A Case Study on the Assessment of Program Quality through CO-PO Mapping and its Attainment

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Abstract: In recent years, accreditation of National Board of Accreditation has become mandatory for all the Autonomous colleges and Universities. NBA stresses on Outcome Based Education to improve the quality of education. It has formulated twelve graduate attributes to measure the quality of the program that a graduate has to acquire from any college/university during his four years of under graduation. The success of any program depends on the attainment of course outcomes and program outcomes. But there is a lack of understanding among the Engineering faculties in CO-PO attainment calculations. This study explores the significance of proper CO-PO mapping and its attainment calculation. CO-PO mapping and its attainment calculations are an integral part of OBE and it helps in continuous quality improvement, which serves as a feedback for OBE loop. CQI is instrumental in identifying any setbacks in Teaching Learning Process and additional solutions are figured out to improve the delivery of the course. In this study, different approaches are suggested to calculate the attainment of COs of the course and POs, PSOs of the program. Results and discussions are done on the attainment of COs of different courses and suggestions for the courses which fail to attain the target has been discussed. A sample of CO-PO attainment calculation for the course Basic Electrical Engineering offered for BTech I Year students has been discussed. Microsoft Office Excel spreadsheet has been used for computation purpose.

Keywords: National Board of Accreditation, Course Outcome, Program Outcome, Outcome Based Education, Continuous Quality Improvement

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1. INTRODUCTION

The Outcome Based Education (OBE) is adopted by AICTE from Washington Accord on 13 June 2014[1,2]. Outcome-based education (OBE) in engineering colleges across the world is a major change that various technical and academic institutions. OBE is outcome-based learning in which the engineering graduates are trained to have better knowledge, skill sets and attitudes. In OBE certain targets are set and teaching learning activities are properly planned and organized to achieve the targets. According to OBE system, the NBA's parameters called Graduate Attributes [3,5] must reflect on a graduate of an engineering program. OBE is an educational process that involves the restructuring of curriculum, assessment methods, and reporting practices in education to reflect a better learning and improving the skills with additional supporting qualities of an engineering graduate instead of accumulating the credits. This approach demands a positive change in the teaching and assessment methods of teaching faculty of academic institutions. Various researchers have discussed the implementation of OBE model [4,10,11,12]. Different assessment and attainment methods of course outcomes (COs) and program outcomes (POs) for NBA Tier II accreditation in engineering colleges through OBE are discussed [7,8,9].

In this paper, assessment of program quality through CO-PO mapping and attainment of COs of the course and POs, PSOs of the program is presented. The following sections give brief description of paper. Section 2 presents process of outcome-based assessment. CO-PO attainment methodology is explained in Section 3. Section 4 explains computations of attainment of COs of Basic Electrical Engineering (BEE) course. Section 5 discusses about CO-PO mapping methodology. Computations of attainment of POs/PSOs with BEE course are discussed in section 6. Continuous quality improvement and conclusion remarks are discussed in sections 7 & 8 respectively.

2. OUTCOME BASED ASSESSMENT

Outcome Based Assessment (OBA) is the process of gathering information about how well a student is achieving specific outcomes. It is a systematic and on-going process of collecting, interpreting, and acting on information relating to the goals and outcomes developed to support the department and institution's mission and vision. The assessment process is depicted in the Fig. 1.
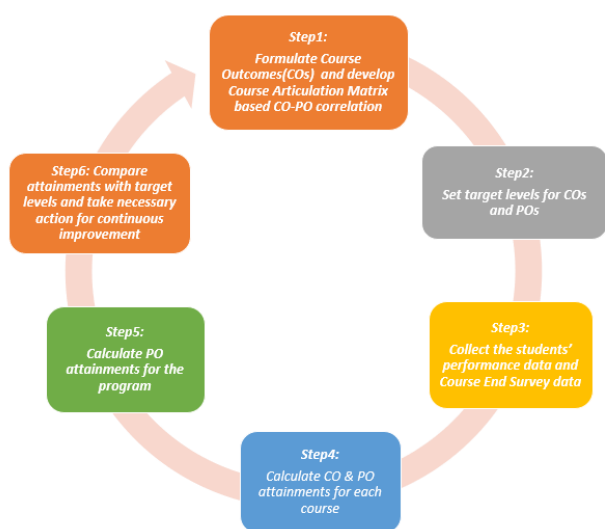
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Fig. 1 Outcome Based Assessment Process

