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Assessment Method for Course Outcome Attainment: A Case Study in Engineering Education

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Abstract— the accreditation process conducted by National Board of Accreditation (NBA) in India is a quality assurance process to determine whether educational institutes are meeting the program objectives. The process involves measuring the attainment of program objectives in terms of Program Ou3tcomes attainment and Course Outcome attainment levels. In this paper we describe the methodology for computation of Course Outcomes attainment we have designed and implemented in Information Technology department as part of the accreditation process. A running example of how the method is shown for one of the core courses in engineering program. Also, a discussion on the utilization of Course Outcome attainment values is done.

Keywords **-** Course Outcome, Internal Assessment, Attainment calculation, NBA

I. INTRODUCTION

With growing number of technical institutions in the country it becomes necessary for one to measure the quality of an institution, especially in terms of objectives achieved by students graduating from the institutions. In this regard All India Council for Technical Education (AICTE) set a committee called National Board of Accreditation, which accredits various programs in Technical institutions in India.

The accreditation process conducted by National Board of Accreditation in India is a quality assurance process to determine whether educational institutes are meeting the objectives. Any student completing graduation is expected to possess certain qualities, during and after the completion of his/her program and are referred to as Program Outcomes (PO), also called Graduate Attributes.

In order to measure the Program Outcomes, each institute defines Course Outcomes (CO) for all the prescribed courses in the various programs offered by it. These parameters need to be assessed periodically to understand whether the Program Outcomes are achieved or not.

In this paper we describe the methodology for computation of Course Outcomes attainment we have designed and implemented in Information Technology department as part of the accreditation process. Section II describes the various assessment tools we have considered for computation of Course Outcome attainment. Section III explains in detail the process of computation of CO attainment utilizing these tools. A running example of how the method is also shown in this section for one of the core courses in engineering program. Section IV gives a discussion on various usages of Course Outcome attainment values.

II. ASSESSMENT OF COURSE OUTCOMES

In this section we present the various tools and how they are mapped for calculation of Course Outcome attainment.

II.I Tools for Course Outcome assessment

The various assessment tools evaluates student's knowledge and ability to apply their skills in continuous assessments like internal examinations, end semester examinations, presentations, assignments, Projects, tutorials etc. These tools are the evidence of student learning. The various tools used for the assessment of Course Outcome are as follows:

1. Internal Assessments for theory courses - 2 mid exams and 2 assignments per semester.
2. Computer Lab Exercises / examinations (Weekly lab exercises , internal examination and end semester external examination)
3. End Semester Examinations for theory courses.

Description of different types of course assessment and evaluation methods:

1. **Internal Assessment:**
   Performance of students in each subject is evaluated internally through MID exams and assignments.
   a. **Mid Exams:** Mid examination consists of two parts: part A comprising of 5 compulsory questions each of which carries 2 marks and Part B comprising of 5 questions of 10 marks each of which the student needs to answer any 3 questions. While descriptive questions test the candidate's ability to express the concept in detail, the short answer questions shows his/her ability to grasp the main concept and to apply the concept concisely on a problem. A satisfactory performance is an indication of attainment of Course Outcomes.

   b. **Assignments:** Minimum of two assignments per semester are to be submitted by the students. The assignments are basically exercise problems to check the ability of the student in applying, solve/implement the concept.

Total Internal assessment is for 25 marks per subject (20 for mid exam and 5 for assignments). There are minimum two mid exams per semester and average of these mid marks is taken for final evaluation.

2. Computer Laboratory Exercises:
To evaluate a student's performance in practical oriented subjects, labs are prescribed as part of the syllabus. A set of prescribed lab programs are given in the lab syllabus for each lab course. Lab sessions are conducted weekly for such subjects and a weekly evaluation is done in every lab session. At the end of the semester internal and external lab exams are conducted. This continuous practical sessions and end semester evaluation helps students to gain practical knowledge on theory as well in application program development. The performance assessed is an evaluation of course outcome.

3. End Semester (external) Examination:
The external examination is for 75 marks comprising of two parts: part A comprising of 10 compulsory questions each of which carries 2 marks and Part B comprising of 8 questions of 11 marks each, of which the student needs to answer any 5 questions. The performance of this along with internals is taken for giving the final program performance for the student. End semester examination becomes primary evaluation criteria for student's performance either in placements or in higher studies such as MS or M.Tech./PhD. In other words this assessment tool is primary for evaluation of attainment for the program.

