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A Case Study on Assessment and Attainment of Course Outcomes, Program Outcomes and Program Specific Outcomes for Tier-II Institutions

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Abstract: *Outcome Based Education (OBE) is targeted at achieving desirable outcomes at the end of programme. Teaching with this awareness and making the associated efforts constitute OBE. Students are responsible for their own learning and assessment is based on outcome rather than content taught in the programme in OBE. This learning outcome could result from a program or a course. This paper is an attempt to provide effective method to assess the Course Outcomes (COs), Program Outcomes (POs) and Program Specific Objectives (PSOs) starting with framing COs by refering Bloom's Taxonomy and then CO-PO mapping later extending it to the attainment of COs, POs and PSOs with precise methods or assessment tools for an Electronics and Communication Engineering programme of tier II institution. This attainment analysis is made to provide continuous improvement in course delivery, assessment and curriculum.*
Key Words: *OBE, CO, PO, PSO*

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I. Introduction

National Board of Accreditation, New Delhi has modified accreditation process in line with International accreditation agencies such as Accreditation Board for Engineering and Technology(ABET),Accreditation Board for Engineering Education for Korea (ABEEK) etc.,[1]. Hence by considering these process guidelines and principles in engineering programmes, the accredited institutions can meet the global standards. The graduates coming from such institutions can stand at the international platform with the similar capacity possessed by the graduates who come from renowned accredited universities. The process of accreditation helps in realizing a number of benefits, such as: [2, 3]

· Helps the Institution to know its strengths, weaknesses and opportunities.
· Initiates Institutions into innovative and modern methods of pedagogy
· Gives Institutions a new sense of direction and identity.
· Provides society with reliable information on quality of education offered.

The technical education programs, willing to apply for NBA accreditation, have to practice the qualitative activities in day to day education process. The quality of these activities is assessed through the attainment of the course outcomes framed for each course of the program, Program Outcomes and Program Specific Outcomes. The outcomes possessed by students during the programme are defined as course outcomes. Immediately after completion of program, the outcomes possessed by the graduates are defined by POs. The outcomes exhibited by the graduate after three to four years of graduation which are possessed during the work-field are defined as Program Educational Objectives (PEO). *PEOs are consistent with the mission of the Institution.* The Specific Outcomes relevant to the program exhibited by the graduate soon after graduation are defined as Program Specific Outcomes (PSO). These achievements of PO and PSO are assessed using one or more processes that will include identifying, collecting and preparing the data for evaluation. Evaluation is again one or more processes for interpreting the data and evidence accumulated through assessment practices. This evaluation process will help in what extent the CO, PO and PSO are being achieved and this results in decisions and actions to improve upon the programme. If assessment is carried out for COs, then attainment of COs will be measured by the performance of the students. These measurements provide the basis for continuous improvement in the quality of learning. [4, 5]

Section II is about framing Course Outcomes, then extent of mapping these COs to POs and PSOs. Finally attainment values are calculated for COs, POs and PSOs by the simple methods using different assessment tools is demonstrated in section III**.** Results and discussions are covered in section IV and concluding remarks are given in section V**.**

II. Framing Course Outcomes

Concept of Course Outcomes:

Course outcomes are the narrower statements that describe what students are expected to know and be able to do at the end of each course and these COs should be observable, measurable and also should specify an action by the student. The COs are framed by referring to Bloom's Taxonomy with proper understanding of each level.

The Figure 1 shows the Bloom's Taxonomy Levels.

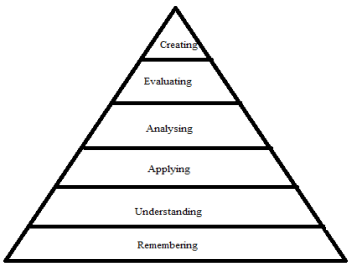

Figure 1: Blooms Taxonomy [6]

Based on this Bloom's Taxonomy the COs of Analog Electronics (C203) course is defined below.

The COs are formulated in increasing order of the complexity of all topics from entire course content rather than considering module –wise.