A. Develop Course Outcomes

The first step in the process of assessment is the formulation of course outcomes. Each subject is referred to as a course in NBA and its outcomes are framed by the course lead and the other course coordinators. These course outcomes are presented before an expert panel consisting of HOD, Professors and senior academicians. These course outcomes are shaped up to a final draft based on the comments of the expert panel. Once the course outcomes are formulated then the process of measuring these outcomes should be specified. Various methods of assessment are followed to measure these course outcomes. The various types of assessment methods are briefly explained below.

B. Identify Methods of Measuring COs

1) Formative Assessment: Formative assessment is taken from the students at varying intervals throughout the course. Formative assessment is a process of evidence gathering about the students' learning progress and performance. Formative assessment has the scope of guiding the instructors in such a way to meet the students learning needs and to make them regulators of their own learning. The following are various assessment tools used to assess the students' learning progress and performance. Cumulative Internal Examinations are used in Formative Assessment. The formative assessment pattern for different courses is shown in Table 1.

Table 1. Formative Assessment pattern for different courses

Type of Course	CAT1	CAT2	AAT	Practice
Integrated Course	✓	✓	✓	✓
Theory Course	✓	✓	✓	
Practical				✓

Course				

Integrated courses are the one which has a fine blend of theory and practical. Course content is designed in such a way that the student will have a chance to study most of the theoretical concepts by realising it in laboratories. In other words, practice-based learning is facilitated in integrated courses.

CAT: (Continuous Assessment Test) Two CAT tests shall be conducted one in the middle of the semester and the other at the end of the semester.

AAT:(Alternate Assessment Test) It is used by the respective course instructor by defining the assessment methods well before the commencement of the course. The formative assessment pattern for internship and project work is shown in Table 2.

Table 2. Formative Assessment pattern for Internship and Project work

Type of Course	Review1	Review2	Viva-Voce
Internship	✓	✓	✓
Mini-Project	✓	✓	✓
Project Work	✓	✓	✓

Internship, Min Project and Project Work assessment is based on two reviews and viva voce.

2) Summative Assessment: Summative assessment is used to evaluate student learning, skill acquisition and academic achievement at the conclusion of a defined instructional period. This assessment is taken by students at the end of the semester to demonstrate the "sum" of what they have or have not learnt. Summative assessment is a process of evidence gathering about the students' learning progress and performance through Semester End Examination (SEE).

3) Assessment Analysis: Course Outcomes of all courses of the program and Program Outcomes are measured by using two assessment methods such as Direct Assessment and Indirect Assessment. The weightage for direct assessment is 90% and indirect assessment is 10%.

4) Direct Assessment: For Course Outcomes attainment, Direct Assessment includes Cumulative Internal Examination (CIE) and Semester End Examination (SEE). CIE is measured based on formative assessment whereas SEE is measured based on summative assessment. Weightage of each examination is shown below in Table 3.

Table 3. Weightage of CIE and SEE

Direct Assessment		
1.	Cumulative Internal Examination (CIE)	30%
2.	Semester End Examination (SEE)	70%

For Program Outcomes attainment (POs), the prescribed POs by NBA are classified as technical POs and non-technical POs. The first five POs and two formulated PSOs

are called technical POs and remaining POs are called non-technical POs. The Integrated courses and theory courses cumulatively contribute for the PO attainment of a batch. These technical POs and PSOs attainment are calculated by adding the contribution level of Integrated and theory courses to each PO and PSO. The attainment level of non-technical POs is calculated using the active student participation in co-curricular and extra- curricular activities within and outside the college along with the contribution of Integrated and theory courses.

