

Study on Assessment of Outcomes of Education

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Abstract: This paper describes the process for assessment of Course Outcomes (COs), Program and Program Specific Outcomes (POs & PSOs). Direct and indirect method was used to assess the COs, POs and PSOs. In the direct method, continuous internal evaluation test, assignment, seminar, end semester examination as well as in the indirect method, number of surveys were carried out to assess the outcomes. Threshold approach was followed for assessing the attainment. Based on the attainment, existing gap can be identified and filled by improving the curriculum, teach learning process and skills of the graduate.

Keywords: Assessment, attainment, course outcomes, program outcomes, program-specific outcomes.

1. Introduction

Nowadays all the educational institutions are focused on Outcome Based Education (OBE). National Board of Accreditation (NBA), India is the permanent signatory member of the Washington Accord and framed specific guidelines to achieve OBE for the educational institutions in India. The outcome of education is to produce high-quality

graduates and contributing their knowledge to the welfare of the stakeholders and society. Outcomes are result oriented thinking and are opposite of input-based education where the emphasis is on the educational process and where we're happy to accept whatever is the result [1]. Any outcomes do not achieve without any specific process. All the process follows the Deming's Quality Cycle such as plan-do-check-act. NBA [2] defines three levels of outcomes such as 1) Program educational objectives (PEOs) 2) Program Outcomes (POs) & Program-Specific outcomes (PSOs) 3) Course outcomes (COs). PEOs are described that, prepare the graduates to achieve a successful career and professional accomplishments after a few years of graduation and it has been framed by considering local and global issues, vision and mission of the institution. POs and PSOs are defined that, acquired knowledge of graduates at the end of the program in all the areas of graduate attributes and specific core field respectively. Totally 12 POs has been defined by NBA, India [2] by considering the graduate attributes such as engineering knowledge, problem analysis, design/ development of solutions, conduct investigation of complex problems, modern tool usage, the engineer and society, environment and sustainability, ethics, individual and teamwork, communication, project management and finance and life-long learning. PSOs have been framed by the respective program by considering specific attributes in that program. COS are described that, acquired knowledge of students at the end of every course. This has been framed for individual courses in the curriculum.

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Kalbande and Rathod [3] developed the software application for the attainment of POs for reducing the clerical work of faculty members. Izham Zainal Abidin et al. [4] discussed about assessment of course outcomes and developed a computerized Microsoft Excel for an engineering course. Soragon and Mahesh [5], Rudagi and Anita [6], Kulkarni and Barot [7] review the attainment of outcomes through case study. But there is limited papers have been available to assess the outcomes by question wise (micro level analysis). But NBA does not mention any specific method for assessing the attainment of outcomes. Therefore, this paper describes the method to evaluate the attainment of COs, POs and PSOs.

2. Assessment of Course Outcomes

All the courses in the undergraduate engineering program have own course outcomes. Each course outcomes will be mapped with POs and PSOs. POs and PSOs will be mapped with PEOs. Figure 1 shows the sequence of framing and assessing of various outcomes. Figure 2 shows the steps for framing the COs [1]. Direct and Indirect method is used to assess the COs. All Internal assessment such as Continuous Internal Evaluation (CIE) test, seminar, assignment, project, and quiz as well as external assessment such as Semester End Examination (SEE) are direct method. Course end survey is the indirect method, which will be collected from the students after completion of each course based on the course outcomes.