C203:

C-Course, **2**-Second year of engineering Programme, **0**-Odd Semester

3-Sequence number of the Subject as per the codes of all subjects studies in that semester. [5]

Table 2.1: COs of Analog Electronics Course

C203.1	Explain working Principle of BJT
C203.2	Explain working Principle of FET
C203.3	Explain working Principle of Oscillator
C203.4	Explain working Principle of Power amplifier and Voltage Regulators
C203.5	Analyze Characteristics of BJT and FET
C203.6	Analyze Characteristics Power amplifier and Voltage Regulators.
C203.7	Design Amplifier for the given specifications.
C203.8	Design Oscillator for the given specifications.
C203.9	Design Voltage regulator for the given specifications.

CO-PO Mapping:

It is a process of representing (preferably in a matrix form) the correlation of COs defined for AE course with POs and PSOs. The PSOs of the Electronics and Communication Engineering department are:

PSO1: Apply the concepts of VLSI, Signal Processing, Embedded Systems, Communication and Networking in the design and Implementation of application oriented Engineering systems.

PSO2: Solve the Engineering problems using hardware and software tools along with soft skills leading to Employability.

The following table 2.2 gives the correlation between COs, POs and PSOs with proper justification.

Table 2.2 CO-PO-PSO Mapping for Analog Electronics Course

Course Outcomes (COs)	**Program Outcomes (POs)**													
	PO1	**P02**	**PO3**	**PO4**	**P05**	**PO6**	**P07**	**PO8**	**P09**	**P010**	**PO11**	**PO12**	**PSO1**	**PSO2**
C203.1	2	-	--	--	--	--	--	--	--	--	--	--	1	1
C203.2	2	--	--	--	--	--	--	--	--	--	--	--	1	1
C203.3	2	--	--	--	--	--	--	--	--	--	--	--	1	1
C204.4	2	--	--	--	--	--	--	--	--	--	--	--	1	1
C205.5	2	2	--	--	--	--	--	--	--	--	--	--	1	1
C203.6	2	2	--	--	--	--	--	--	--	--	--	--	1	1
C203.7	2	2	1	--	--	--	--	--	--	--	--	--	1	1
C203.8	2	2	1	--	--	--	--	--	--	--	--	--	1	1
C203.9	2	2	1	--	--	--	--	--	--	--	--	--	1	1

Table 2.2.1 shows the relevant justification for each level of mapping of individual COs to different POs and PSOs

Table 2.2.1 Justification for CO-PO-PSO Mapping

CO's	Mapped PO's	Justification for PO Mapping	Justification for PSO Mapping
C203.1	PO1-2 PSO1-1 PSO2-1	Moderate knowledge of science and mathematics is pre-requisite for learning BJT and after learning student will be able to apply his knowledge to solve real world problems.	For all course outcomes PSO1 and PSO2 are mapping at slight level since the course contains a fundamentals that are prerequisite to learn the advanced courses of ECE like VLSI and also it is a most significant part of Competitive exams like GATE,IES etc .,which give opportunity to the students for higher study and employability.
C203.2	PO1-2 PSO1-1 PSO2-1	Medium level knowledge of science and mathematics is pre-requisite for learning FET and after learning student will be able to apply his knowledge to solve real world problems.	
C203.3	PO1-2 PSO1-1 PSO2-1	Moderate knowledge of basic mathematics and science is required to understand the working principle of Oscillators.	
C203.4	PO1-2 PSO1-1 PSO2-1	Moderate knowledge of basic mathematics and science is required to understand the working principle of Power amplifiers and Voltage Regulators.	
C203.5	PO1-2 PO2-2 PSO1-1 PSO2-1	Moderate level knowledge in mathematics and science is pre-requisite to understand and solve numerical on Power Amplifiers and also problem solving skills are required for analysis of frequency response characteristics of BJT and FET.	
C203.6	PO1-2 PO2-2 PSO1-1 PSO2-1	Moderate level knowledge in mathematics and science is pre-requisite to understand and solve numerical on Power Amplifiers and also problem solving skills are required for analysis of frequency response characteristics of BJT and FET.	
C203.7	PO1-2 PO2-2 PO3-1 PSO1-1 PSO2-1	In order to determine various circuit elements for design purpose of oscillator frequency moderate level of engineering knowledge and problem solving skills are essential.	
C203.8	PO1-2 PO2-2 PO3-1 PSO1-1 PSO2-1	In order to determine various circuit elements for design purpose of power amplifiers with the given specification moderate level of engineering knowledge and problem solving skills are essential.	
C203.9	PO1-2 PO2-2 PO3-1 PSO1-1 PSO2-1	In order to determine various circuit elements for design purpose of Voltage regulators with the given specification, moderate level of engineering knowledge and problem solving skills are essential.	