5) *Indirect Assessment:* For Course Outcomes attainment (COs), indirect assessment includes Course End Survey (CES), which is conducted on COs of each course at the end of the course in on-line mode. For Program Outcomes attainment (POs), indirect assessment has three components and they are:

1. Student Exit Survey (SES)
2. Co-Curricular Activities (CCA)
3. Extra-Curricular Activities (ECA)

Student Exit Survey (SES) is conducted on Program Outcomes (POs) and Program Specific Outcomes (PSOs) at the end of the program in on-line mode. Student exit survey is used in attainment calculation of both Technical and Non-Technical POs where as Co-Curricular Activities and Extra-Curricular Activities are used only in attainment calculation of Non-Technical POs.

3. CO AND PO ATTAINMENT METHODOLOGY

The calculation of CO & PO attainments is based on the performance of the students in all assessments conducted in the course. The procedure to calculate CO & PO attainments is given below.

- *Step1: Formulate appropriate Course Outcomes (COs) around 4 to 6 and develop Course Articulation Matrix based CO-PO correlation*
- *Step2: Set target levels for COs and POs*
- *Step3: Collect the students' performance data and Course Exit Survey data.*
- *Step4: Calculate CO & PO attainments for each course based on direct and indirect assessments*
- *Step5: Use PO attainments of each course, student exit survey, co-curricular and extra-curricular activities data to calculate PO attainments for the program*
- *Step6: Compare attainments with target levels and take necessary action for continuous improvement*

4. CO ATTAINMENT COMPUTATIONS OF BEE COURSE

CO attainment computations of Basic Electrical Engineering course of BTech I semester is presented here. The basic information of the course is given in Table 4.

Table 4: Basic Information of Course

ACADEMIC YEAR:	2019-20	BATCH:	2018-2022
REGULATION:	VCE R18	PROGRAM:	B.Tech EEE
COURSE NAME:	Basic Electrical Engineering	COURSE CODE:	A4203
YEAR & SEM:	I YEAR & I SEM	COURSE LEAD:	MR. B. RAJAGOPAL REDDY
COURSE TYPE:	INTEGRATED	DESIGNATION /DEPARTMENT:	ASSOCIATE PROFESSOR/ EEE

A. Mapping of COs in Formative Assessment

CAT1 and CAT2 are Continuous Assessment Tests 1 and 2 which is conducted at the end of first two units and the remaining three units respectively. The questions from CAT1 and CAT2 mapped with the corresponding COs. AATs and Lab sessions are also mapped with the corresponding COs. Questions fall under corresponding COs in formative Assessment are given in Table 5.

Table 5. Questions fall under corresponding COs in Formative Assessment

CO #	CAT1	CAT2	AAT	PRACTICE
A4203.1	Q2a, Q2b	Q3b	AAT1, AAT2, AAT3	DDE, LT, FLE
A4203.2	Q1a, Q3a		AAT1, AAT2	DDE, LT, FLE
A4203.3		Q1b, Q2a, Q2b	AAT1	
A4203.4	Q1b, Q3b	Q1a, Q3a	AAT3	DDE, LT, FLE
A4203.5			AAT1	DDE, LT, FLE
AAT1: Team Based Assignments	AAT2: Remedial Test	AAT3: Online Quiz	DDE: Day-to-Day Evaluation	LT: Lab Test
FLE: Final Lab Exam				

Target for each CO is defined as " 65% of students getting more than or equal to 60% (Academic Threshold) of marks (Set by the Program)". The actual marks secured by each student for each CO in CIE (Formative Assessment), AAT and practice are recorded and tabulated for each CO as shown in Fig. 2. The CO contribution of each student is computed based on assessment tool and their performance when compared with total marks is also recorded. Number of students who have contributed more than 60% marks for each CO is calculated with respect to the actual number of

students contributed for that particular CO. This is CO attainment for a particular CO through CIE.

Fig. 2 CO Attainments through CIE

B. Mapping of COs in Summative Assessment

Summative Assessment refers to Semester End Examination and the questions from this assessment are mapped to the corresponding COs are shown in Table 6.

