

Attainment of Course Outcomes: - A Sample Empirical Case Study for incorporating Outcome based education

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Abstract: Outcome based education (OBE) is now inevitable and is a directive for education as per standards stated by National board of accreditation (NBA). Course outcomes (CO) and Program outcomes (PO) are two crucial aspects pertaining towards effective OBE incorporation. To achieve this, mapping of course outcomes with program outcomes is a major concern. As per accreditation guidelines of NBA direct and indirect tools must be deployed for calculating the attainment of Program Outcomes. Certain CO-PO mapping strategies must also be defined. This paper presents an empirical case study of the subject "Operating Systems and Administration" in the third Semester of Computer engineering curricula of Savitiri bai Phule Pune University (SPPU), India. The Paper gives a threefold contribution: - a) proposes an empirical algorithm to estimate the correlation between the CO and PO. b) Three direct schemes of CO attainment are designed along with two indirect schemes c) Final attainment estimation is done by integrating the above proposed schemes.

Keywords: Outcome Based Education, Course Outcomes, Program Outcomes, attainment level.

1. Introduction

National Board of Accreditation (NBA), India has become the permanent signatory member of the Washington Accord on 13th June 2014[1]. Every technical institute strives towards excellence. Technical institutes are promoted and recognized for excellence by NBA [2]. The Outcomes of an outcome based education system must be measurable and identifiable that prepares the graduates for professional practices [3]. Course outcome is an important aspect for OBE [4][5]. The program outcomes [POs] listed in table 1 is defined by the National Board of Accreditation. Every course outcome maps to some the program outcomes. Attainment of the course outcome is possible by various direct and indirect tools [6]. This paper is organized in 5 sections. The section immediately followed by is the literature survey that puts forth the basic designing process adopted in our department for finalizing the course outcomes. The course outcomes are designed taking into consideration the cognitive level based on blooms taxonomy [7]. The third section proposes a CO-PO correlation estimation algorithm followed by an empirical case study for a course. Section 4 focuses on three direct methods for attaining the course outcomes. The first method calculates the course attainment based on the university

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examination results of the 126 students of third semester in the department. This method deploys the attainment calculation based on the set target levels. The second direct attainment method is based on the University examination results, practical performances, internal marks and Oral examination. The third method is based on blooms technology based Unit test question paper evaluation.

Table 1. Program Outcomes defined by NBA

	Program Outcome
PO1	Engineering Knowledge
PO2	Problem Analysis
PO3	Design/Developmeny of Solutions
PO4	Conduct Investigations of Complex Problems
PO5	Modern tool Usage
PO6	The Engineer and the Society
PO7	Environment and Sustainability
PO8	Ethics
PO9	Individual and Team owrk
PO10	Communication
PO11	Project Management and Finance
PO12	Lifelong learning

The fifth section proposes two indirect methods for attaining the course outcomes. Final Course outcomes attainment is calculated as eighty percent on the average of three direct attainment methods and 20 percent on the attainment achieved by indirect method followed by conclusion.

2. Literature Survey

The course outcomes in our department are defined by certain brainstorming sessions in a team comprising of various faculty members, module and course coordinators and the program coordinator. Fig1 enlists all the necessary inputs required for preparation of course outcomes.



Fig 1 Inputs for finalizing course outcomes

Table 2 below presents the outcomes finalised for a third semester course, “Operating System administration”.