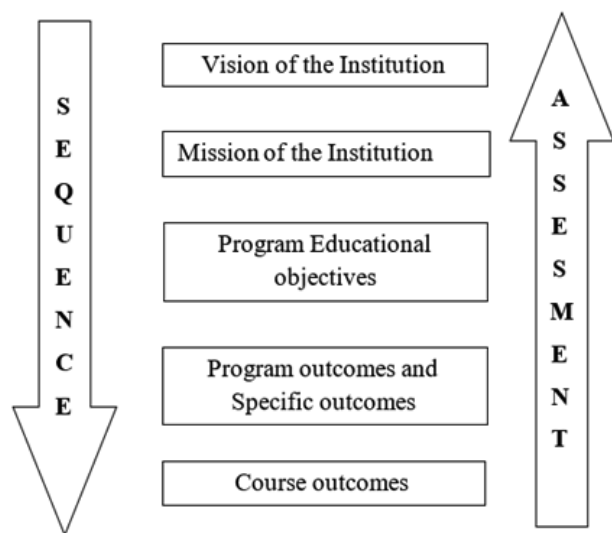


Fig. 1: Sequence of Framing and assessing of outcomes

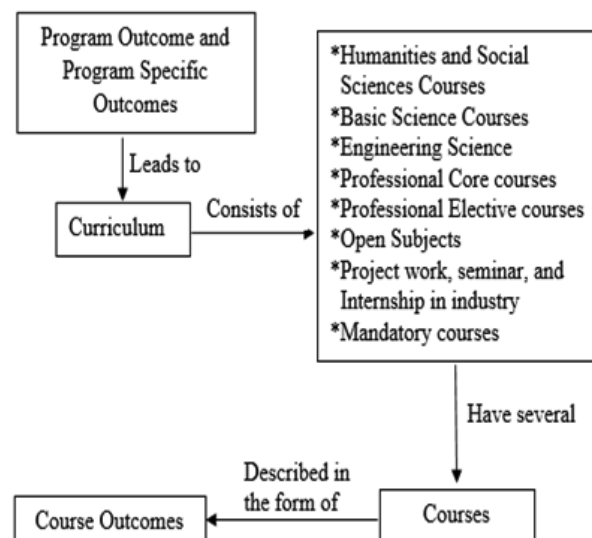


Fig. 2 : Framing of Course Outcomes

Totally five course outcomes have been framed for every course. Questions in the internal evaluation test and SEE are mapped with each course outcomes and presented in Table 1. Percentage of attainment of each course outcome is calculated based on the marks scored by the individual student for the individual question.

Mapping between course outcomes and questions is explained by an example below

Co 1: Analyse indeterminate beams and frames by matrix flexibility method

Question 1: What is element flexibility matrix of the beam element?

Justification: Element flexibility matrix is needed to analyse any indeterminate beams. So this question is strongly mapped with the CO1

Table 1. Mapping of questions with COs

Assessment Tools (A.T)	Max. Marks	Course Outcomes				
		CO1	CO2	CO3	CO4	CO5
CIE TEST1 (CIE1)	50	Q1 to Q6 (2*) & Q11a or Q11b(16*)	Q7 to Q9 (2*) & Q10 (16*)			

CIE TEST2 (CIE2)	50		Q1 to Q3 (2*) & Q11 (16*)	Q4 to Q9 (2*) & Q11 (16*)		
CIE TEST3 (CIE3)	50				Q1 to Q5 (2*) Q10 (16*) or Q11 b (16*)	Q6 to Q9 (2*) Q11a or Q11 b (16*)
Assignment	25	Q1	Q2	Q3	Q4	Q5
Semester end examination (SEE)	100	Q1, Q2 (2*)& Q11 (16*)	Q3, Q4 (2*)& Q12 (16*)	Q5, Q6 (2*) & Q13 (16*)	Q7, Q8 (2*) & Q14 (16*)	Q9, Q10 (2*)& Q15 (16*)
*Marks of each questions, Qn- question number						

First CIE covers the CO1 and CO2 and its marks details of student-1 is depicted in Table 2. Marks scored by student-1 in CIE, assignment, and SEE are presented in Table3.

Table 2. Details of marks in CIE 1

Question Number	Co Number	Maximum Marks	Obtained Marks
1	CO1	2	2
2	CO1	2	2
3	CO1	2	2
4	CO1	2	2
5	CO1	2	2
6	CO1	2	2
7	CO2	2	2
8	CO2	2	0
9	CO2	2	0
10	CO2	16	6
11a	CO1	16	14
11b	CO1	16	Choice

Table 3. Obtained Marks by student in one course (Direct method)

A. T	Course Outcomes									
	CO1		CO2		CO3		CO4		CO5	
	M	O	M	O	M	O	M	O	M	O
CIE1	28	26	22	8						
CIE2			28	6	22	15				
CIE3							26	20	24	15
A	5	2	5	3	5	4	5	3	5	3
SEE	80 out of 100									
M= Maximum Marks; O = Obtained Marks										

The performance of the students in the internal evaluation (IE) test and SEE were assessed. The percentage of marks of each COs was calculated by marks scored in the respective CO out of total marks contribution of that CO