II.II Mapping assessment tools for calculation of Course Outcomes attainment levels:

1. Internal Assessment:
Performance of students in each course is evaluated internally through MID exams and assignments by the respective faculty teaching the course. Questions in the mid exam and assignments are mapped to the CO's of the respective subject by the faculty. On completion of evaluation of the mid exam scripts and also the assignment given to students, the faculty tabulates the marks obtained in mid exam with their respective CO's in the format as shown in Fig 1.

Fig 1. CO Mapping Format for Mid exam

Department of IT

ACADEMIC YEAR 2014-15

Course Outcome attainment - Internal Exam I

Year : Sem: Sec: MID:

Subject :

			PART A(Question No:CO mapped)					PART B(Question No:CO mapped)				
S.No	ROLL NO	Name	1 :CO 1	2 :CO 3	3 :CO 2	4:CO 2	5 :CO 1	6:CO 1	7 :CO 3	8 :CO 2	9 :CO 2	10:CO 2

Calculation of Course Outcome Attainment for mid exams

i. Utilizing the tabulated marks the class average for each question is calculated as

$$CA = \left\lfloor \frac{Total\ marks\ obtained\ by\ all\ students}{No.\ of\ students\ attempting\ the\ question} \right\rfloor$$

ii. The number of students having marks greater than or equal to the Class Average marks for each question is then calculated (GCA).

iii. Percentage of students having marks greater than the Class Average marks, P.CA, for each question is calculated as

$$P.CA = \frac{GCA}{No.\ of\ students\ attempting\ the\ question}$$

iv. For each Course Outcome of the course calculate Course Outcome attainment as follows:

a) List the questions that map to the given CO.
b) The percentage of students attained the given CO, P.CO, is given by

$$P.CO = \frac{\sum P.CA \text{ of Questions mapped to the CO}}{No. \text{ of questions mapped to this CO}}$$

2. End Semester (external) Examination:
The process for calculating the CO's attainment for external examination is very much similar to the one used for internal examination, however the process of data collection is different. The questions in the external examinations are also mapped to the CO's of the respective course by subject experts. Since our institution is autonomous, we obtained special permissions from Dean Academics and Controller of Examinations through Principal to collect question wise marks obtained by the students in end examinations to enable us to calculate CO attainment for all courses of the program. Faculty were deputed from the department to collect the data from examination department and tabulate the same in the format as shown in Fig 2. *The process for calculation of Course Outcome Attainment for end exam is same as that used for internal assessment, as explained before.*

Fig 2. CO Mapping Format for external exam

Department of IT
ACADEMIC YEAR 2016-17
Course Outcome attainment - End Exam

Year : Sem:
Subject :

	Question Number - Course Outcome Number																		
	PART A										PART B								
S.No	Q1: CO 1	Q2: CO 3	Q3: CO 1	Q4: CO 2	Q5: CO 4	Q6: CO 5	Q7: CO 5	Q8: CO2	Q9: CO 1	Q10: CO6	Q11: CO1	Q12: CO3	Q13: CO2	Q14: CO3	Q15: CO2	Q16: CO5	Q17: CO6	Q18: CO4	Total Marks (Max: 75)

3. Computer Laboratory Exercises:
At the end of the semester there will be internal and external lab exams with an evaluation for 25 and 50 marks respectively. The lab programs are mapped to the CO's of the respective lab course by subject experts. Each student is given any one or two programs from the prescribed set for both internal and external exams. The corresponding faculty tabulates the marks obtained in internal and external exam with their respective CO's in the format as shown in Fig 3.

Fig 2. CO Mapping Format for external exam

Department of IT
ACADEMIC YEAR 2016-17
Course Outcome attainment - Lab Exam

Year : Sem:
Subject :

S.No	ROLL NO	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Total Marks

The process for calculation of Course Outcome Attainment for computer Laboratory internal and external exams are same as that used for mid assessment and external examination of a theory course as explained before.

III. CO ATTAINMENT CALCULATION

In this section we describe the methodology used for calculating CO attainment levels in general for any course. The same method was applied for all the courses in the program. Also, we present a running example for better understanding of the methodology.

III.I Calculating the final CO attainment levels for a Course:
Once the CO attainment values for a course using the assessment tools have been calculated, the final CO attainment values are calculated using the formula stated below:

$$CO_i.AL = x * CO_{iInt} + y * CO_{iExt}$$

Where,

- $CO_i.AL$ is the Course Outcome Attainment level for i^{th} Course Outcome of the course,
- CO_{iInt} is the Course Outcome value obtained from the internal assessment for i^{th} Course Outcome of the course,
- CO iExt is the Course Outcome value obtained from the external examination for ith Course Outcome of the course,
- x is the weight given for internal assessment and y is the weight given for external examination.

