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Calculation and appraisal of the course outcomes of the electronics course

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Abstract

The purpose of this research work was to assess and evaluate the course outcomes of the electronics course of the Bachelor of Science in Electrical and Electronic Engineering program incorporating higher-order thinking skills and complex engineering problem-solving skills among the students. This course is one of the essential course courses of BSc in EEE program of study and as such, its course outcomes are associated with three program outcomes. To compute and appraise the course outcomes of this course and hence its impact on the program outcomes, we used direct assessment data from various formative and summative assessment tests during a particular semester. For this purpose, an assessment plan was prepared and then test data were used to evaluate the outcome. Finally, statistical analysis is performed to check whether a particular student cohort of electronics courses could achieve this or not. All of the 46 participating students have attained the benchmark set before the start of the course. Finally, course survey results and a few recommendations are provided as a measure of the continuous quality improvement method.

Keywords: Assessment; course outcome; electronics; evaluation; outcome-based education.

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1. Introduction

The Board of Accreditation for Engineering and Technical Education (BAETE) gives accreditation to various engineering programs at the undergraduate level offered by the institution of higher learning. The BAETE works under the shade of the Institution of Engineers Bangladesh (IEB), which is the graduate engineers' professional body in Bangladesh (BAETE, 2019). A graduate engineer needs to get a practicing engineering certificate from the IEB for recommending any engineering design work. However, if a student receives an engineering graduate from a non-accredited program, then he/she can't get the practicing engineering certificate from the IEB. As a result, graduates of non-accredited engineering programs suffer to get suitable jobs in reputed companies. Therefore, to increase the graduates' employability in the engineering sectors, all engineering program leaders aspire to get accreditation from BAETE. However, this is not going to be an easy task. Only strong leadership in the engineering program can help a program to get the accreditation because to get accreditation, the program needs to convert its curriculum into an Outcome-Based Curriculum (OBC) by following the Outcome-Based Teaching-Learning (OBTL) as well as Outcome-Bases Assessment and Evaluation (OBAE) processes. Keeping the same view in mind, the EEE department of Southeast University (SEU) converted its curriculum into an OBC with effect from the Spring 2019 Semester (Bhuyan and Tamir, 2020; EEE-PO, 2020) following the BAETE Manual Version 1.0 (BAETE, 2019). Then the department again fine-tuned the OBC according to the BAETE Manual Version 2.0 (BAETE, 2019) for accreditation of the current regular program.

The number of government-run and private-sector-operated universities is growing each year in Bangladesh along with the engineering programs as well because of the government's initiative to expand higher education opportunities across all districts of the country. So far, 108 private and 52 public universities (including two approved public universities in the northern districts of Naogaon and Thakurgaon) are operating in Bangladesh (UGC, 2022). The University Grants Commission (UGC) of Bangladesh is also emphasizing Outcome-Based Education (OBE) to meet up national and global needs and challenges. So, to improve the quality of education, universities should look for quality students. However, quality students also seek quality education. As such, private universities are looking for program accreditation so that they can highlight their strengths in this regard among prospective and aspiring students (Tuli, Singh, Mantri & Sharma, 2022). Since the eligibility criteria to apply for the program accreditation to BAETE is to have an Outcome-Based Education system, therefore, to get Outcome-Based Accreditation (OBA), steadily all engineering programs in Bangladesh are transferring to the OBE system (BAETE, 2020).

The implementation of the OBC in the EEE Department of SEU is underway from the Spring 2019 semester. Course outcomes for all the courses of the program of study are prepared and mapped to the program outcomes as well as well-defined assessment and evaluation plans have been prepared (EEE-PO, 2020).

1.1. Purpose of study

This paper describes the assessment and evaluation processes of the course outcomes of the electronics course including the course outcomes (COs) preparation, mapping to the relevant program outcomes (POs) with the knowledge profiles (WKs), and complex engineering problem-solving (CPs) issues. Besides, the computation processes of the attainment of COs and POs, course outcome surveys, and recommendations for further improvement as a measure of the Continuous Quality Improvement (CQI) method have been presented (BAETE, 2019).

1.2. Literature Review

The most essential prerequisite to getting accreditation for any program is to demonstrate the attainments of course and program outcomes as well as program educational objectives of the program by their graduates during a particular period (BAETE, 2019). The attainment of course outcomes largely show the students' learning achievement during a specific semester. These are to be demonstrated through any one or all of the three domains of Bloom's taxonomy, viz. cognitive, psychomotor, and affective domains (Asheim et al., 2017; Abdeljaber and Ahmad, 2017). Course outcomes-related information guides the program leaders to get the program outcome attainment information, to improve further their program curriculum, teaching-learning strategies, assessment, and evaluation methods, etc. (Mustaffa et al., 2019; Pleasants, 2021). Therefore, the assessment and evaluation of course outcomes (COs) are crucial to evaluate the PO attainment of the OBE system (Bhuyan and Khan, 2020; Bhuyan and Tamir, 2020). From the measurement of COs, one can get a perfect sketch of the students in an explicit cohort of students and as such their POs as well (Bhuyan and Khan, 2020; Kilty et al., 2021). Besides, this helps to recommend the CQI process and its future implementation procedures (Sikander et al., 2017).

A sustainable assessment technique was established for remedial actions for the further enhancement of the course outcome to make sure the quality of the undergraduate engineering teaching-learning (Mahadevan et al., 2013). However, an effective assessment plan is a mandatory requirement to ensure quantitative and qualitative along with direct and indirect measurements appropriately as per the ABET prescription (ABET, 2010).

