills required to solve various transient problems of DC electrical circuits are also above expectations

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Good Satisfactory Developing
-

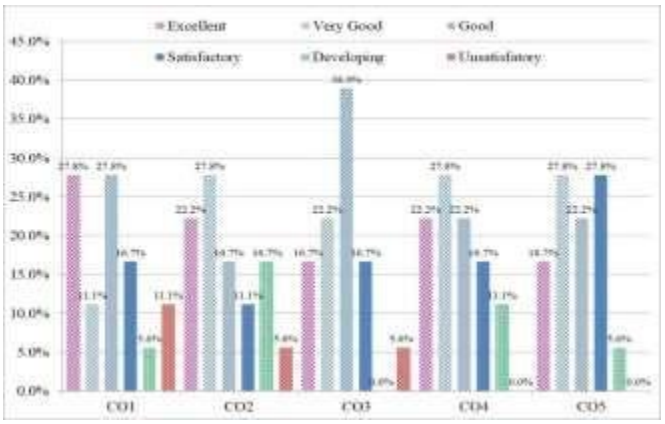
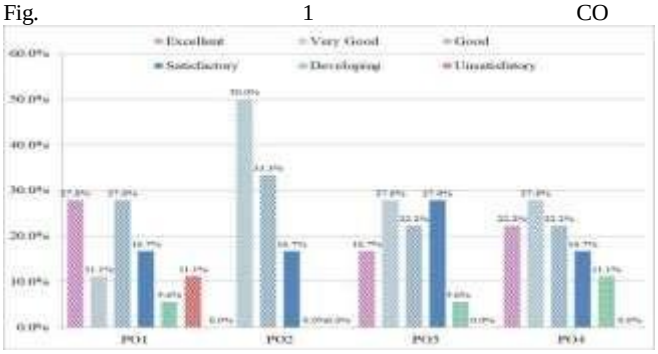


Fig. 1 CO



aluation attainment report summaryFig. 2 PO evaluation attainment report summary

As illustrated in Figures 1 and 2, the findings were used to create visual representations of the percentages of completion for each CO and accompanying PO. Given that the course standard for success is 50%, we can deduce that the vast majority of students were able to complete all course objectives and make progress on their personal outcomes (POs) as a result of taking this course. However, the remaining pupils who were unable to meet their COs and POs need a great deal of attention.

A. Recommendations for Enhancement

The EEE division has compiled a list of possible solutions to the issue of low completion rates for COs and, by extension, for the associated performance objectives. However, each semester's instructor will choose the maximum number of recommended actions that will be implemented. These are strategies for furthering each student's development. However, a course instructor is not required to rely only on these strategies; rather, he or she is free to devise other methods of assisting students in need. Commonly used corrective actions for the electrical circuits course include the following:

a. Having students do more independent work that is more relevant to achieving a particular CO of electrical circuit course; b. Assigning students with field surveys on collecting electrical energy data, electrical circuit troubleshooting; c. Having students do more home works and assignments on various problems and derivations related to electrical circuits.

d. Increasing the number of weak students' tutoring courses

pupils in the areas where they may most need improvement.

a. Recommending a few different books that are utilized as references at the best colleges to study electrical circuits.

b. Adopting a new approach to instruction in order to help a specific student who is struggling to meet the COs.

c. The instructor prepares comprehensive lecture notes for each class, covering all the essentials of electrical circuits and network theories, making it simple for students to absorb the course material and master the circuit theorems.

d. applying the principles and theories of electrical circuits to actual-world numerical problems, with the use of real-time data. Interest in the material will increase as a result.

e) Illustrating real-world applications of electrical circuits and the applicable rules and theories.

Concerned faculty members are required by the EEE Department to maintain a record of all steps to be taken to raise the achievement level of COs/POs, and to submit a report at the end of the semester in which the course was offered to indicate whether or not the achievement levels of the COs/POs have risen significantly as a result of the remedial measures suggested by the course teacher of the previous semester.

CONCLUSION

An OBE-based curriculum and teaching-learning process is described in this article as the means by which the EEE Department at SEU is implementing the outcome-based assessment and evaluation procedure necessary for the certification of the BSc in EEE program. Several direct assessment techniques are used in this model to calculate electrical circuit COs. course, and hence its impact on a number of OPs. Multiple PIs are designed to test and measure what students have learned and if they have mastered the material necessary to pass the course. Institutions can better identify problem areas and implement solutions when they use a standardized method to track progress toward programmatic objectives. The approach presented here is quite general and may be used to evaluate COs in almost any kind of educational setting. Both the data collection and analysis in this research were done by hand. The faculty members need to spend a lot of time on these activities. Our long-term goal is to create a software application that would streamline the procedure of determining the value of any engineering degree program in terms of its COs and, by extension, its POs.

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