Table 2. Course Outcome for Operating System administration		
CO No.	Course Outcomes	Cognitive Level
1	Ability to describe various open source operating systems like Unix/Linux	2
2	Ability to execute Basic shell script commands and Admin commands	3
3	Ability to acquire Knowledge of file organization and storage systems.	2
4	Ability to demonstrate the concepts booting, rebooting and shutting down	3
5	Ability to differentiate between the traditional and modern assess control, also should able to understand the processes in detail.	4
6	Ability to develop shell programs for adding new users and assigning assesses rights to them.	6

3. Proposed CO-PO Correlation Estimation Algorithm

This section proposes a method for estimating the Correlation between the course and the program outcomes

Process of defining CO-PO correlation matrix

- Map every Course Unit with Every CO
- Map every Course Unit with Every PO
- Identify Number of contact hours utilized for the CO - PO mapping and actual number of hours allocated to units
- Calculate number of contact hours for specific CO

$$\text{No of contact hours} = (\text{number of hours}) / (\text{number of mapped CO})$$
- Calculate percentage number of contact hours for Specific PO

$$\text{No of contact hours} = (\text{number of hours}) / (\text{number of mapped PO})$$
- $\% \text{ CO-PO Correlation} = ((\text{Summation of number of CO}) * (\text{number of PO contact hours}) * 100) / (\text{Total Number of contact hours})$
- Strength of mapping is defined at three levels:
 - Low - 1, Medium - 2, Strong - 3
- Methodology to estimate the strength level

Sr. No	Empirical Justification for strength level estimation	Strength Level for Correlation between CO-PO
1	If No. of contact hours > 17% and <= 25% of Classroom session addressing a particular PO	PO addressed at level 3
2	If No. of contact hours >10% and <=17% of Classroom sessions addressing a particular PO	PO addressed at level 2
3.	If No. of contact hours <=10% of classroom sessions addressing a particular PO	PO addressed at level 1

4. Case Study for " Operating System Administration

"The course, "Operating systems and administration (OSA)" is mentioned in the third semester of undergraduate curricula of computer engineering. The course is divided in six units. The university also mentions the number of contact hours required for every unit in the course. As per the syllabi of SPPU the no of contact hours for OSA is 40. Also unit wise classification is specified as 8 hours for unit number 4 and 6 and 6hours for other 4 units.

Dry-Run of the CO-PO Correlation Estimation Algorithm for Operating System Administration

Step a) Map Course Unit with Course Outcomes

Table 1 Unit CO Mapping

	CO1	CO2	CO3	CO4	CO5	CO6
Unit 1	✓	-	-	-	-	-
Unit 2	✓	✓	-	-	✓	-
Unit 3	✓	✓	✓	-	✓	✓
Unit 4	✓	✓	✓	✓	-	✓
Unit 5	✓	✓	✓	✓	✓	✓
Unit 6	✓	✓	✓		✓	✓

Step b) Map Course Unit with Program Outcomes

Unit	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
1	✓		✓	-	-	-	-	-	✓	✓	-	✓
2	✓		✓	-	-	-	-	-	✓	✓	-	✓
3	✓	✓	-	-	✓	-	-	-	✓	✓	-	✓
4	✓	✓	✓	✓	✓	-	-	-	✓	✓	-	✓
5	✓	✓	-	✓		-	-	-	✓	✓	-	✓
6	✓	✓	✓	✓	✓	-	-	-	✓	✓	-	✓

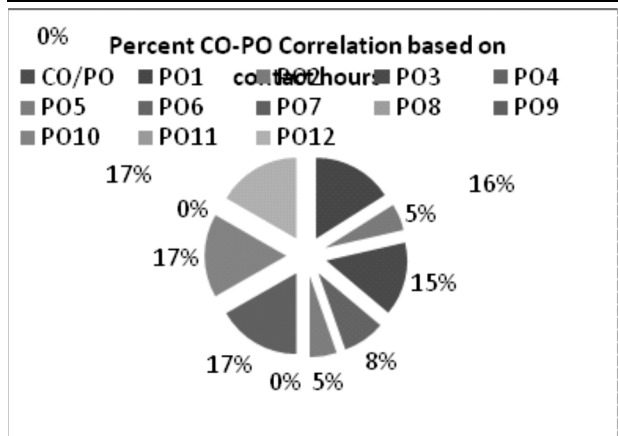
Step c, d, e and f) % CO- PO Correlation