There are numerous assessment forms to calculate the course and program outcomes (Nguyen, Nguyen & Ba Le, 2022; Mamedova et al., 2023). Of them, the direct and indirect assessment formats are being widely utilized by program educators (Terry et al., 2007; Jayarekha and Dakshayini, 2014). However, direct assessment formats are mostly being utilized to assess the course outcomes and then the program outcomes as per mapping in the curriculum as suggested by many researchers (Shaeiwitz and Briedis, 2007).

When the course outcomes are assessed using the direct assessment technique then it is performed based on pieces of evidence that provide information on the mastery of specific course contents attained by the students of a specific cohort. The direct assessment scheme comprises numerous components, for example, the midterm or final examination questions, quiz-type questions, class test questions (usually short questions), assignments, etc. (Harvey et al., 2010; Bhuyan and Khan, 2020; Bhuyan, 2020). An alternative way of measuring the direct assessment is to use performance indicators to compute the program outcomes from the courses taught by the faculty members (Gurocak, 2008; Alzubaidi, 2017). These performance indicators should have some assessable characteristics aligned with the mapped program outcomes based on the course outcomes of some of the courses of the curriculum (Rogers, 2003).

Electronics is a very important and fundamental core course in the curriculum of the Bachelor of Science in Electrical and Electronic Engineering program. The contents of this course are divided into two parts; accordingly, the course is named Electronics I, and Electronics II each with three credits (EEE-CC, 2020). In the dominating model, we need to select a few courses to check whether the students can attain the specified course outcomes and hence the program outcomes. Therefore, various attempts must be made for the students so that they can comprehend the theories, electronic circuits, and their application areas. To make the learning effective, some e-learning techniques are being developed and applied in some cases, for example, web and applet-based e-resources, and online videos on electronics lecture series, and these techniques were found satisfactory for achieving the course outcomes (Singh, 2011). However, for this purpose, faculty members should devise some motivational techniques for their courses to make them functional (Bhuyan and Khan, 2018; Liew et al., 2021; Boya-Lara, Saavedra, Fehrenbach & Marquez-Araque, 2022; Gong, Deng, Wang & Chen, 2022).

The researchers also proposed software-based teaching and self-assessment methods measuring the course outcomes of another electronics-based high-level course, like semiconductor device using the SUPREM software package, which was used by the students for designing various semiconductor devices (Rizkalla and Yokomoto, 2001).

1.3. Conceptual background of the study

In Bangladesh, any admission-seeking student in the Bachelor of Science in Electrical and Electronic Engineering (BSc in EEE) program wants to know whether the program is accredited or not because it affects their future job prospects in the country and abroad. As such, the program leader works very hard to get their program accredited as early as possible because this also ensures that the program has the minimum financial and physical resources as well as maintains the minimum standard of the program. A program needs to demonstrate that its students are attaining a minimum benchmark level of their set program outcomes of the outcome-based teaching-learning and assessment-evaluation processes. As such, the EEE department of SEU took some steps to measure the course and program outcomes from a few courses (Bhuyan and Tamir, 2020). Before that, the same department developed the outcome-based curriculum and made it effective in the Spring 2019 Semester and devised some guidelines for the outcome-based teaching-learning and assessment-evaluation processes (Bhuyan, 2020). Accordingly, each course outcome of the electronics course was interrelated to one program outcome out of the twelve POs specified by the BAETE (BAETE, 2019). The course teacher who teaches this electronics course has to do it. Then he needs to prepare an assessment plan by identifying the components of direct assessment tools from various assessment strategies. After that, the course teacher requires to set questions following Bloom's Taxonomy levels and map course outcomes. The numerical score of each student is tabulated as per this assessment plan keeping the answer scripts as the pieces of evidence. From the tabular data, COs are computed for each student and so does the associated POs. Finally, the COs and POs are evaluated and analyzed for each student of the cohort of electronics course by the faculty members. Besides, the accuracy of the data should also be scrutinized to decide on the PO attainment (Mehdi and Naaj, 2013). The prime objective of the current research work is to devise a scheme to calculate and appraise the course outcomes of electronics courses to compute the achievement of the program outcomes. However, there are some other objectives as well as given below-

i. Prepare an assessment scheme for computing the achievement of the course outcomes of the electronics course
ii. Devise a method to provide necessary knowledge profiles and complex engineering problem-solving skills related to electronics.
iii. Calculate and appraise the accomplishment of COs of each student of the electronics course.
iv. Calculate and appraise the accomplishment of program outcomes that have been linked to the course outcomes of the electronics course.
v. Find the robust and feeble points of the course contents, and teaching-learning strategies, and recommend curative activities that are required to undertake by the program head for CQI.

2. Materials and Methods

2.1. Data Collection instrument

CO assessment scores were collected for the Electronics I and II courses offered in the Spring and Summer 2020 Semesters respectively. The Department of Electrical and Electronic Engineering began to materialize the outcome-based curriculum (OBC) in the Spring 2019 Semester. Examination pieces of evidence were preserved for these direct assessment tools after entering data into the assessment file as per Tables 3-4 to compute COs and then POs.

2.2. Participants

In the Spring and Summer 2020 Semesters, 24 and 22 students under the new outcome-based curriculum took Electronics I and II courses respectively, and these were the participants for the study.

2.3. Ethics

Oral consent was sought from all participants. Also, the study sought the necessary permissions from the school authorities and the teachers who participated and aided the study and its procedures.

