

Method for Assessment and Attainment of Course and Program Outcomes for Tier-I Institutes in India

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Abstract: Outcome-Based Education (OBE) is an important mode for student-centered education that gives direction to measure student performance through outcomes. As per the June 2015 format of the National Board of Accreditation, it is mandatory to implement Outcome Based Education (OBE) in technical education institutes. For effective OBE execution, it becomes necessary to introduce small changes in the teaching-learning process and significant changes in the assessment tools. This paper presents the methodology to be employed for the implementation of OBE and measurement of course outcomes and program outcomes in Tier-I institutes (Autonomous) in India.

Keywords: Outcome Based Education, NBA, Course Outcomes, Program Outcome, Attainment

1. Introduction

Technical education has a key role in the development of any nation. Demand for quality of education and an employable workforce is ever-increasing globally. It is often reported that there is growth in education providers over the years. In India, there are around 4000 engineering colleges with a capacity of about 14 Lakh seats. The recent surveys conducted by different government and private

agencies reported that about 80 % of engineering graduates are unemployable (Aspiring Minds, 2019) . The need for quality assurance in technical education thus becomes essential. A teacher transforms technical knowledge, employment skills, and necessary information to students in an existing teaching-learning process regarding technical education. There is a need to measure engineering graduates' ability as the present system lacks in this aspect. The students' learning and understanding of engineering courses are judged through an examination system that seeks answers to the questions, mostly from textbooks. But the fact is that we need to shift from the present Output-Based Education to an Outcome-Based Education system to meet the desired goals. The term Outcome Based Education was first presented by William Spady in 1994 through his book "Outcome-Based Education: Critical Issues and Answers", American Association of School Administrators. Outcome-Based Education (OBE) system help us adopt the measures to find out what the students can do. The continuous innovations in industries, global competition, and new business requirements have led to raising the bar for fresh engineering graduates' employability and success in a professional career (A.Kavitha et al., 2018).

B Kanmani et al. (2015) presented continuous improvements in the teaching-learning-process in outcome-based education. It is inferred that the self-assessment/review by the faculty at the end of the semester shall lead to a gradual improvement in the attributes addressed. Mr. Kiran B. Malagi et al. (2016) discussed the method for Attainment Measurement of

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CO's and PO's for Tier-II Institutions. The proposed method helps in preparing an effective lesson plan, drawing quality question paper. Drakshayani D N (2016) has reported a preliminary study on the attainment of course outcomes for outcome-based education in mechanical engineering using a case study of material science and metallurgy. VA Kulkarni et al. (2017) developed a case study through CO, PO mapping, and attainment for students of Tier-II institutes. The developed rubrics assessment is revealing of continuous improvement strategy that can be easily adaptable by faculty and students across engineering streams.

India became a signatory member of the Washington Accord on June 13, 2014. The Washington Accord is an international accreditation agreement for professional engineering academic degrees. Students obtaining a professional degree from accredited programs in any of the signatory countries are accepted by the other signatory countries as having met the academic requirements for entry to the practice of engineering. The Washington Accord covers undergraduate engineering degrees under Outcome Based Education (Sawant, 2016). National Board of Accreditation (NBA) had preferred for Outcome-Based Education (OBE) after India is a full signatory member of the Washington Accord.

The NBA has adopted the accreditation process through Tier-I and Tier-II formats. The Tier-I is used by autonomous institutes while Tier-II is meant for the affiliated institutes.

2. Outcome-Based Education

In outcome-based education, "product defines the process." Outcome-Based Education is an approach to education in which decisions about the curriculum, instruction, and assessment are driven by the exit learning outcomes that the students should demonstrate at the end of a program or a course. The OBE implementation is generally understood as a compliance-driven activity instead of a performance-driven activity. The outcomes of a program are the measure of abilities acquired by the graduate at the end of the program. The guidelines for desired outcomes are defined by the accreditation bodies. The National Board of Accreditation (NBA), the accreditation authority in India, has defined the desirable twelve program outcomes (POs).

Engineering Graduates will be able to:

1. Engineering knowledge
2. Problem analysis
3. Design/development of solutions
4. Conduct investigations of complex problems
5. Modern tool usage
6. The engineer and society
7. Environment and sustainability
8. Ethics
9. Individual and teamwork
10. Communication
11. Project management and finance
12. Life-long learning

In addition to the above POs, the program which is going for accreditation may define the program-specific outcomes (PSOs), which reveal the exact outcome of that program.

Program Specific Outcomes:

The Production engineering curriculum prepares graduates to:

PSO 1: Apply principles of engineering, basic science, and mathematics to model, analyze, design production systems and processes.

PSO 2: Plan, operate, control, maintain, and improve production systems, components, and processes.

PSO 3: Be prepared to work professionally as a production/mechanical engineer.

3. Implementation of Outcome-based education in Tier-I institutes; Case study of Production Engineering program at SGGS Institute of Engineering and Technology.

3.1 Define course outcomes:

To start the implementation of OBE in our institute, the first step is to define the course outcomes (COs)

for each course. COs are the statement that describes what students would be able to do at the end of the course. The course outcomes are framed as per Bloom's Taxonomy levels. It is ensured that while defining the CO should be attainable and measurable. The course outcomes of the course “Strength of material” are provided in table 1 as an example.