Table 3 Cos Pos Mapped to Units

Unit	CO's Mapped	PO's Mapped	No. Of Hours
1	CO1 (6)	PO1,PO3,PO9,PO10,PO12(1.2)	6
2	CO1,CO2,CO5(2)	PO1,PO3,PO9,PO10,PO12(1.2)	6
3	CO1,CO2,CO3,CO5,CO6(1.2)	PO1,PO2,PO5,PO9,PO10,PO12(1)	6
4	CO1,CO2,CO3,CO4,CO6(1.6)	PO1,PO2,PO3,PO4,PO5,PO9,PO10,PO12(1)	8
5	CO1,CO2,CO3,CO4,CO5,CO6(1)	PO1,PO2,PO4,PO9,PO10,PO12(1)	6
6	CO1,CO2,CO3,CO5,CO6(1.6)	PO1,PO2,PO3,PO4,PO5,PO9,PO10,PO12(1)	8
Total			40
Eg.	Correlation of CO1-PO3 As CO1 and PO3 mapping is in unit 1,2,4 and 6 Correlation percentage = (CO-PO mapping of (Unit 1+2+4+6)*100)/140 Correlation percentage = $\frac{[(6*1.2)+(2*1.2)+(1.6*1)+(1.6*1)]*100}{40}$ Correlation percentage = $\frac{[(7.2+2.4+1.6+1.6)*100]}{40}$ Correlation percentage = $\frac{12.8*100}{40}$ Correlation percentage = 32		

Step g and h:-. Number of Percentage Contact hours for Specific CO

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	36.03	12.1	33.1	19.1	12.1	-	-	-	37.7	37.2	-	37.5
CO 2	14.52	12.5	15.5	10.5	10.5	-	-	-	18.5	18.5	-	18.5
CO 3	11.2	11.2	8.1	10.2	12.22	-	-	-	13.52	13.52	-	13.52
CO 4	6.51	6.51	4.1	6.51	6.51	-	-	-	6.51	6.51	-	6.51
CO 5	14.52	8.51	9.2	6.51	7.1	-	-	-	14.52	14.52	-	14.52
CO 6	13.52	13.52	8.1	10.52	8.1	-	-	-	10.52	10.52	-	10.52
Overall	2	1.66	1.66	1.83	1.5	-	-	-	2.16	2.16	-	2.16



5. Direct Schemes for CO-PO attainment

This section puts forth 3 direct methods for course attainment

a) Method 1:- Target setting for University results

Algorithm:

Step1: Set the target Assessment level based on Previous 2 year's Results Analysis

Step 2: For Attainment:- Calculate the Percentage of student's performance in each band: - (First class with distinction, second class, and pass class)

Step 3 : Attainment level 1:- 60 percent students securing more than set target level

Step 4: Attainment level 2:- 70 percent students securing more than set target level

Step 5: Attainment level 3:- 80 percent students securing more than set target level

Table 4 Direct Attainment Method 1: - Case for OSA

	2014-15	Target Level Set for 2015 -16	Target Achieved (2015-16)	Attainment Level
No of Students Appeared	144		156	
No of Students Passed	125		138	
Average Pass Percentage	81.81%	90%	88.46%	2.93
Percentage of Students in FC & Distinction	18/125 = 14.40%	20%	25/138=18.11%	2.71
Percentage of Students in Second class	61/125 =48.8%	50%	61/138=44.20%	2.65
Percentage of Students in Pass class	46/125 =36.8%	40%	52/138=37.68%	2.82

a) Method 2:- Attainment through University Results(SPPU), Unit tests(UT) and practical's(PR)

Step1: Perform Results Analysis SPPU, UT and PR.

Step 2: Attainment level 1(Low):- Students in range of marks between 40-50

Step 3: Attainment level 2 (Moderate):- Students between 50-60

Step 4: Attainment level 3 (High):- Students in range >60

Step 5: Apply Attainment Formula (No of Students

Passed in low level *1 + (No of Students Passed in moderate level *2 + (No of Students Passed in high level * 3) / No. of students Passed.

