

# Impact of Quality of Question Papers and Rubrics in Outcome Based Education in Engineering - A Case Study Approach

Shahanaz Ayub

Faculty at Department of Electronics and Communication Engineering,  
Bundelkhand Institute of Engineering and Technology (BIET),  
Jhansi, UP, India  
E-mail: sayub@bietjhs.ac.in

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**Abstract**—Outcome based education in Engineering is essential criteria for NBA accreditation of engineering programs which ensures quality in education, teaching learning process and hence adds the value worldwide proving the attainments of set outcomes. NBA ( National Board of Accreditation) has prescribed twelve program outcomes also called graduate attributes which a graduating UG student must attain. To attain this program outcomes, the courses in the curriculum is so designed that the course outcomes are very well mapped with program outcomes. To find out the course outcome attainment there are direct and indirect assessment methods. Direct assessment method is based on examination marks obtained in end semester examination, class tests, tutorials, assignment and indirect assessment is based Rubrics as course exit survey. Student feedback is taken in indirect assessment and it is proved that influence of positive psychology plays a vital role in maximum outcomes attainment with indirect assessment. Direct assessment weightage is considered to be 80% and indirect assessment weightage is considered to be 20%. As the direct assessment is based on examinations, the quality of question paper plays an important role in attainment. If the questions in the question paper is not properly mapped with course outcomes then the further mapping of Course outcomes to program outcomes does not reach to proper attainment. This whole process of direct and indirect assessment is explained in this paper with one proper example of course "EEC604 Microcontroller" in third year of B.Tech Electronics and Communication Engineering program at Bundelkhand Institute of Engineering and Technology Jhansi, UP, India

**Keywords:** Outcome based Education, NBA, Accreditation, CO-PO Mapping, Rubrics, Attainment.

## Introduction

National Board of Accreditation is an autonomous body for accreditation of Engineering programs. It has prescribed essential parameters/ outcomes [1] to be achieved and the system follows is outcome based education ( OBE). Accreditation not only boosts the confidence in stakeholders but students get worldwide recognition through their degrees as they have gained the graduate attributes prescribed by NBA. NBA has prescribed 12 graduate attributes which are

also called as Program Outcomes ( POs). Every curriculum is structured with theory and laboratory courses. Each course is designed with atleast 3 to 6 course outcomes. Formulation of these course outcomes is done by a course committee during the design of the course syllabus. These course outcomes are designed based on levels of Revised Blooms Taxonomy[2,3,4]. There are six levels of Revised Blooms Taxonomy as Understand, Remember, Apply, Analyse, Evaluate and Create. In UG and PG Engineering programs, first two levels that is Understand and remember are not considered while formulation of Course Outcomes ( COs) and POs. To evaluate the attainment of POs, attainment of COs is important. The course outcomes of all the courses are mapped to 12 program outcomes. The levels of mapping are 1 for LOW, 2 for MODERATE, 3 for HIGH. It may be possible that some of the program outcomes are not at all mapped with course outcomes. In such cases "-" is put. To illustrate this mapping which is also called as Course Articulation Matrix[5,6] for one course is given in table 1 for the course EEC604 Microcontroller subject of Sixth semester of B.Tech Electronics and Communication Engineering program at Bundelkhand Institute of Engineering and Technology ( BIET), Jhansi, UP, India. Where EEC604 is course code and Microcontroller is course title (see Table 1).

The course outcomes ( COs) of this course are,

After the successful completion of the course, students will be able to,

I. COEEC604.1 : Apply the basic principles of microcontroller based design and development.(PO-1 m, PSO-1s)

II. COEEC604.2 : Apply the knowledge of fundamentals of microcontroller programming and interfacing technology to solve engineering problems (PO-1 m, PO-3 s, PSO-1s, PSO-2s)

III. COEEC604.3 : Apply the knowledge of programming using modern tools for interfacing (PO -5 s, PSO-1s)

IV. COEEC604.4 : Design a functional prototype for real world applications. ( PO-3 s, PSO-1s, PSO-2s)

V. COEEC604.5 : Undertake problem identification, formulation and selection of appropriate microcontroller . (PO-2 s, PSO-1s)

**Table 1: Course Articulation Matrix or CO-PO mapping of course EEC604 Microcontroller**

COs of EEC604	PO1	PO2	PO3	PO4	PO5
CO1	2	-	-	-	-
CO2	2	-	3	-	-
CO3	-	-	-	-	3
CO4	-	-	3	-	-
CO5	-	3	-	-	-

As the main focus of this research paper is on quality of question papers and Rubrics for attainment, hence attainment of Program Specific Outcomes (PSOs) is not considered as PSOs may vary from Institute to Institute but Program Outcomes are same for all those who refers to Washington Accord for Accreditation and these are similar to 12 Graduate Attributes prescribed by NBA. These 12 Program Outcomes are given here briefly to understand the further discussion.