Evidences for the Compliance of mapping Levels can be shown using the Question Papers of IA and University exams, Class room Assignments ,GATE and IES exam Questions. The levels defined in the CO-PO matrix are considered to have the following weightage:
Level 1: Low Level 2: Medium Level 3: Substantial [5].

III. CO and PO Attainment

The attainment values of the COs indicate the ability of the students to solve the engineering problems related to Analog Electronics Course. This CO-PO Attainment reflects Faculty insight towards the development of a student with professional skills hence this CO-PO mapping and attainment gives substantial opportunity for tier-2 students to bridge the gap of Employability. The attainment of COs, POs and PSOs is calculated using two methods namely Direct and Indirect assessment Methods.
The following table 3.1 shows the tools used to assess the COs and POs using Direct and Indirect assessment methods.

Direct Assessment Methods:

These are the tools that are used to evaluate the attainment of COs, POs and PSOs through the performance of students in IA tests, Assignments ,University Exams, Practical tests and Project work etc.,

Table 3.1 Direct Assessment Methods

Direct Assessment Methods				
Sl.no	**Direct Assessment Tool**	**Method Description**	**Frequency**	**Weightage**
1.	Internal Assessment Test	The Internal Assessment marks in a theory paper shall be based on three tests. An improvement test may be conducted for the desirous students before the end of the semester to give an opportunity to improve their Internal Assessment Marks. It is a parameter to continuously assess the attainment of course outcomes w.r.t course objectives. Average of the higher marks obtained from any two tests shall be the Internal Assessment Marks for the relevant subject.	At the end of 4th, 8^{th} and 12^{th} weeks of each semester.	20% for Calculation of CO attainment. 80% for Calculation of PO and PSO Attainment
2.	Assignments	Assignment can be one of the measuring criteria to mainly assess student's knowledge.	Once in a semester	20% for Calculation of CO attainment. 80% for Calculation of PO and PSO Attainment
3.	University Examination	Semester examination (theory or practical) are the metric to assess whether all the course outcomes are attained or not. Semester Examination is more focused on attainment of course outcomes and uses a descriptive exam.	Once in a semester	80% for Calculation of CO Attainment
4.	Practical Examination (Internal and External)		Once in a semester	80% for Calculation of CO Attainment
5	Project Work(Internal and External Examination)	The IA marks in case of projects in the final year shall be based on the evaluation at the end of 8th semester by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the project guide.	Once in an year	20%+80% respectively for Calculation of CO attainment. 80% for Calculation of PO and PSO Attainment

CO attainment through indirect method can be considered as the Course Exit Survey and weightage for that is 20 % (optional).

Indirect Assessment Methods:

These are the tools that are used to measure the attainment of POs and PSOs through survey in which a questionnaire is set for alumni and final year students in different perspective by covering all the POs and PSOs through this questionnaire feedback is collected then it is customized to different levels as Low (1), Medium (3) and Substantial (3) for individual PO and PSO.

Table 3.2 shows various Indirect methods adopted to calculate the attainment of POs and PSOs.

Table 3.2 Indirect Assessment Methods

Indirect Assessment Methods for measuring attainment of POs and PSOs				
Sl no	**Indirect Assessment Method**	**Method Description**	**Frequency**	**Weightage**
1.	Alumni: Survey Questionnaire	Collect variety of information about program Satisfaction and college from the Alumni.	Once in an year	20%
2.	Exit Survey: Feedback Questionnaire	Collect variety of information about program Satisfaction and college from the final year students.	Once in an year	20%

III. Results and Discussion

Calculation of CO attainment is shown in table 3.3 using only 2 assessment tools such as IA and Assignments. The bit wise marks have been entered with respect to COs in excel sheet for the all internal assessment and assignments.