2.4. Procedure

2.4.1. Design of Course Contents

The curriculum of any program has detailed course contents to assist the course teacher to set course outcomes of that particular course by taking a broad idea about that specific course. They also get the idea from here what knowledge and skills are to be given to the students through the outcome-based teaching-learning process by designing complex engineering problems for the learners. The detailed course contents of Electronics I and II are given below:

“Course Code: EEE215; Course Title: Electronics I; Course Credit: 3

2.4.1.1. Rational of the Course

For undergraduate students studying electronic and Electrical Engineering, one of the core requirements is to develop their understanding of the basic operation of electronic devices and their real-life applications. The basics of the p-n junction and therefore semiconductor diodes, BJT, and MOSFET are considered one of the major branches of electronics and integrated circuits. This course will focus on designing electronic circuits, their biasing, characteristics, physical and region of operations, etc. This course is essential because it provides the fundamentals for designing and analyzing electronic circuits.

2.4.1.2. Course Content

This mainly deals with the P-N junction and its applications; Bipolar Junction Transistor (BJT) and its operational details. Metal Oxide Semiconductor Field Effect Transistor (MOSFET) and its device physics, applications, etc.

Course Code: EEE225; Course Title: Electronics II; Course Credit: 3

2.4.1.3. Rational of the Course

This course is very indispensable for the students to the fundamental knowledge for designing and analyzing electronic circuits embedding BJTs/MOSFETs such as basic transistor amplifiers, oscillators, and wave-shaping circuits. Throughout this course, students are going to learn about the analysis of different amplifier circuits and the low-frequency response of an amplifier using h parameters and develop an ability to analyze the high-frequency transistor model. This course offers knowledge of various multistage and power amplifier configurations, oscillators or signal generators, feedback concepts with circuits, differential amplifiers, and all active filters using op-amps. The properties and different applications of op-amps are also introduced elaborately.

2.4.1.4. Course Content

This course deals with the frequency response of the amplifiers; operational amplifiers and their applications; feedback amplifiers; Signal generators and oscillators: their basic principles of operations and applications. Power Amplifiers: their classifications, operations, and applications.” (EEE-CC, 2020).

2.4.2. Preparation of Course Outcomes

In an outcome-based education system, course outcome (CO) is a basic component in achieving the program outcomes of the students. It states what the students are going to achieve upon the successful finishing point of a certain course. Therefore, each CO should be measurable, observable, and specific as per its statement. It specifies unambiguously what knowledge and skills the students are going to develop due to their participation in that course. A CO of a certain course consists should have the following constituents to make it with such attributes (Chandna, 2015):

i. Action verb following Bloom's taxonomy
ii. The course-specific issue
iii. An accomplishment level of the students
iv. Accomplishment standard of the students
v. Conditions or constraints or contexts under which the CO needs to be achieved though it is not mandatory

In an outcome-based curriculum (OBC), there may be both lower and higher-level course outcomes. Since both of these two electronics courses are important and placed in the second year's first and second semesters respectively, therefore, the thoughtful consideration and achievement of these course outcomes are very significant. The course outcomes of these two courses are written to develop the understanding ranges of the students from the very basic level to the highest level of knowledge as per Bloom's Taxonomy. There are five and four-course outcomes respectively prepared for these two electronics courses as given below-

2.4.2.1. Course Outcomes of Electronics I course

After the successful completion of this course, the students will be able to-

[CO1] Explain the basic concept of band structure, doping, and carrier transport in semiconductors and apply the concept and operating principles of p-n junction as various circuit elements, such as in rectifier, clipper, clamper, logic gates, and voltage regulator circuits

[CO2] Explain the operation principles of BJT, MOSFET, and their characteristics under DC biasing

[CO3] Analyze the AC response of the BJT amplifiers by applying the *r*-parameter, *h*-parameter, small-signal equivalent circuit models, and Ebers-Moll models

[CO4] Evaluate different device performance parameters by analyzing MOSFET amplifier circuits

[CO5] Design various amplifiers, pre-amplifiers, oscillators, switching, and electronic controller circuits using the basic diode, BJT, MOSFET, and CMOS.

2.4.2.2. Course Outcomes of Electronics II course

After the successful completion of this course, the students will be able to-

[CO1] Explain the physical operation, performance characteristics, and frequency response of voltage amplifiers and operational amplifiers and their application as arithmetic and active-filtering circuits

[CO2] Compute the output power, efficiency, and frequency response of various classes of power amplifiers

[CO3] Analyze various signal/waveform generator circuits, and feedback circuits using operational amplifiers, BJT, and MOSFET

[CO4] Design various electronic application circuits addressing societal needs with appropriate considerations for public health, safety, and environmental concerns

2.4.3. Program Outcomes

Program outcomes of an undergraduate engineering curriculum indicate the types of knowledge, skills, and attitudes that are going to be developed by the graduates at their successful exit point of the program. However, these program outcomes must be described by the academic program at the beginning of the program so that the admission-seekers can also know it before entering the program. The graduates attain these POs by going through an extensive range of theory and laboratory courses and various practical learning experiences. In other words, it can be viewed as cumulative learning experiences from various courses after the successful completion of the degree program.

The outcome-based curriculum of the BSc in EEE program has a total minimum degree requirement of 153 credits, of them 72 credits are core courses including many theory and laboratory courses following the guidelines of the UGC, Bangladesh (UGC, 2018), and BAETE, Bangladesh policies (BAETE, 2019). Twelve program outcomes incorporating eight knowledge profiles (from WK1 to WK8) specified in the BAETE Manual were adopted straightforward by using the appropriate modifiers for the BSc in EEE program with an ambition that the graduates will attain all these twelve POs at the exit point of their graduation (EEE-PO, 2020). Five and four COs of two electronics courses are linked with three POs of the program (such as PO1, PO2, and PO3). These are mentioned in the BAETE manual (BAETE, 2019).