#### Twelve Program Outcomes/ Graduate Attributes

1. Engineering knowledge
2. Problem analysis
3. Design & Development of Solutions
4. Investigation of Complex Problem
5. Modern tool usage
6. Engineer and society
7. Environment& sustainability
8. Ethics
9. Individual & team work
10. Communication
11. Lifelong learning
12. Project management & finance

#### Methodology

Step 1. Form the Course articulation Matrix that is Mapping of Course Outcomes of Course EEC604

Step 2. Set the Target for attainment levels, this may be different for all program outcomes but here it is same for all and it is kept as 2, as decided by the departmental committee.

Step 3. Course Outcomes attainment is done by Direct Assessment and Indirect Assessment[7]. 80% of Direct assessment and 20% of Indirect assessment is taken.

Step 4. Direct assessment is done on the basis of marks obtained in End Semester Examination ( ESE), Class Tests ( CTs) and Continuous Assessment ( CA) i.e. attendance and performance in the class, assignments, tutorials, Quizzes, Mini project or some other tools.

Step 5. In this paper, the method used in the department is followed. ESE Weightage is 70%, CTs weightage is 20% and CA is 10%.

Step 6. Indirect assessment is done on the basis of course exit survey. Rubrics is the tool used for indirect assessment. assessment levels are kept as 1 for Very POOR, 2 for POOR, 3 for GOOD, 4 for Very GOOD, 5 for Excellent.

Step 7. ESE question paper is taken and all the questions are mapped to Course Outcomes.

Step 8. Class Tests papers are taken and all the questions are mapped to Course Outcomes.

Step 9. CO attainment based on Continuous assessment is equally given to all COs. Microcontroller to all the 12 Program Outcomes.

**Table 2: Rubrics for Indirect Attainment**

S. No.	Question	Level
1	Can you apply the basic principles of microcontroller based design and development	
2	Can you apply the knowledge of fundamentals of microcontroller programming and interfacing technology to solve engineering problems	
3	Can you apply the knowledge of programming using modern tools for interfacing	
4	Can you design a functional prototype for real world applications.	
5	Can you undertake problem identification, formulation and selection of appropriate microcontroller .	

Step 10. For Indirect assessment, the course exit survey is conducted for all students ( 61 students i.e. strength of the class). Rubrics is followed as given in step 6.

The survey is conducted as given in table 2 for each student(see Table 2). The levels are set as given in step 6. The survey is conducted on last day of the ESE. This just ensures the 100 % attendance for conducting survey.

**Illustrations**

As per Step 7, ESE paper is taken, total marks for ESE of course EEC604 are 50. Total 4 questions were asked.

Q1. 12 marks ( Attempt any 3 out of 5, each question carries 4 marks ) mapped to CO1

Q2. 12 marks ( Attempt any 3 out of 5, each question carries 4 marks ) mapped to CO3

Q3. 14 Marks ( Attempt any 2 out of 3, each question carries 7 marks ) mapped to CO2 and CO5 equally.

Q4. 12 Marks ( Attempt any 3 out of 5, each question carries 4 marks ) mapped to CO4.

Assessment levels for ESE, CTs, CA and Indirect Assessment are kept same as,

1 for 60% or more than 60% students score 60% or more than 60% marks.

2 for 70% or more than 70% students score 60% or more than 60% marks.

3 for 80% or more than 80% students score 60% or more than 60% marks.

Table 3 shows COs attainment based on ESE marks (see Table 3).