Attainment of Course Outcome (Internal Test):

Table 3.3: Calculation of Attainment by Internal Assessment and Assignment Tools

		Internal Exam	**IA-1**								**IA-2**								**IA-3**								**assignment**
		Q.NO	**1.a**	**1.b**	**2.a**	**2.b**	**3.a**	**3.b**	**4.a**	**4.b**	**1.a**	**1.b**	**2.a**	**2.b**	**3.a**	**3.b**	**4.a**	**4.b**	**1.a**	**1.b**	**2.a**	**2.b**	**3.a**	**3.b**	**4.a**	**4.b**	
		Max Marks	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**8**	**7**	**10**
		CO's	**CO1**	**CO1**	**CO2**	**CO2**	**CO1**	**CO1**	**CO2**	**CO2**	**CO3**	**CO3**	**CO4**	**CO4**	**CO4**	**CO4**	**CO5**	**CO5**	**CO6**	**CO6**	**CO7**	**CO7**	**CO8**	**CO8**	**CO9**	**CO9**	1,2,3,5
Sl.No	**USN**	**NAME**																									
1	USN1	Student1	3		2						6				6	1					6	6					8
2	USN2	Student2	3				2	2					3	3	6	6					4	5	4	4			9
. .	. .																										
41	USN41	Student41	5	6			5	6					6								6	6			1		8
42	USN42	Student42	7	1			6	7			6	6	5						6		6	6					8
		Marks Scored	260	130	20	8	136	122	113	114	99	89	103	6	161	124	56	48	92	82	185	184	35	61	129	105	383
		Participation	42	35	4	1	22	24	19	18	20	18	20	3	29	28	11	10	16	15	31	32	10	12	26	20	42
		Maximum Actual Marks	**6**	**7**	**6**	**7**	**6**	**6**	**6**	**6**	**6**	**7**	**6**	**7**	**6**	**6**	**6**	**6**	**6**	**7**	**6**	**7**	**6**	**6**	**6**	**6**	10
		CO's	**CO1**	**CO1**	**CO2**	**CO2**	**CO1**	**CO1**	**CO2**	**CO2**	**CO3**	**CO3**	**CO4**	**CO4**	**CO4**	**CO4**	**CO5**	**CO5**	**CO6**	**CO6**	**CO7**	**CO7**	**CO8**	**CO8**	**CO9**	**CO9**	1,2,3,5
		Target	3.60	4.20	3.60	4.20	3.60	3.60	3.60	3.60	3.60	4.20	3.60	4.20	3.60	3.60	3.60	3.60	3.60	4.20	3.60	4.20	3.60	3.60	3.6	3.60	6
		Student Attaining Target	30.0	15.0	3.00	1.00	19.0	18.0	18.0	15.0	16.0	10.0	18.0	0.00	27.0	20.0	11.0	6.00	15.0	10.0	30.0	28.0	5.00	10.0	19.0	13.0	42
		Attainment	0.97	0.43	0.75	1.00	0.86	0.75	0.95	0.83	0.80	0.56	0.90	0.00	0.93	0.71	1.00	0.60	0.94	0.67	0.97	0.88	0.50	0.83	0.73	0.65	1

Marks Scored: Sum of marks of each vertical column.
Participation: Number of students attempted that particular question.
Maximum Actual Marks: Maximum marks allotted for that question.
Target: Set benchmark which is taken i.e., 60% of the maximum marks allotted for that question.
Student Attaining Target: No of students scoring equal of more than target marks.
Attainment: Number of students scoring equal or more than target marks divided by number of students attempting that question.
The tables 3.3.1 and 3.3.2 show the set and attained levels of CO, PO and PSOs from the above table 3.3.

Table 3.3.1: Set and Attained levels of COs Obtained from the Matrix

COs	**% of Attainment**	**Set Level**	**Attained Level**
CO-1	80.0	3	3.0
CO-2	91.00	3.00	3.00
CO-3	79.00	3.00	2.00
CO-4	64.0	3.00	1.00
CO-5	87.00	3.00	3.00
CO-6	80	3.00	3.00
CO-7	92	3.00	3.00
CO-8	67.00	3.00	1.00
CO-9	69.00	3.00	1.00

Methodology	
Level 1:	60% of Students scoring more than 60% of Marks
Level 2:	70% of Students scoring more than 60% of Marks
Level 3:	80% of Students scoring more than 60% of Marks