2.4.4. Mapping of course outcomes with program outcomes and assessment plans

Performance Indicators (PI) focus on the most specific factors to quantify the attainment level of course outcomes and hence program outcomes (ABET, 2010). Therefore, the exact PI selection is an essential factor to measure the course outcomes properly. In Electronics I and II courses, direct methods were used to measure course outcomes. After completing a course, the students obtain letter grades for the course to indicate their performance and CO attainment in percentage to demonstrate their attributes to become graduates (Gurocak, 2008; EEE-PO, 2020).

Knowledge, skills, and attitudes are the three key elements that are mapped to the twelve program outcomes and these three skills are required to be achieved to some extent through several course outcomes. The faculty members need to map the course outcomes, performance indicators, teaching-learning methods, assessment-evaluation strategies, etc. To provide appropriate knowledge of electronics courses and enable the students with the proper attributes at different levels of the cognitive domain as per Bloom's Taxonomy, suitable teaching-learning approaches must be developed because, for the different types of undergraduate engineering courses, it has been observed that the cognitive domain of Bloom's taxonomy is in effect considering the teaching-learning strategies conducted by several researchers (Bhuyan, 2014; Bhuyan and Khan, 2014; Bhuyan et al., 2014; Bhuyan et al., 2018). Tables 1-2 show these mappings of COs and POs along with assessment plans.

Table 1

CO-PO mapping, taxonomy domain, teaching-learning strategy, and assessment tools of Electronics I course

Course Outcome		PO	Taxonomy Domain/Level	Teaching-Learning Strategy	Assessment Strategy
[CO1]	Explain the basic concept of band structure, doping, and carrier transport in semiconductors and apply the concepts and operating principles of p-n junction as various circuit elements, such as in rectifier, clipper, clamper, logic gates, and voltage regulator circuits	PO1	Cognitive/ Analyze	Lectures Discussions with the students Question and Answer Problems solving in the class Interactive teaching	Class Test Assignment Midterm Exam
[CO2]	Explain the operation principles of BJT, MOSFET, and their characteristics under DC biasing	PO1	Cognitive/ Analyze	Lectures Discussions with the students Question and Answer	Class Test Assignment Midterm Exam

			Problems solving in the class Interactive teaching	
[CO3] Analyze the AC response of the BJT amplifiers by applying the *r*-parameter, *h*-parameter, small-signal equivalent circuit models, and Ebers-Moll models	PO2	Cognitive/ Analyze	Lectures Discussions with the students Question and Answer Session Problems solving in the class Interactive teaching	Class Test Assignment Final Exam
[CO4] Evaluate different device performance parameters by analyzing MOSFET amplifier circuits	PO2	Cognitive/ Evaluate	Lectures Discussions with the students Question and Answer Session Problems solving in the class Interactive teaching	Assignment Final Exam
[CO5] Design various amplifiers, pre-amplifiers, oscillators, switching, and electronic controller circuits using the basic diode, BJT, MOSFET, and CMOS	PO3	Cognitive/ Create	Lectures Discussions with the students Question and Answer Session Problems solving in the class Interactive teaching	Assignment Final Exam

Table 2

CO-PO mapping, taxonomy domain, teaching-learning strategy, and assessment tools of the Electronics II course

Course Outcome	PO	Taxonomy Domain/Level	Teaching-Learning Strategy	Assessment Strategy
[CO1] Explain the physical operation, performance characteristics, and frequency response of voltage amplifiers and operational amplifiers and their application as arithmetic and active-filtering circuits	PO1	Cognitive/ Analyze	Lectures Discussions with the students Question and Answer Problems solving in the class Interactive teaching	Class Test Assignment Midterm Exam
[CO2] Compute the output power, efficiency, and frequency response of various classes of power amplifiers	PO1	Cognitive/ Apply	Lectures Discussions with the students Question and Answer Problems solving in the class Interactive teaching	Class Test Assignment Midterm Exam
[CO3] Analyze various signal/waveform generator circuits, and feedback circuits using operational amplifiers, BJT, and MOSFET	PO2	Cognitive/ Analyze	Lectures Discussions with the students Question and Answer Session Problems solving in the class Interactive teaching	Class Test Assignment Final Exam
[CO4] Design various electronic application circuits addressing societal needs with appropriate considerations for public health, safety, and environmental concerns	PO3	Cognitive/ Create	Lectures Discussions with the students Question and Answer Session Problems solving in the class Interactive teaching	Class Test Assignment Final Exam

2.4.5. Course and Program Outcome Assessment

Tables 3-4 express the itemized components for measuring the CO attainment of Electronics I and II courses. These components comprise several direct assessment tools, like class tests and assignments (part of formative assessment tool), midterm and final examinations (part of summative assessment tool), etc. Tables 3-4 are also showing the question label and its allotted marks, the level of the cognitive domain, and mapped COs. COs are mapped linearly with the POs (Bhuyan and Tamir, 2020).

Table 3

Assessment Plan of Electronics I Course

Assessment Tool				Mapping with Course Outcome				
Item	Question #	Cognitive Level	Allotted Marks	CO1	CO2	CO3	CO4	CO5
Class Test1	Q2	C2: Understand	4.0	√				
Class Test2	Q2	C3: Apply	4.0		√			
Class Test3	Q1	C3: Apply	3.0			√		
Assignment1	Q4	C3: Apply	4.0	√				
Assignment2	Q3	C4: Analyze	3.0		√			
Assignment3	Q2	C4: Analyze	4.0			√		
Assignment4	Q1	C5: Evaluate	3.0				√	
Assignment5	Q1	C6: Create	5.0					√
Midterm Examination	Q1(a)	C2: Understand	3.0		√			
	Q1(b)	C3: Apply	4.0		√			
	Q2(a)	C3: Apply	5.0	√				
	Q3(b)	C4: Analyze	5.0	√				
Final Examination	Q1(a)	C4: Analyze	3.0			√		
	Q2(b)	C5: Evaluate	5.0				√	
	Q3(a)	C4: Analyze	5.0			√		
	Q3(b)	C5: Evaluate	5.0				√	
	Q4	C6: Create	10.0					√
Total	17	-	75.0					