CIE 1 and Assignment gives the contribution to CO1 as shown in Table 3. Percentage of marks of CO1 of student-1 through internal evaluation is calculated by Percentage of Marks of CO1_{IE}

$$= \text{Average} \left[\frac{[O. M \text{ of CO1 in CIE 1}]}{[M. M \text{ of CO1 in CIE1}]} + \frac{[O. M \text{ of CO1 in A}]}{[M. M \text{ of CO1 in A}]} \right]$$

$$= \left[\frac{[26]}{[28]} + \frac{[2]}{[5]} \right] * 100$$

$$= 66\%$$

In the SEE, the obtained marks of individual question by the students was not known. So the COs in the SEE was calculated approximately. In this method, the percentage distribution of each question for each CO was calculated and presented in Table 4. Student-1 scored 80 marks out of 100 in one course of SEE. The percentage of marks of CO1 in SEE is calculated as

Percentage of Marks of CO1_{SEE}

$$= \left[\frac{\text{Percentage distribution of questions in CO1} * O. M}{\text{Maximum Marks}} \right]$$

$$= \left[\frac{0.2 * 80}{100} \right] * 100$$

$$= 16\%$$

Table 4. Percentage Distribution of questions

Assessment tools	Course Outcomes				
	CO1	CO2	CO3	CO4	CO5
SEE	20%	20%	20%	20%	20%

Similarly all the COs was assessed. The assesment of COs through SEE is approximate, so minimum weightage was given to SEE. 80 % and 20 % weightage was given for internal assessment and SEE respectively in the assessment of Cos.

Total Percentage of marks of CO1 of student-1 is

= 80 % Percentage of Marks of CO1 IE + 20 % of Percentage of Marks of CO1_{SEE}

$$= 0.8*66 + 0.2*16 = 56\%$$

Class average mark was taken as bench marks. Attainment of COs were calculated by percentage of number of student scored more than or equal to class average marks. Assessment of attainment of course outcomes by direct method is presented in Table 5

Table 5. Assessment of attainment of COs by Direct Method

S. No	Name of Student	% marks of CO1	% marks of CO2	% marks of CO3	% marks of CO4	% marks of CO5
1	Student 1	56	34	63	58	52
2	Student 2	47	53	59	66	66
3	Student 3	56	56	56	59	59
4	Student 4	52	58	64	59	59
Class Average Marks		52.75	50.25	60.5	60.5	59
No of Students more than the class average marks		2	3	2	1	3
Attainment by direct method		50%	75%	50%	25%	75%

Course ends survey is the Indirect Assessment tool. Course end survey was carried out at the completion of each course (end of the semester). The course end survey assessed by a range of attributes such as excellent, good, satisfactory, and poor as well as it is framed based on each COs. Attainment of each CO by course end survey of sample course is presented in Table 6.

Table 6. Attainment of each CO by Course End Survey

Course End Survey						
Attributes	Weightage (W)	CO1	CO2	CO3	CO4	CO5
		Number of respondent (R)				
Excellent (E)	4	20	20	10	30	10
Good (G)	3	20	20	10	10	30
Satisfactory (S)	2			10		
Poor (P)	1	0	0	10		
Total Number of Strength		40	40	40	40	40
Attainment		88%	88%	63%	94%	81%

Weightage was assigned for each attribute and the percentage of attainment was calculated as,

Percentage attainment of CO1

$$= \left[\frac{(WE * RE1) + (WG * RG1) + (WS * RS1) + (WP * RP1)}{\text{Total strength} * 4} \right]$$

$$= \left[\frac{(4 * 20) + (3 * 20)}{40 * 4} \right] * 100$$

$$= 87.5 \%$$

where, WE = Weightage for excellent = 4,

WG = Weightage for good = 3,

WS = Weightage for satisfactory = 2, and

WP = Weightage for poor = 1

RE1, RG1, RS1 and RP1 = Number of excellent, good, satisfactory, and poor given by the respondent for the CO1 respectively.

Table 7. Final CO Attainment

CO	Attainment from Direct Method	Attainment from Indirect attainment	Weightage for Direct Method	Weightage for indirect Method	Final CO Attainment	Whether Target (60%) level reached or not
			80 %	20 %		
CO1	50%	88%	40%	18%	58%	No
CO2	75%	88%	60%	18%	78%	Yes
CO3	50%	63%	40%	13%	53%	No
CO4	25%	94%	20%	19%	39%	No
CO5	75%	81%	60%	16%	76%	Yes

Table 8. Comparison of CO attainment

Batch	Academic Year	CO1	CO2	CO3	CO4	CO5
2013-2017	2015-2016	58	78	53	39	76
2014-2018	2016-2017	62	76	67	50	80
2015-2019	2017-2018	71	80	74	65	81