Table 3.3.2: PO and PSO Attainment Levels

POs	Set Level	Attained Level
PO-1	3.00	3.00
PO-2	2.00	2
PO-3	2.00	2.00
PSO1	3.00	2.00
PSO2	3.00	2.00

Methodology
PO Set Level: Target for each PO is set at programme level. PO Attainment(Attained t Level)= 3*Effective Contribution of this course at level 3 + 2*Effective Contribution of this course at level 2 + 1 *Effective Contribution of this course at level 1

Note: As the question paper pattern has optional questions, here for counting students participation, only the no. of students those who have attempted the respective questions is considered, if questions are not optional, then for the calculation of CO attainment all the students who appear for the test have to be taken into consideration.

With reference to the table 3.3 the following table gives the summary of Set and Attained Level of COs, POs and PSOs.

Table 3.4: Summary of CO, PO and PSO Attainment Values

COs	Set	Attained	POs	Set	Attained
C203.1	3.00	3.00	PO1	3.00	3.00
C203.2	3.00	3.00	PO2	2.00	2.00
C203.3	3.00	2.00	PO3	2.00	2.00
C203.4	3.00	1.00			
C203.5	3.00	3.00	**PSOs**	**Set**	**Attained**
C203.6	3.00	3.00	PSO1	3.00	2.00
C203.7	3.00	3.00	PSO2	3.00	2.00
C203.8	3.00	1.00			
C203.9	3.00	1.00			

By observing the values from table 3.4 the justification for attainment values of COs is provided in table 3.5

Table 3.5: Justification of CO Attainment

COs	Justification
C203.1	Attainment is satisfactory.
C203.2	Attainment is satisfactory.
C203.3	More focus should be given on oscillator principles.
C203.4	More clarification is required towards power amplifier and Voltage regulators concepts.
C203.5	Satisfactory attainment is achieved
C203.6	Attainment is satisfactory.
C203.7	Attainment is satisfactory.
C203.8	Design concepts of oscillators need to be focused more in the upcoming semester.
C203.9	Design aspects of power amplifier and voltage regulators for the given specification have to be taught more clearly to bring better understanding.

Following table 3.6 shows CO attainment through University exams, these values can be given with 80% weightage and Internal Assessment CO attainment with 20% weightage.

Table 3.6: CO Attainment through University Exams

Sl.no	USN	NAME	IA Marks	EXT. Marks		Attainment Level Set	3	2
1	USN1	Student1	19	6		**Target (Marks)**	20	28
2	USN2	Student2	20	22		**No. of Students achieved Target**	39	29
.	.	.	.	.		**Total no. of Students**	42	42
42	USN42	Student42	19	21		**% of students achieved Target**	0.92	0.69
						Achieved Level	3	1

CO target set for the AE course is =3*0.2+2*0.8=**2.2**

Attained Target is (After exam) =3*0.2*0.92+1*0.8*0.69=**1.1**

Since CO3, CO4, CO8 and CO9 are having lesser attainment values compared to set benchmark for those COs, the necessary actions should be planned and implemented as a part of continuous improvement in the next semester when the same course is taught to different batch of students and the improvement in the CO attainment values have to be observed and recorded.

Similar Methodology for calculation of Attainment of CO, PO and PSOs has to be adopted for all the other courses of a programme and the values have to be recorded in attainment matrices separately, average of all the values obtained from the PO attainment matrix is considered as the attainment value of that particular PO from that batch of programme. Similarly observations on all POs and PSOs attainment values have to be made and those observations and action plans have to be mentioned in the criterion 7, there by necessary actions should be implemented to boost the attainment values as well as to improve the quality of Students Performance.

IV. Conclusion

Curriculum, Assessment and Evaluation are the major tools by which Program Outcomes are attained and this attainment is assessed by direct and indirect methods. Main contributing factors to indicate the performance of a programme is attainment of COs and POs. Hence the simplified approach is proposed in this paper towards the attainment calculation in synchronization with framing COs, CO-PO Mapping with proper justifications. As a result, the CO attainment for AE subject is 50% less compared to target set. Analysis of these attainment values will help the programme to implement innovative methodologies to improve quality of the performance by students as a part of continuous improvement in the subsequent years.

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