Table 4

Assessment Plan of Electronics II Course

Assessment Tool				**Mapping with Course Outcome**			
Item	**Question #**	**Cognitive Level**	**Allotted Marks**	**CO1**	**CO2**	**CO3**	**CO4**
Class Test1	Q3	C3: Apply	3.0	√			
Class Test2	Q1	C3: Apply	3.0		√		
Class Test3	Q2	C3: Apply	4.0			√	
Assignment1	Q3	C4: Analyze	4.0	√			
Assignment2	Q2	C3: Apply	4.0		√		
Assignment3	Q2	C4: Analyze	5.0			√	
Assignment4	Q3	C6: Create	5.0				√
Midterm Examination	Q1(a)	C3: Apply	5.0		√		
	Q2(a)	C3: Apply	5.0	√			
	Q3(b)	C4: Analyze	5.0	√			
Final Examination	Q1(a)	C4: Analyze	4.0			√	
	Q2(b)	C5: Evaluate	5.0				√
	Q3(a)	C4: Analyze	5.0			√	
	Q4(a)	C6: Create	6.0				√

Assessment Tool				Mapping with Course Outcome			
Item	Question #	Cognitive Level	Allotted Marks	CO1	CO2	CO3	CO4
Total	**14**	**-**	**63.0**				

After that, the COs and POs are calculated as per the formula of equations (1) and (2) discussed in an earlier article, which is not repeated here for brevity (Bhuyan, 2020).

Tables 5-6 exhibit the question-setting summary of the assessment plan as per Tables 3-4 based pm the domains of Bloom's taxonomy (Bhuyan and Khan, 2020).

Table 5
Distribution of question settings as per the levels of Bloom's Taxonomy's cognitive domain for the Electronics I course

Cognitive Levels		Questions			
Level #	Level Name	Number of Questions		Marks of Questions	
		In Count	In %	In Number	In %
C2	Understand	2	11.8%	7	9.3%
C3	Apply	5	29.4%	20	26.7%
C4	Analyze	5	29.4%	20	26.7%
C5	Evaluate	3	17.6%	13	17.3%
C6	Create	2	11.8%	15	20.0%
Total		**17**	**100.0%**	**75**	**100.0%**

Table 6
Distribution of question settings as per the levels of Bloom's Taxonomy's cognitive domain for the Electronics II course

Cognitive Levels		Questions			
Level #	Level Name	Number of Questions		Marks of Questions	
		In Count	In %	In Number	In %
C3	Apply	6	42.9%	24	38.1%
C4	Analyze	5	35.7%	23	36.5%
C5	Evaluate	1	7.1%	5	7.9%
C6	Create	2	14.3%	11	17.5%
Total		**14**	**100.0%**	**63**	**100.0%**

Table 7 shows the attainment levels based on the numerical scores directly contributed to each CO from different assessment tools mentioned in Tables 3-4. Initially, the minimum CO attainment benchmark was set at 50%. It means that 50% of the students of Electronics I and II courses must achieve this minimum score, and as such, we can say that the cohort has achieved the benchmark level, highlighted in yellow color in Table 7 (Bhuyan, 2020).

Table 7

Attainment level due to the percentage of numerical scores contributed to each CO and PO

Performance Level		Numerical Score
Excellent	Achieved	80% and Above
Very Good		70-79%
Good		60-69%
Satisfactory		50-59%
Developing	Not achieved	40-49%
Unsatisfactory		Below 40%

2.4.6. PO Assessment

The scores from COs of electronics courses are mapped to POs for each student as revealed in Tables 1-2. The partial attainment of each PO is computed using the formula of equation (2) as per the previous article (Bhuyan, 2020).

3. Results

At first, all data are used for computing COs after entering into the assessment tables. Then the POs are computed as per mappings of COs with the POs in Tables 1-2. A sample of the assessment table of the Electronics I course is depicted in Fig. 1. Besides, a portion of a sample midterm exam question is shown in Fig. 2. The question has been prepared as per Table 3. From the answer script of every student, then data is inputted in the assessment table of Fig. 1. Then these components are added to get the total marks for a particular CO for every student and then its percentage is computed to have the attainment levels of that CO.