**Table 3: CO attainment on ESE marks**

Question	Q1	Q2	Q3	Q4
Mapped to	CO1	CO3	CO2, CO5	CO4
Max Marks	12	12	14	12
Roll No.	Marks Obtained			
1	7	4	12	10
2	10	7	12	8
3	6	9	5	8
4	12	4	13	10
:	:	:	:	:
:	:	:	:	:
61	12	8	12	10
No. of students scoring 60% or more than 60% marks	50 i.e 50/61 i.e 81.96%	43 i.e 43/61 i.e 70.49%	56 i.e 56/61 i.e 91.80%	50 i.e 50/61 i.e 81.96%
<b>Attainment</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>3</b>

As per Step 8, CT paper is taken, total marks for CT of course EEC604 are 15. Total 2 questions were asked in each CT.

CT1

Q1. 8 marks ( Attempt any 4 out of 6, each question carries 2 marks ) mapped to CO1

Q2. 7 marks ( Attempt any 2 out of 3, each question carries 3.5 marks ) mapped to CO3

CT2

Q1. 8 Marks ( Attempt any 4 out of 6, each question carries 2 marks ) mapped to CO2 .

Q2. 7 Marks ( Attempt any 2 out of 3, each question carries 3.5 marks ) mapped to CO4.

CO5 is not mapped with any of the questions in CTs. Table 4 shows CO attainment based on CT marks ( see Table 4).

**Table 4. CO attainment on CT marks**

CT	CT1	CT1	CT2	CT2
Question	Q1	Q2	Q1	Q2
Mapped to	CO1	CO3	CO2	CO4
Max Marks	8	7	8	7
Roll No.	Marks Obtained			
1	7.5	3.5	6	3
2	5.5	3	8	5
3	6.5	0	2.5	5
4	8	2	5	6
:	:	:	:	:
:	:	:	:	:
61	8	4.5	7.5	7
No. of students scoring 60% or more than 60% marks	52 i.e 52/61 i.e 85.24%	43 i.e 43/61 i.e 70.49%	43 i.e 43/61 i.e 70.49%	37 i.e 37/61 i.e 60.66%
<b>Attainment</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>

As per step 9, CO attainment based on CA is calculated. Maximum marks for CA were 10. All 61 students scored more than 60% marks. So CO attainment for all COs is 3 each.

As per step 10, a course exit survey is conducted on Rubrics as given in table 2.

Table 5 shows the CO attainment based on Indirect assessment ( see Table 5).

**Table 5: CO attainment on Indirect Assessment marks**

Question	Q1	Q2	Q3	Q4	Q5
Mapped to	CO1	CO3	CO2	CO4	CO5
Max Marks	5	5	5	5	5
Roll No.	Marks Given by student				
1	4	3	3	4	4
2	3	4	4	4	4
3	4	5	4	2	4
4	5	3	3	3	4
:	:	:	:	:	:
:	:	:	:	:	:
61	3	3	3	3	3
No. of students	56	54	54	51	51

scoring 60% or more than 60% marks	i.e 56/61 i.e 93.33 %	i.e 54/61 i.e 90%	i.e 54/61 i.e 90%	i.e 51/61 i.e 83.6%	i.e 51/61 i.e 83.6%
<b>Attainment</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>

Final CO attainment is shown in table 6 (see Table 6).

DA is Direct Assessment.

for CO1 to CO4,

$$DA = 0.7 \text{ ESE} + 0.2 \text{ CT} + 0.1 \text{ CA}$$

for CO5, as none of the question was mapped with CO5

$$DA = 0.9 \text{ ESE} + 0.1 \text{ CA}$$

IA is Indirect Assessment.

FA is final CO attainment.

$$FA = 0.8 \text{ DA} + 0.2 \text{ IA}$$

**Table 6. Final CO attainment- FA**

COs	Attainments					
	ESE	CT	CA	DA	IA	FA
CO1	3	3	3	3	3	3
CO2	3	2	3	2.8	3	2.84
CO3	2	2	3	2.1	3	2.28
CO4	3	1	3	2.6	3	2.68
CO5	3	-	3	3	3	3

PO attainment is calculated as ,

$$\text{CO attainment} \times \text{PO mapping level} / 3.$$

From Table 1, Cell 2 x 2 i.e cell of second row and second column is showing PO1 mapping level 2, and this cell corresponds to CO1, as CO1 final attainment FA is 3, PO1 attainment =

$$3 \times 2 / 3 = 2$$

Similarly, From Table 1, Cell 3 x 2 i.e cell of third row and second column is showing PO1 mapping level 2, and this cell corresponds to CO2, as CO2 final attainment FA is 2.84, PO1 attainment =

$$2.84 \times 2 / 3 = 1.89.$$

And so on all the PO attainments are calculated and shown in Table 7 (see Table 7).