Table 6. Questions fall under corresponding COs in Summative Assessment

CO #	SEE
A4203.1	Q1a
A4203.2	Q1b, Q1d, Q1g, Q2a, Q2b, Q3c
A4203.3	Q1c, Q1h, Q31, Q3b, Q3d, Q4a, Q4b
A4203.4	Q1f, Q5a, Q5b, Q5c, Q5d
A4203.5	Q1e, Q1i, Q1j, Q6a, Q6b

Target for each CO is defined as " 65% (Target) of students getting more than or equal to 60% (Academic Threshold) of marks (Set by the Program)". Form a team of experts to decide the Performance Threshold and Target. Target is usually decided based on previous results of the course. Performance Threshold can be same for entire institute; however, Target can be varied for each program.

The actual marks secured by each student for each CO in SEE tabulated as shown in Fig. 3. The CO contribution of each student is computed and their performance when compared with total marks is also recorded. Number of students who have contributed more than 60% marks for each CO is calculated with respect to the actual number of

students contributed for that particular CO. This is CO attainment for a particular CO through SEE.

Fig. 3 CO Attainments through SEE

C. Indirect Assessment for CO Attainments

At the end of each course students will give feedback on each PO which is termed as Course End Survey(CES).

The CO attainments are computed based on weightages assigned for CIE, SEE and Direct Assessment, Indirect Assessment of the course. Total CO attainments of BEE course are shown in Fig. 4. The comparison of CO attainments with target values are shown in Fig. 5.

Fig. 4 Total CO Attainments of the BEE Course

CO attainment for the course Basic Electrical Engineering is given as an illustrative example. Likewise, the CO attainment for all courses of a particular batch is calculated. The CO attainment of the first semester is depicted in the Fig. 6. It is evident that CO4(A4203.4) is not attained where as other COs got attained. The reasons behind non-attainment of CO4 are discussed in section 7. The total number of COs and its attainment in Electrical and Electronics Engineering program for a particular batch is calculated and is shown in the Fig. 7.

5. CO-PO MAPPING (COURSE ARTICULATION MATRIX) METHODOLOGY

CO of a particular course is mapped with the POs with a correlation level of 1, 2 and 3 (Slight or Low, Moderate or Medium, and Substantial or High respectively) through Course Articulation Matrix. CO-PO mapping or Course Articulation Matrix(CAM) is matrix having rows are COs of a course and columns are POs and PSOs which has a

relation with COs. To obtain this correlation matrix the following steps are suggested:

Step1: Identify key elements of each PO and PSO
Step2: Identify key elements of each CO
Step3: Find the co-relation levels using key elements of POs/PSOs and COs.