Table 5 Direct Attainment Method 2: - Case for OSA

	OSA	SPP U		UT		PR
	Appear ed	156		156		156
	Passed	138		109		151
	Failed	18		49		05
	Result	88.46		68.88		96.79
Low (1) pass class	40-50	52(37.68)	12-15	11(10.09)	20-25	18(11.92)
Moderate (2)	51-59	61(44.20)	16-17	41(37.61)	26-29	12(7.94)
High (3)	>= 60	25(18.11)	>= 18	57(52.29)	>=30	121(80.13)
Attainment		1.59		2.42		2.68

a) Method 3:- Attainment through Blooms Taxonomy level of Question Paper

Step1: Categorize all the questions (unit test question paper) in the blooms taxonomy levels

Step 2: Map the Question paper with CO's Level wise

Step 3: Map the Question paper with PO's Level wise

Step 4: Map CO-PO Blooms level

Step 5: Calculate the Final Attainment by combining attainment of questions.

Dry Run above algorithm for the sample course OSA

Step 1 and 2)

Q. No	CO1	CO2	CO3	CO1	CO2	CO3	Blooms Level
1a	2	-	-	-	-	-	2
1b	1	1	-	-	-	-	2
2a	1	1	-	-	-	-	2
2b	1	1	-	-	-	-	2
3a	1.33	1.33	-	-	1.33	-	4
3b	0.66	0.66	-	-	0.66	-	2
4a	1.33	1.33	-	-	1.33	-	4
4b	0.66	0.66	-	-	0.66	-	2
5a	2	-	2	-	-	-	4
5b	0.66	-	0.66	-	0.66	-	2
6a	-	-	1	-	1	-	2
6b	-	-	1	1	-	-	2
Av	1.16	1	1.16	1	0.94	-	2.5

Step 3) Mapping the Question paper with PO's Level wise

Q.No	P O 1	P O 2	P O 3	P O 4	P O 5	P O 6	P O 7	P O 8	P O 9	P O 10	P O 11	P O 12	B T L
1a	1	-	1	-	-	-	-	-	-	-	-	-	2
1b	1	-	1	-	-	-	-	-	-	-	-	-	2
2a	1	-	1	-	-	-	-	-	-	-	-	1	2
2b	1	-	1	-	-	-	-	-	-	-	-	1	2
3a	2	-	-	-	-	-	-	-	-	-	-	2	4
3b	1	-	-	-	-	-	-	-	-	-	-	1	2
4a	2	2	-	-	-	-	-	-	-	-	-	-	4
4b	1	1	-	-	-	-	-	-	-	-	-	-	2
5a	2	-	-	-	-	-	-	-	-	-	-	2	4
5b	1	-	-	-	-	-	-	-	-	-	-	1	2
6a	1	-	-	-	-	-	-	-	-	-	-	1	2
6b	1	-	-	-	-	-	-	-	-	-	-	1	2
Av	1.25	1.5	1	1	-	-	-	-	-	-	-	1.25	2.5

1.25 1.5 1 1 - - - - - - - 1.25 2.5

Step 4) Map CO-PO blooms level

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	3	0	0	0	0	0	0	0	0	3
CO2	3	2	2	0	0	0	0	0	0	0	0	3
CO3	3	0	1	0	0	0	0	0	0	0	0	3
CO4	1	0	0	0	0	0	0	0	0	0	0	1
CO5	3	2	1	0	0	0	0	0	0	0	0	3
CO6	3	0	3	0	0	0	0	0	0	0	0	3
Avg	2.67	2.0	2.0	0	0	0	0	0	0	0	0	2.67