**Table 7. PO Attainments**

COs of EEC604	PO1	PO2	PO3	PO5
CO1	$3 \times 2 / 3 = 2$	-	-	-
CO2	$2.84 \times 2 / 3 = 1.89$	-	2.84	-

CO3	-	-	-	2.28
CO4	-	-	2.68	-
CO5	-	3	-	-
Average	1.945	3	2.76	2.28
<b>Target level</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>
<b>Target achieved?</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>

### Inferences

Throughout the Illustrations shown above, consider that the questions in the ESE paper and CT papers are mapping fully with corresponding CO. But if the level of questions mapping with CO should have been low i.e 1 then the final attainments would have been as shown in Table 8 ( see Table 8).

**Table 8: Final CO attainment with low quality of question paper- FA<sub>L</sub>**

COs	Attainments					
	ESE	CT	CA	DA	IA	FA
CO1	$3 \times 1/3 = 1$	$3 \times 1/3 = 1$	3	1.2	3	1.56
CO2	$3 \times 1/3 = 1$	$2 \times 1/3 = 0.67$	3	1.134	3	0.71
CO3	$2 \times 1/3 = 0.67$	$2 \times 1/3 = 0.67$	3	0.903	3	1.32
CO4	$3 \times 1/3 = 1$	$1 \times 1/3 = 0.33$	3	1.066	3	1.45
CO5	$3 \times 1/3 = 1$	-	3	1.2	3	1.56

If the level of questions mapping with CO should have been moderate i.e 2 then the final attainments would have been as shown in Table 9 ( see Table 9).

**Table 9. Final CO attainment with Moderate quality of question paper- FA<sub>M</sub>**

COs	Attainments					
	ESE	CT	CA	DA	IA	FA <sub>M</sub>
CO1	$3 \times 2/3 = 2$	$3 \times 2/3 = 2$	3	2.1	3	2.28
CO2	$3 \times 2/3 = 2$	$2 \times 2/3 = 1.33$	3	1.966	3	2.17
CO3	$2 \times 2/3 = 1.33$	$2 \times 2/3 = 1.33$	3	1.497	3	1.80
CO4	$3 \times 2/3 = 2$	$1 \times 2/3 = 0.67$	3	1.834	3	2.07
CO5	$3 \times 2/3 = 2$	-	3	1.8	3	2.04

**5. Results and Discussions**

Table 7 shows, when questions in the question papers were highly mapped with COs, the target levels in PO attainment were achieved.

Table 10 shows, when questions in the question papers were low mapped with COs, the target levels in PO attainment were not achieved and the gaps between attained values and target values are high (see Table 10).

**Table 10. PO Attainments with FA<sub>L</sub>**

COs of EEC604	PO1	PO2	PO3	PO5
CO1	1.04	-	-	-
CO2	0.47	-	0.71	-
CO3	-	-	-	1.32
CO4	-	-	1.45	-
CO5	-	1.56	-	-
Average	0.755	1.56	1.08	1.32
<b>Target level</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>
<b>Target achieved?</b>	<b>No</b>	<b>No</b>	<b>No</b>	<b>No</b>

Table 11 shows, when questions in the question papers were moderately mapped with COs, the target levels in some PO attainment were not achieved and the gaps between attained values and target values are high for not attained POs(see Table 11).

**6. Conclusion**

This case study shows that quality of question papers and rubrics in Outcome Based Education in Engineering plays a vital role in outcome attainments.

**Table 11. PO Attainments with FA<sub>M</sub>**

COs of EEC604	PO1	PO2	PO3	PO5
CO1	1.52	-	-	-
CO2	1.45	-	2.17	-
CO3	-	-	-	1.80
CO4	-	-	2.07	-
CO5	-	2.17	-	-
Average	1.49	2.17	2.12	1.80
<b>Target level</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>
<b>Target achieved?</b>	<b>No</b>	<b>Yes</b>	<b>Yes</b>	<b>No</b>

Similarly, as mentioned in the methodology, that the course exit survey was conducted on the last day of ESE that is before the declaration of the result of the students. During the survey, students were aware of their CT marks and not the ESE marks but still the survey gives 100% attainment because the teaching learning is effective in outcome based education and because of this positive psychology, student develops the confidence that she/he has attained the course outcomes.

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