With this method we can write proper justification to entries of correlation levels in CAM. This method is explained with example of one of the CO of BEE course as shown in Fig. 7. There is another method called Feel Satisfaction Method, where we get correlation levels, based feel factor without any analytical computations.
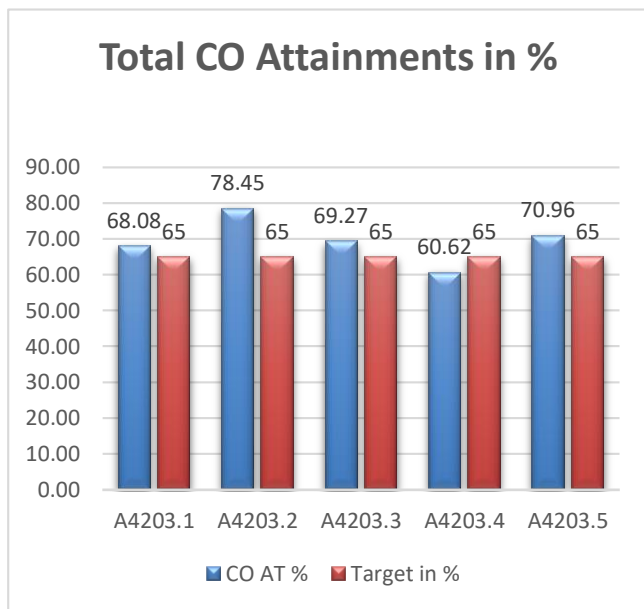
Attainment of Course Outcomes of all the courses								
TARGET: 65% OF STUDNETS SHOULD GET MORE THAN OR EQUAL TO 60%								
Course	CO#	Total CO AT through DA in %	Total CO AT through IDA in %	90% OF Total CO AT through DA	10% OF Total CO AT through IDA	Total CO AT through DA & IDA in %	Target AT in %	CO Attained (YES/NO)
MATHEMATICS-I	A4001.1	66.78	86.85	53.43	8.69	62.11	65	NO
	A4001.2	72.79	84.63	65.51	8.46	73.97	65	YES
	A4001.3	71.37	84.81	64.23	8.48	72.72	65	YES
	A4001.4	59.93	84.81	53.94	8.48	62.42	65	NO
	A4001.5	71.90	84.26	64.71	8.43	73.13	65	YES
TECHNICAL ENGLISH	A4005.1	67.41	73.52	59.34	7.35	66.69	65	YES
	A4005.2	66.29	78.15	67.29	7.81	75.11	65	YES
	A4005.3	65.70	84.26	61.09	8.43	69.51	65	YES
	A4005.4	67.71	86.85	57.69	8.69	66.37	65	YES
	A4005.5	70.01	84.81	53.28	8.48	61.76	65	YES
PROBABILITY THEORY AND NUMERICAL METHODS	A4004.1	59.34	86.85	59.34	8.69	68.02	65	YES
	A4004.2	67.29	84.81	67.29	8.48	75.78	65	YES
	A4004.3	61.09	78.15	61.09	7.81	68.90	65	YES
	A4004.4	57.69	86.85	57.69	8.69	66.37	65	YES
	A3004.5	53.28	84.81	53.28	8.48	61.76	65	YES
BASIC ELECTRICAL ENGINEERING	A4203.1	63.28	93.86	56.95	9.39	66.34	65	YES
	A4203.2	73.22	86.70	65.90	8.67	74.57	65	YES
	A4203.3	67.18	90.10	60.46	9.01	69.47	65	YES
	A4203.4	57.70	86.90	51.93	8.69	60.62	65	NO
	A4203.5	69.34	95.54	62.41	9.55	71.96	65	YES

Fig. 5 CO Attainments of all the Courses

NO. OF COs ATTAINED	284
NO. OF COs NOT ATTAINED	42
TOTAL NO. OF COs IN THE PROGRAM	326
% OF COs ATTAINED	87.12
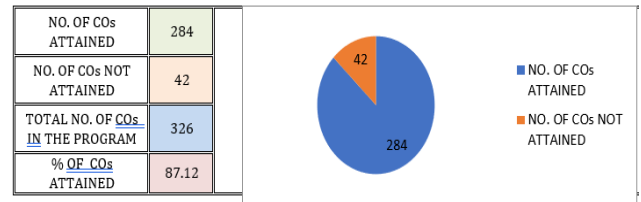
Fig. 6 Status of CO Attainments of the Program

Total CO Attainments in %

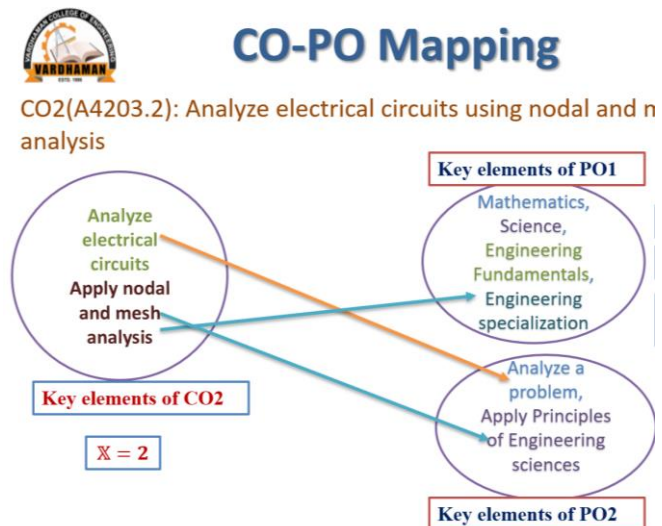Fig. 4 CO Attainment Comparison with Target values