The weights used for theory courses and lab courses are as below:

- For Theory Courses (Maximum Marks =100)
  - x = 0.25, i.e., 25% weightage given to Internal assessment.
  - y = 0.75, 75% weightage given to External examination.

- For Lab Courses (Maximum Marks =75)
  - x = 0.33, 33% weightage given to Internal assessment.
  - y = 0.67, 67% weightage given to External examination.

III.II A Running Example:

CO attainment calculation is shown for one of the core courses "Design and Analysis of Algorithms" which is a course taught in III year I Semester.

Internal Assessment:
There are 2 mid exams for every course. At the end of the mid exam the corresponding faculty tabulates the marks obtained in the format shown previously. The questions in the 2 mid exams of "Design and Analysis of Algorithms" course map to the COs as shown in Table 1.

Table 1. CO Mapping for DAA in both mid exams

Question No.	1	2	3	4	5	6	7	8	9	10
Course Outcome Mapped in Mid I	1	3	2	2	1	1	3	2	2	2
Course Outcome Mapped in Mid I	4	6	5	5	6	4	6	4	5	6

It is clearly seen that the Course Outcomes of the course are distributed among questions – both short answer type and descriptive in both the mid exams.

For each internal exam the total marks obtained by all students for each question is calculated. Utilizing this the class average is computed and then the percentage of students obtaining marks greater than or equal to class average is obtained as explained earlier. The calculations for mid I and II exams for "Design and Analysis of Algorithms" course computed are shown in Fig 3 through 6 respectively.

Fig 3. Calculations for Mid I

Question No	Part A (Max Marks =2)					Part B (Max Marks =10)				
	1	2	3	4	5	6	7	8	9	10
CO Mapping	1	3	2	2	1	1	3	2	2	2
Total marks obtained by all students (In a class of 60)	90	71	61	49	47	196	171	149	102	115
No. of students attempted the questions	51	50	47	38	34	34	33	28	17	18
No. of students obtaining marks ≥ class average	51	50	47	38	34	29	22	17	11	16
Percentage of students with marks ≥ class average marks	100	100	100	100	100	85.3	66.7	60.7	64.71	88.9

Fig 4. Course Outcome Attainment for mid I

Course Outcome No.	$\frac{\sum P.CA \text{ of Questions mapped to the CO}}{No \text{ of questions mapped to this CO}}$	P.CO
Course Outcome 1	(100+100+85.29411765)/3	95.1
Course Outcome 2	(100+100+60.71428571+64.70588235+88.88888889)/5	82.86
Course Outcome 3	(100+66.66666667)/2	83.33

Fig 5. Calculations for Mid II

Question No	Part A (Max Marks =2)					Part B (Max Marks =10)				
	1	2	3	4	5	6	7	8	9	10
CO Mapping	4	6	5	4	6	4	6	4	5	6
Total marks obtained by all students	84	77	73	62	62	203	221	215	149	153
No. of students attempted the questions	47	46	44	41	40	29	33	29	20	20
No. of students obtaining marks ≥ class average	47	46	44	41	40	11	26	20	13	14
Percentage of students with marks ≥ class average marks	100	100	100	100	100	37.9	78.8	68.97	65	70

Fig 6. Course Outcome Attainment for mid II

Course Outcome No.	$\frac{\sum P.CA \text{ of Questions mapped to the CO}}{\text{No of questions mapped to this CO}}$	P.CO
Course Outcome 4	(100+100+37.9310+68.9655)/4	76.72
Course Outcome 5	(100+65)/2	82.5
Course Outcome 6	(100+100+78.7878+70)/2	87.2

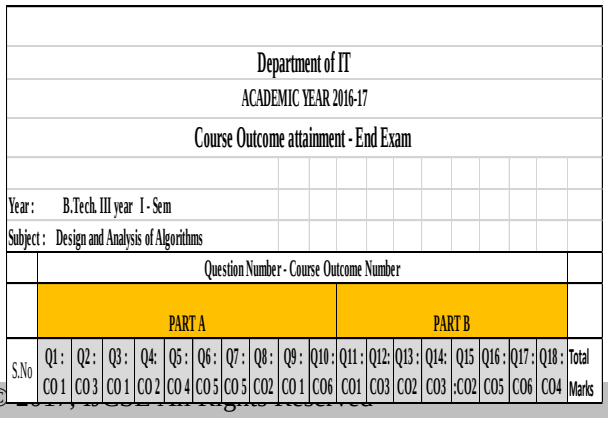
Calculations for both the mid exams for each section are computed similarly. Final values of Course Attainment for internal assessment are obtained by taking an average of section A, B and are tabulated as shown in Table 2.