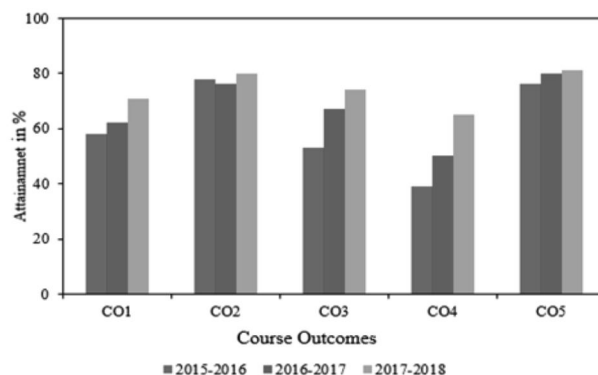


Fig. 3 : Comparison of Course Outcomes

The final attainment of CO was calculated by combining the results of the direct and indirect methods and presented in Table 5. Comparison of CO attainment for the past three years are presented in Table 8 and shown in Figure 3.

It is observed that, attainment of COs increased gradually. The weightage given for direct and indirect assessment was 80 % and 20 % respectively. Here, target (60 %) is set, to check whether the CO attained a target level or not. If all COs are attained, increase the target level for the next set of students for the respective course. If one or more COs are not reached the target level, identify the gap and plan to improve the teaching/learning process to attain the target level for the next set of students

3. Assessment of POS and PSOs

POs and PSOs are achieved through the course outcomes of individual courses (Direct Method) and other co-curricular, extra-curricular activities, program exit survey, employer's feedback, alumni feedback (indirect method), etc. Attainment of a POs/PSOs depends both on the attainment levels of associated COs and the strength to which it is mapped [1].

Table 9. Attainment of POs and PSOs (Direct Method) of Structural Analysis -I

Co Number	Percentage of CO Attainment	Statement of course outcomes	Program Outcomes				Specific Outcomes	
			Mapping strength (MS)					
			a	b	d	l		1
CO1	58	Analyse indeterminate beams and frames by matrix flexibility method	3	3	2	2	3	
CO2	78	Analyse indeterminate beams and frames by matrix stiffness method.	3	3	2	2	3	
CO3	53	Develop finite element equation for various elements	3	2		2	3	
CO4	39	Analyse indeterminate beams and frames by plastic theory.	3	3	2	2	3	

CO5	76	Analyse the space truss, beams in curved planes and cable structures.	3	3	2	2	3
POs and PSOs Attainment			60.8	56.8	41.8	40.5	60.8
Correlation levels 1, 2 or 3 are defined as 1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High)							

Mapping between COs and POs, & PSOs is presented in Table 9. Table 10 shows the justification for mapping of CO1 with various POs and PSOs.

Table 10. Justification for mapping between CO1 with POs and PSOs

CO1	PO _a	Student has to apply engineering knowledge to analyse the indeterminate beams and frames. So CO1 substantially map with PO _a
	PO _b	Student has to * Identify the end condition and whether the frame is subjected to sway or without sway? *Formulate the element flexibility matrix and analyse indeterminate beams and frames. So CO1 substantially map with PO _b
	PO _d	Student has to provide conclusion to some extent based on the analysis of results So CO1 moderately map with PO _d
	PO _l	Student has an ability to enhance life-long learning skills to some extent. So CO1 moderately map with PO _l
	PSO1	Student has to analyse all structural elements. So CO1 substantially map with PSO1

where,

(Poa) Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering

(Pob) Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

(Pod) Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions problems

(Pol) Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

(PSO1) Plan, analyse, and design, all kinds of Civil Engineering Projects

Totally 12 POs and 2 PSOs have been framed and assessed. The POs and PSOs were mapped with individual course outcomes based on their correlation between them like strong (3), medium (2) and, low (1) and it is presented in Table 9 for the course Structural Analysis 1.

Percentage of attainment of POd calculated as,

$$= \left\{ \left(PCO1 \frac{MS1-a}{Max.MS} \right) + \left(PCO2 \frac{MS1-a}{Max.MS} \right) + \left(PCO3 \frac{MS1-a}{Max.MS} \right) \right. \\ \left. + \left(PCO4 \frac{MS1-a}{Max.MS} \right) + \left(PCO5 \frac{MS1-a}{Max.MS} \right) \right\} \\ = \left\{ \left(58 \frac{3}{3} \right) + \left(78 \frac{3}{3} \right) + \left(53 \frac{3}{3} \right) \right. \\ \left. + \left(39 \frac{3}{3} \right) + \left(76 \frac{3}{3} \right) \right\} \\ = 60.8 \%$$

where, PCO1, PCO2, PCO3, PCO4, PCO5 = Percentage of attainment of CO1, CO2, CO3, CO4, and CO5 respectively.