Fig. 7 CO-PO Mapping Methodology

6. PO ATTAINMENT COMPUTATIONS OF BEE COURSE

PO attainments are obtained using CO attainments and Co-PO Mapping(CAM). PO1 attainment computations of BEE

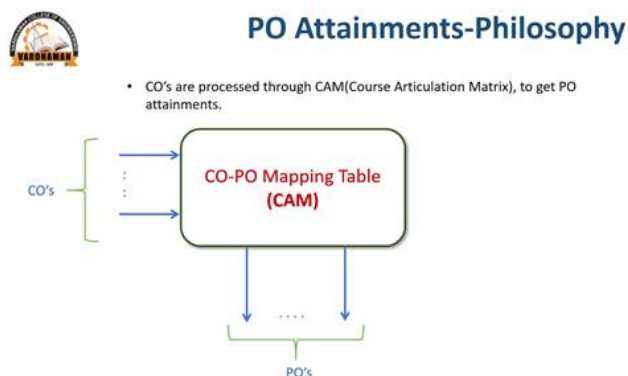course is shown in Fig. 7 based on CO attainments and CO-PO mapping.

Fig. 8 CO-PO Mapping Philosophy

PO1 attainment computations of BEE course is shown in Fig. 9 based on CO attainments and CO-PO mapping.

Fig. 9 Computation of PO1 Attainments of BEE Course

Likewise, PO and PSO attainment calculations is done for all the courses in a program. This type of Assessment is called as Direct Assessment. Indirect assessment of POs and PSOs is done using Student Exit Survey, Co-curricular and Extra-curricular activities mapped with the corresponding POs and PSOs. Attainments of POs and PSOs through Indirect assessment is shown in Table 6. Comparison of Technical POs and PSOs attainments and Non-Technical POs attainments with respective target values are shown Fig. 10 and Fig. 11 respectively.

Table 7. Attainments of POs Through IDA in %

PO #	Student Exit Survey	Co-Curricular Activities	Extra-Curricular Activities	Total PO AT% Through IDA
PO1	71.36			71.36
PO2	72.11			72.11
PO3	79.17			79.17

PO4	75.00			75.00
PO5	71.67			71.67
PO6	77.08	86.15	70.77	78.00
PO7	74.58	82.05	81.03	79.22
PO8	82.55	97.03	81.03	86.87
PO9	75.83	97.03	81.03	84.63
PO10	78.33	97.03	62.56	79.31
PO11	73.19	85.13	93.33	83.88
PO12	72.92	92.31	70.77	78.67
PSO1	68.56			68.56
PSO2	65.26			65.26