Figure 1

A sample of the assessment table of the Electronics I course

Course Level Assessment																
PO >>			PO1												PO1	
CO >>			CO1						CO2							
Tools >>			CT1 Q1	Mid Q2(a)	Mid Q3(b)	Assg1 Q4	Total	In %	CT2 Q2	Mid Q1(a)	Mid Q1(b)	Assg2 Q3	Total	In %	Total	In %
SL #	Student ID #	Student Name	4	5	5	4	18	100.0%	4	3	4	3	14	100.0%	32.0	100.0%
1	SID1	NAME1	0	5	4	3	12	66.7%	4	3	4	1	12	85.7%	24.0	75.0%
2	SID2	NAME2	2	5	5	3	15	83.3%	4	4	4	1	13	92.9%	28.0	87.5%
3	SID3	NAME3	0	5	5	3	13	72.2%	2	3	2	0	7	50.0%	20.0	62.5%
4	SID4	NAME4	4	5	2	3	14	77.8%	3	3	3	3	12	85.7%	26.0	81.3%
5	SID5	NAME5	4	5	3	3	15	83.3%	3	2	3	0	8	57.1%	23.0	71.9%
6	SID6	NAME6	2	5	4	3	14	77.8%	3	3	3	3	12	85.7%	26.0	81.3%
7	SID7	NAME7	3	5	4	3	15	83.3%	3	3	3	2	11	78.6%	26.0	81.3%
8	SID8	NAME8	3	5	3	3	14	77.8%	4	2	4	3	13	92.9%	27.0	84.4%
9	SID9	NAME9	4	5	4	3	16	88.9%	2	2	2	1	7	50.0%	23.0	71.9%
10	SID10	NAME10	5	5	5	3	18	100.0%	2	3	2	0	7	50.0%	25.0	78.1%
11	SID11	NAME11	4	5	3	3	15	83.3%	3	3	3	3	12	85.7%	27.0	84.4%
12	SID12	NAME12	2	5	4	3	14	77.8%	3	2	3	0	8	57.1%	22.0	68.8%
13	SID13	NAME13	3	5	4	3	15	83.3%	3	3	3	3	12	85.7%	27.0	84.4%
14	SID14	NAME14	3	5	3	3	14	77.8%	3	3	3	2	11	78.6%	25.0	78.1%
15	SID15	NAME15	4	5	4	3	16	88.9%	2	3	2	0	7	50.0%	23.0	71.9%
16	SID16	NAME16	4	5	3	3	15	83.3%	3	3	3	3	12	85.7%	27.0	84.4%
17	SID17	NAME17	2	5	4	3	14	77.8%	3	2	3	0	8	57.1%	22.0	68.8%
18	SID18	NAME18	3	5	4	3	15	83.3%	3	3	3	3	12	85.7%	27.0	84.4%
19	SID19	NAME19	3	5	3	3	14	77.8%	3	3	3	2	11	78.6%	25.0	78.1%
20	SID20	NAME20	4	5	3	3	15	83.3%	2	3	2	0	7	50.0%	22.0	68.8%
21	SID21	NAME21	2	5	4	3	14	77.8%	3	3	3	3	12	85.7%	26.0	81.3%
22	SID22	NAME22	3	5	4	3	15	83.3%	3	2	3	0	8	57.1%	23.0	71.9%
23	SID23	NAME23	3	5	3	3	14	77.8%	3	3	3	3	12	85.7%	26.0	81.3%
24	SID24	NAME24	4	5	4	3	16	88.9%	3	3	3	2	11	78.6%	27.0	84.4%

Figure 2

A sample of partial midterm examination questions for assessment of the Electronics I course

Program: BSc in EEE
Midterm Examination, Fall 2019 Semester
EEE 215 Electronics I
Section: 1

Full Marks: 30 **Time: 1.5 Hrs.**

Answer all questions from the following three questions of this question paper. Answers should be written in the supplied answer scripts.

[*The marks on the right hand side in square brackets indicate marks allocated for that question only*]

1. (a) How a dc load line can be obtained of a transistor connected in Common Emitter (CE) configuration? Indicate the operating point on the line drawn on the output characteristics curve. CO2 C2 3.0

   (b) .....

2. .....

3. (a) .....

   (b) Draw the current directions, input and output waveforms of a full-wave bridge rectifier circuit shown in Fig. 1 (a). CO1 C4 5.0

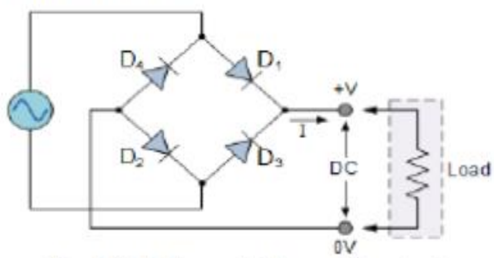


Fig. 1 (a) Full-wave bridge rectifier circuit

   (c) .....

3.1. Course Outcome Evaluation

Figures 3 and 4 demonstrate the achievement standing of the course outcomes of Electronics I and Electronics II courses respectively concerning the number of students achieving the corresponding COs. It is observed that all 24 students achieved the minimum satisfaction level in CO1 and CO2, but CO3-CO3 couldn't be achieved by 1 or 2 students only. However, the overall achievement level is above the minimum benchmark level (i.e., 50%) set by the program. As such, we can deduce that the students attained the course outcomes for Electronics I and II courses. Therefore, they can contribute to their corresponding POs from this course. It is observed that the achievement rates (above developing level) of the Electronics I course for five-course outcomes, CO1-CO5 are 100.0%, 100.0%, 62.5%, 91.7%, and 95.8%. On the other hand, the achievement rates (above the developing level) of the Electronics II course for four-course outcomes, CO1-CO4 are 100.0%, 100.0%, 90.9%, and 100.0%.