MS1-a = Mapping strength between CO1 and program outcome 'a', Max.MS= Maximum mapping strength, which is 3

Similarly, the attainment of POs and PSOs for each course was assessed and consolidate at the end of the program. Furthermore, an indirect assessment was included in the attainment of POs and PSOs, such as students (exit survey), employer's survey, alumni's survey, etc. These surveys were taken at the end of the duration of the program. For the final assessment of POs and PSOs, 70 % and 30 % weightage was given for direct and indirect assessment respectively and it depicted in Table 11. Distribution of weightage between direct and indirect assessment varies depends upon the number of surveys taken in the indirect method.

Target was set as 60 % for 2013-2017 batch students. The attainment of POs and PSOs was checked against target level. The results of the attainment are presented in Table 11. The results for

Table 11. Final Attainment of POs and PSOs (2013-2017)

Identification of outcome	Assessment through				Final Attainment (70% of Direct Attainment + 30% of Indirect attainment)	Whether Target (60%) the level reached or not
	Courses	Student's Exit Survey	Employer's Survey	Alumni's Survey		
POa	61	81	75	75	65.8	yes
POb	56	82	81	77	63.2	yes
POc	55	85	80	72	62.2	yes
POd	53	86	80	77	61.4	yes
POe	55	80	81	78	62.4	yes
POf	53	82	81	81	61.5	yes
POg	49	92	88	77	60	yes
POj	53	88	82	79	62	yes
POi	59	87	75	76	65.1	yes
POj	55	84	85	80	63.4	yes
POk	48	92	88	88	60.4	yes
POl	55	85	88	83	64.1	yes
PSO1	52	90	85	82	62.1	yes
PSO2	51	93	88	85	62.3	yes
Assessment in percentage						

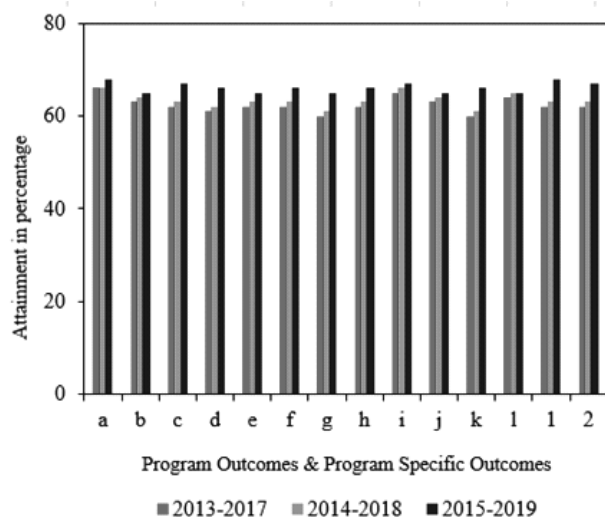
the past three batch student are presented in Table 12 and shown in Figure 4. Results of 2013-2017, shown that all the POs and PSOs attain the target level. Hence, the target level was increased as 65 % for the next batch (2014-2018) of students. It was observed that POa and POi reached the target level. Remaining outcomes did not reach the target level. So the gap was identified and action taken was implemented for the next batch (2015-2019) students. Improving or introducing the new teaching-learning process, improve the curriculum, etc., are the some of the action taken. So the 2015-2019 batch, reached the target level 65 %. Hence target level can be increased for next batch of students.

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Table 12. Final Attainment of POs and PSOs

POs & PSOs /	Batch		
	2013-2017	2014-2018	2015-2019
a	66	66	68
b	63	64	65
c	62	63	67
d	61	62	66
e	62	63	65
f	62	63	66
g	60	61	65
h	62	63	66
i	65	66	67
j	63	64	65
k	60	61	66
l	64	65	65
1	62	63	68
2	62	63	67

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**Fig. 4 : Comparison of Program & Program Specific Outcomes**

4. Conclusion

A method to find the attainment of COs, POs, and PSOs has been described. It can be implemented using Microsoft Excel software. A direct and indirect method for assessment has been explained.

Assessment of outcomes facilitates the continuous quality improvement of engineering educations. This procedure will be helpful for those who new for outcome based education.

5. Acknowledgment

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