Step 5

Case 1- If Blooms Level 5-6

Attainment Level 3: > 60%

Attainment Level 2: > 50%

Attainment Level 1: > 40%

Case 2- If Blooms Level 3-4

Attainment Level 3: > 70%

Attainment Level 2: > 60%

Attainment Level 1: > 50%

Case 3- If Blooms Level 1-2

Attainment Level 3: > 80%

Attainment Level 2: > 70%

Attainment Level 1: > 50%

Table 6 Direct Attainment Method 3:- Case for OSA

Q.No	Average Marks	Total Marks	Blooms Taxonomy	Actual attainment As per Algo
1a	3	6	2	1
1b	2	4	2	1
2a	4	6	2	2
2b	3	4	2	2
3a	4	6	4	2
3b	3	4	2	3
4a	4	6	4	2
4b	3	4	3	3
5a	5	6	4	3
5b	3	4	2	2
6a	3	6	2	1
6b	3	4	2	2
Total				2

6. Indirect Schemes for CO-PO attainment.

This section proposes two schemes for indirect attainment estimation.

a) Method 1:- Attainment through course exit survey forms.

A questionnaire is prepared for the students to know the understanding of the subject. The questionnaires had three point scale estimation for every question.

Sample Questionnaire including sample question like "Rate yourself regarding the basic knowledge of Operating systems gained at the end of the course" was prepared as a part of course exit survey. This survey was carried out for the class of 156 students.

Table 7 Indirect Attainment Method 3:- Case for OSA

Question Number	No of students with Low scale	No of students with Medium scale	No of students with High scale	Total
1	23	27	106	156
2	101	22	33	156
3	22	108	26	156
4	20	25	111	156
5	11	22	123	156
6	23	12	121	156
7	11	12	133	156
8	02	144	10	156
9	112	13	31	156
10	101	18	37	156
Average	39.2	40.3	73.1	

Total attainment = $39.2 * 1/100 + 40.3 * 2/100 + 73.1 * 3/100$ $(0.392 + 0.806 + 2.19)/3 = 1.131$

b) Method 2:- Attainment through seminars/workshop survey forms.

Feedback forms are designed and circulated among the students after the seminar/workshops organized. Two Seminars were arranged for the students. Feedbacks for both the workshops were collected and the attainment calculation was done in the same manner as for the course exit survey forms. For first seminar the attainment was 2.13 and for the second it was 2.66.

Final Attainment by Integration	
CO Attainment by	Attainment Value
Direct Tools	
Method 1 : Attainment by SPPU Results setting target value	2.7
Method 2: a) Attainment by SPPU Theory results + Internals	1.59
b) Attainment by UT	2.42
c) Attainment by Practical's	2.68
Method 3 : Attainment by Blooms Taxonomy Level based mapping	2
Indirect Tools	
Method 1 :-Course Exit Survey	1.131
Method 2 :- Seminar1	2.13
Seminar 2	2.66
Total Course Outcome attainment for OSA is estimated as: - 80 percent of average direct methods attainment + 20 percent of average indirect methods= $1.82+0.47=$ 2.29	

6. Conclusion:-

In this paper an empirical method was proposed to find the correlation between the course outcomes and the program outcomes. Three direct attainment methods and two indirect attainment methods were developed to find the overall attainment of the course. As per the directives given by the NBA, attainment for the course was calculated by considering 80 percent weight for direct method and 20 percent weight for the indirect method. All the above methods were tested for the sample case of the course Operating system administration. The Expected CO attainment of any subject is its maximum strength value i.e. 3. So the final attainment value taking averages of all direct

methods and indirect methods for OSA is derived as 2.29. This value can be claimed as satisfactory. Future scope includes designing indirect attainment methods based on rubrics.

Acknowledgement

The authors would like to acknowledge the management Hon. Sanjay D Patil, president, Hon. Satej .D. patil, chairman Hon.Col(rtd).S.K.Joshi, Campus director, D Y Patil educational complex Akurdi for providing conducive environment to carry out the entire statistical evaluations. Thanks to Principal Dr. Balapgoal and Vice Principal P Malathi for their continuous support.

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