Figure 3

Summary of CO attainment chart for Electronics I course

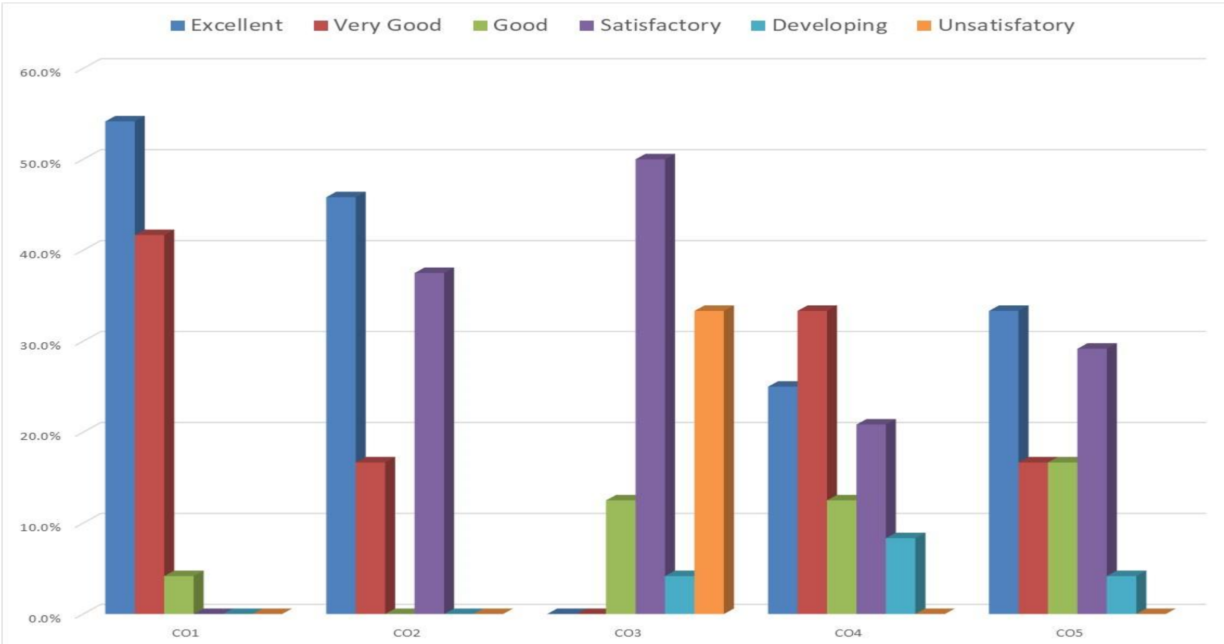
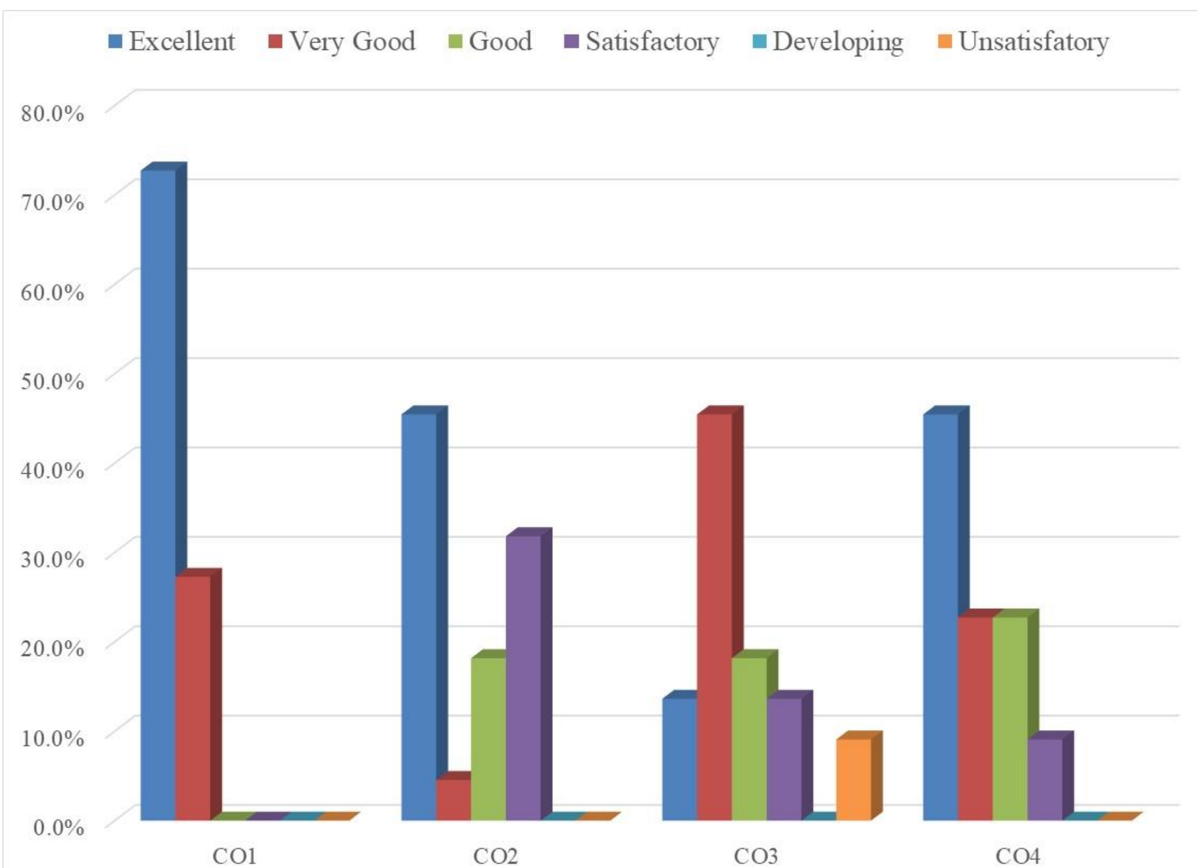


Figure 4

Summary of CO attainment chart for Electronics II course



3.2. Program Outcome Evaluation

Figures 5 and 6 demonstrate the achievement standing of the program outcomes of Electronics I and Electronics II courses respectively concerning the number of students achieving the corresponding POs through these two important courses. It is observed that the partial achievement rates (above developing level) through Electronics I course for three program outcomes, PO1, PO2, and PO3 that are mapped to the five-course outcomes, CO1-CO5 are 100.0%, 91.7%, and 95.8% respectively. On the other hand, the partial achievement rates (above developing level) through the Electronics II course for three program outcomes, PO1, PO2, and PO3 that are mapped to the four-course outcomes, CO1-CO4 are 100.0%, 90.9%, and 100.0% respectively.