Table 8. Total PO & PSO Attainments of the Program

| Total PO and PSO Attainments in %					
PO #	PO AT% Through DA	PO AT% Through IDA	Total PO AT% (90% of DA+10% IDA)	Target in %	PO Attained (YES/NO)
PO1	71.29	71.36	71.29	70	YES
PO2	72.78	72.11	72.71	70	YES
PO3	73.44	79.17	74.02	70	YES
PO4	78.05	75.00	77.74	70	YES
PO5	79.87	71.67	79.05	70	YES
PO6	73.72	78.00	74.15	70	YES
PO7	85.14	79.22	84.55	70	YES
PO8	77.73	86.87	78.64	70	YES
PO9	95.29	84.63	94.22	70	YES
PO10	90.67	79.31	89.53	70	YES
PO11	81.00	83.88	81.28	70	YES
PO12	95.14	78.67	93.50	70	YES
PSO1	74.25	68.56	73.68	70	YES
PSO2	73.14	65.26	72.35	70	YES
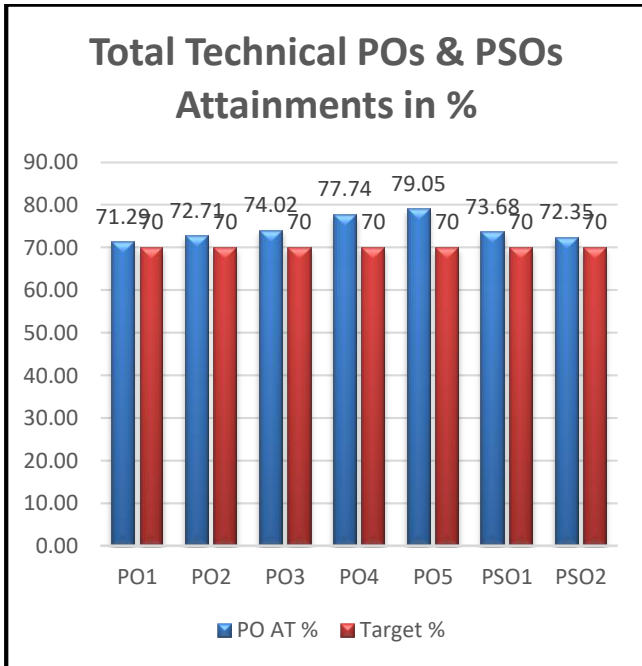
Fig. 10 Comparison of Technical POs and PSOs Attainments with target values
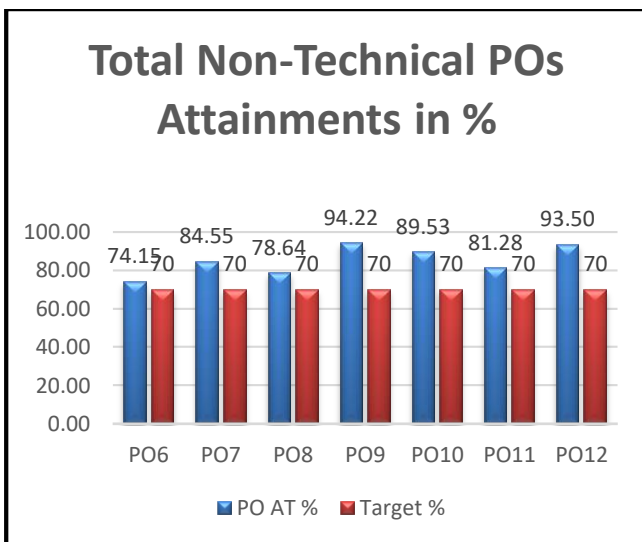

Fig. 11 Comparison of Non-Technical POs attainments with target values

7. CONTINUOUS QUALITY IMPROVEMENT

The program must evaluate the attainment of student outcomes, these evaluations must be used as inputs for continuous quality improvement. Therefore, by closing the loop at course level, program level and Institute level, we ensure continuous quality assurance for stake holders. Other available information may also be used to assist in the continuous improvement of the program.

A. CO attainments level comparisons and action taken for improvement

The attainment levels of each COs of the course are compared with target levels and the observations are recorded. The outcome of CO4 is about analysis of solution of transient networks, that requires strong knowledge in differential equations and Laplace transforms. It is observed that the students of the respective class are not good in in differential equations and Laplace transforms. It is suggested that mathematical background of class students need to be identified and special classes can be arranged to improve mathematical fundamentals.

B. PO/PSO attainments level comparisons and action taken for improvement

The attainment levels of each POs and PSOs of the program are compared with target levels and the observations are recorded. If any PO is attained, then it is suggested to increase the target level or strengthen the assessment tools. If any PO is not attained, the attainment gap is identified, then course wise observations are made, and the actions taken are recommended.

8. CONCLUDING REMARKS

In this paper, computations of the attainment of COs of BEE course and POs, PSOs of the program. Results and discussions are done on the attainment of COs of different courses and suggestions for the courses which fail to attain the target has been discussed. A sample of CO-PO attainment calculation for the course Basic Electrical Engineering offered for BTech I Year students has been discussed. Continuous quality improvement is discussed and suggested few improvements.

Acknowledgement

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