Table 2. CO Attainment for internal assessment

CO No.	P.CO for section A	P.CO for section B	Final P.CO for Internal Assessment
CO 1	95.1	86.11	90.60
CO 2	82.86	85.57	84.22
CO 3	83.33	87.5	85.42
CO 4	98.95	76.72	87.84
CO 5	100	82.5	91.25
CO 6	100	87.19	93.60

End Semester (external) Examination:
On completion of evaluation of external scripts and result announcement a few deputed faculty from the department tabulates the marks obtained in the external exams in the format shown previously. The questions in the external exams of "Design and Analysis of Algorithms" course map to the COs as shown in Fig 7.

Fig 7. CO Mapping for DAA in external exams



Department of IT

ACADEMIC YEAR 2016-17

Course Outcome attainment - End Exam

Year: B.Tech. III year I - Sem

Subject: Design and Analysis of Algorithms

	Question Number - Course Outcome Number																		
	PART A										PART B								
S.No	Q1 : CO 1	Q2 : CO 3	Q3 : CO 1	Q4: CO 2	Q5 : CO 4	Q6 : CO 5	Q7 : CO 5	Q8 : CO2	Q9 : CO 1	Q10 : CO6	Q11 : CO1	Q12: CO3	Q13 : CO2	Q14: CO3	Q15 :CO2	Q16 : CO5	Q17 : CO6	Q18 : CO4	Total Marks

Calculations for End Examination:
For the external exam the total marks obtained by all students for each question is calculated. Utilizing this the class average is computed and then the percentage of students obtaining marks greater than or equal to class average is obtained as explained earlier. The calculations for external exam for "Design and Analysis of Algorithms" course computed are shown in Fig 8 and Table 3 shows the CO attainment calculations for the same.

Fig 8. Calculations for external exam

Question No	Part A (Max Marks =2)										Part B (Max Marks =11)							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CO Mapping	1	3	1	2	4	5	5	2	1	6	1	3	2	3	2	5	6	4
Total marks obtained by all students	110	62	188	110	101	142	71	158	135	48	829	471	529	258	87	446	367	626
No. of students attempted the questions	65	38	95	62	58	77	48	81	69	33	88	50	61	28	9	53	42	76
No. of students obtaining marks ≥ class average	65	38	95	62	58	77	48	81	69	33	64	39	42	25	8	36	30	54
Percentage of students with marks ≥ class average	100	100	100	100	100	100	100	100	100	100	72.7	78	68.85	89.28	88.8	67.92	71.4	71.05

Table 3. CO Attainment for external exam

CO No.	$\frac{\sum P.CA \text{ of Questions mapped to the CO}}{\text{No of questions mapped to this CO}}$	P.CO
CO 1	(100+100+100+72.7)/4	93.18
CO 2	(100+100+68.85+88.8)/4	89.44
CO 3	(100+78+89.28)/3	89.1
CO 4	(100+71.05)/2	85.53
CO 5	(100+100+67.92)/3	89.31
CO 6	(100+71.4)/2	85.71

Course Outcome Attainment Calculation
Once the CO attainment for the internal and external assessments have been done the final CO attainment values are calculated by applying a 0.25 weightage for internal assessment and 0.75 weightage for external assessment. The calculations for "Design and Analysis of Algorithms" course computed are shown in Table 4.

Table 4. Calculation of Final CO Attainment

CO No.	Internal Assessment attainment value (IA)	End Exam attainment value (EE)	CO Attainment Level = (0.25*IA + 0.75*EE)

CO 1	90.60	93.18	92.54
CO 2	84.22	89.44	88.13
CO 3	85.42	89.1	88.18
CO 4	87.84	85.53	86.11
CO 5	91.25	89.31	89.79
CO 6	93.60	85.71	87.69

IV. CONCLUSION

In this paper we have discussed the methodology we have used for computation of Course Outcome attainment for the courses prescribed in the syllabus of engineering program. The method so described can be utilized for inferring information on attainment of individual Course Outcome, attainment of a Course as a whole and finally attainment of various Program Outcomes to which the course is mapped to. The method described has been applied to all the courses in a similar manner and the CO attainment values has been obtained. Course Outcome attainment target levels for each CO in each course was set based on the importance and level of difficulty of the CO by subject experts in the department. The target CO attainment level differ for internal assessment, end examination and also differ across the various courses of the program. Also, the set levels are higher for the internal assessment when compared to the ones set for external examination for each course of the program.

The computed values of CO attainment was compared to the target values to infer whether a Course Outcome is attained or not. Based on the discrepancies between the set target level and attainment level of each CO, necessary actions are recommended to improve the program curriculum. Improvements may be made by suggesting changes in course structure like adding new courses, additional electives, incorporating many training programs including modification of regulations.

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