Figure 5

Summary of partial PO attainment chart for Electronics I course

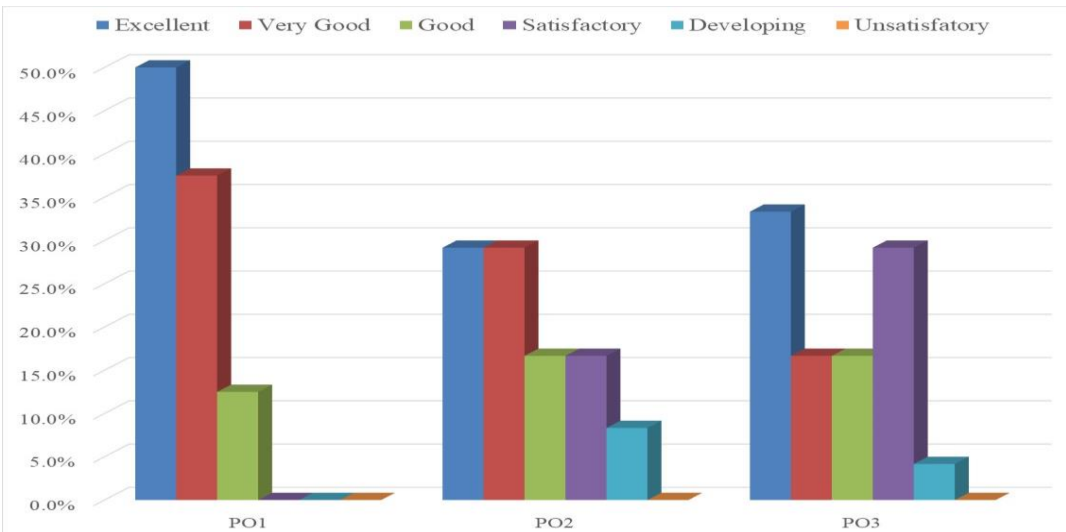
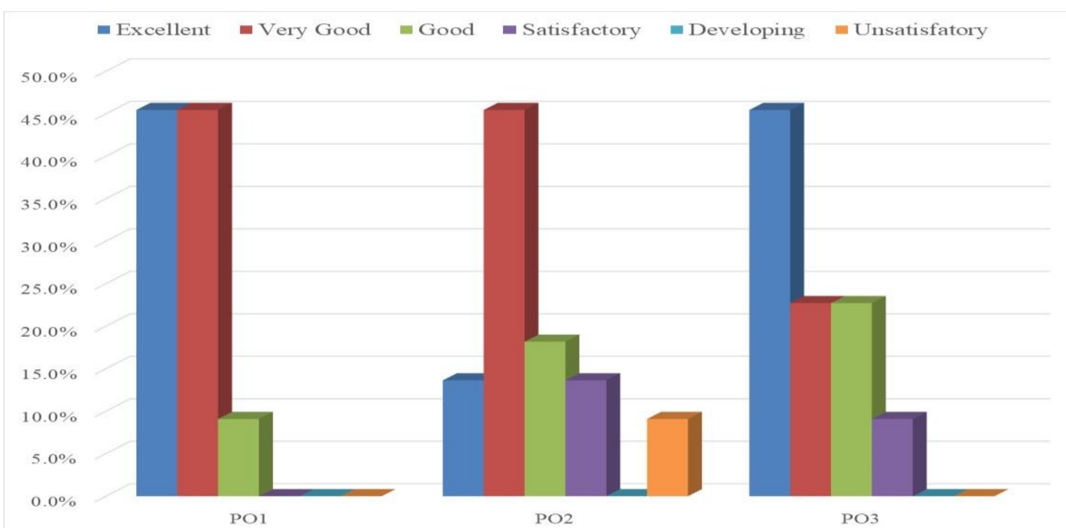


Figure 6

Summary of partial PO attainment chart for Electronics II course



3.3. Suggestions for Performance Improvement

After the assessment and evaluation work, the faculty member of the course suggested the following improvement action plans that seem good for Electronics I and II courses:

a) Giving more assignments on complex engineering problems on electronics;
b) Engaging students inside the classroom for more time than spending lecturing
c) Keeping them busy with individual and team works to assist them in achieving COs;
d) Tutoring the relatively less meritorious students determined from formative assessments;
e) Suggesting alternative books for self-studying electronics course;
f) Updating teaching-learning strategies to improve learning outcomes;
g) Refining the lecture slides and notes to ensure a clear understanding of course materials to the students;
h) Designing complex engineering problems from real-life situations;
i) Setting questions more on the higher orders of the cognitive domain (from Apply to Create levels).
j) Involving students with investigative research tasks on electronics-based design, simulation, and execution.

The Department of EEE needs several proficient faculty members to carry out investigative research works on electronics-based circuit design, modeling, simulation, and implementation. Without recruiting expert faculty members, this is a very difficult task to implement an outcome-based education system by designing complex engineering problems and activities based on real-life engineering. This is part of the continuous quality improvement process.

4. Conclusions

This research paper informs a simple technique to calculate and appraise the course outcomes of the electronics course and thereby its role concerning the partial attainment of three program outcomes out of a total of 12 POs. This modest model relies on some direct assessment strategies of both formative and summative types to compute the CO and thereby PO attainment status. The concerned faculty members of the courses assess and evaluate the COs and POs through an applicable assessment plan, question preparation and moderation, answer sheet checking, data collection, data entry, computation based on the defined formulae, and finally preparing the CQI plan.

In the future, we need to develop some performance indicators to fix the CO and PO determination correctly for different courses of the program. If the recommendations of each faculty member can effectively be implemented through various CQI cycles, then the quality of the program would rise and hence the future student intake in terms of quantity and quality would be raised. This will make the program or the department of the university strategically more viable and sustainable.

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