Table 1: Sample Course Outcomes

Course Code	Name of Course
PR 232	Strength of Materials
PR 232.1	Define, compute, and describe properties of engineering material, their behavior.
PR 232.2	Compute stresses and strains using analytical and graphical methods.
PR 232.3	Demonstrate the knowledge of critical loads, buckling of beams, strain energy, and torsion for simple problems.
PR 232.4	Analyze beams and columns under different loading and supporting conditions.

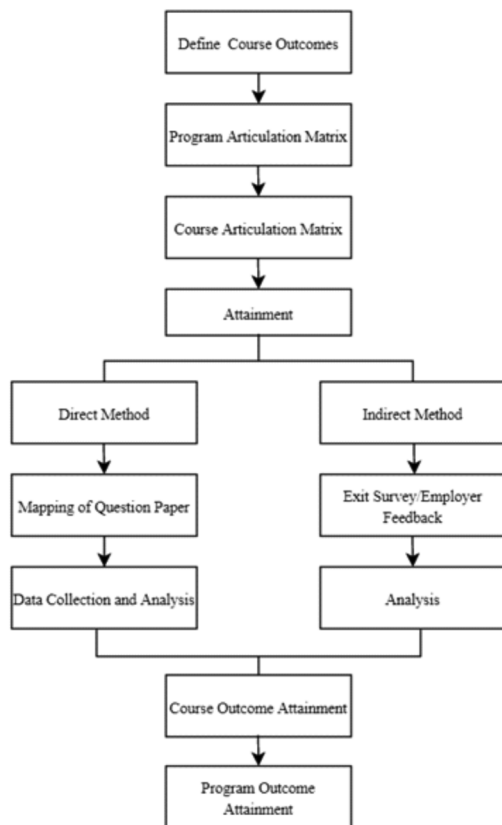


Fig.1:Flow chart for measurement of PO/PSO attainment

3.2 Preparation of program articulation matrix and course articulation matrix

The program articulation matrix is the mapping of courses with POs and PSOs. Different courses of the program with 12 POs and 3 PSOs are mapped on the scale of 1-2-3, where 1-represents Low rating, 2- Moderate rating, and 3- High rating. The sample program articulation matrix of a few courses in the Production engineering program is shown in Table 2.

Table 2 : Sample Program articulation matrix

Course Code	Name of Course	PO												PSO					
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
PR 232	Strength of Materials	1	3	1													2		3
PR 233	Thermal Engineering- I	1	3	1	2												2	1	2
PR 231	Casting and Welding	1	2	1		2	1										2	2	2
PR 243	Engineering Metallurgy	1	2		2	2											2	1	2
PR 245	Machine Drawing and CADD	1				3											1	2	3
PR3 52	Machine Design	2	2	3		3											2		2
PR3 55	Production Planning and Control	1					2						2				1	3	2
PR3 72	Heat and Mass Transfer	2	2	2												1	2		1
PR4 71	Production/Operations Management	2							2				3			1	2	2	
PR 472	Project Management	2	2			1			2				3					3	2
PR4 73	Quality and Reliability Engineering	2			3	2										3	2	2	
PR4 74	Computer-Aided Design		2			3	2									2	3	2	
PR 487	Final Project	1	3	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2

From the table, it is evident that a course may not have a mapping with all POs and PSOs. It can correspond to relevant PO/PSO. The mapping of the courses with POs and PSOs is done by the course

Table 3 : Sample course rating

PO/ PSO	Rating	Justification
PO 1	2	Conduction, convection, radiation, and the heat exchanger related simple engineering problems are solved using the knowledge of engineering fundamentals. The course curriculum contains principles of 1-D Heat transfer and other topics that moderately relate to PO1

PO 2	2	Students learn and solve complex design problems on heat exchangers. The course curriculum enables students to do the above moderately.
PO 3	2	The course contents enable students to address environmental issues in radiation heat transfer. Solar radiations: principles, use, and the greenhouse effect are taught to the students. The relation with PO 3 is moderate.
PO 12	1	The course help students for life-long learning as there exist an opportunity in topics like convection heat transfer. Thus, the correlation with PO 12 is low
PSO 1	2	Students acquire basic knowledge for the design of heat exchange systems by using principles of engineering and mathematics; hence the rating of the PSO is 2
PSO 5	1	Few course topics help students to work as professional mechanical/production engineer

coordinator based on his subject knowledge and experience. The sample example for the course “Heat and Mass transfer” is given in table 3 to describe how the mapping rating is done.

Similarly, the course articulation matrix is prepared for all the courses of the program. The course articulation matrix is the mapping of course outcomes with the POs and PSOs.

3.3 Attainment of course outcome:

The attainment of the COs of each course is measured by two methods

1. Direct Assessment
2. Indirect Assessment

3.3.1 Direct Assessment:

The student performance in different courses is to be evaluated by considering two theory examinations, mid-term, which is of 30 marks, and end-term, which is of 70 marks.

1. The question papers are set in accordance with the course outcomes for respective courses. Mapping of the questions and CO is prepared for mid-semester and end semester examination separately.

Table 4 : Sample mapping of questions with course outcomes

	Q.1	Q.2	Q.3	Q.4
CO1	Y	Y		
CO2	Y	Y	Y	
CO3	Y			
CO4	Y			Y

2. The sample mapping matrix between CO and questions is given below:

3. The question wise marks of each course for each student are recorded to measure the attainment.

4. From the recorded data, the number of students who have attempted the said question is determined.

5. If a student scores a minimum of 40% marks (or pre-set value) out of total marks allotted to the said question, then he is considered to have attained that course outcome.

6. Numbers of students acquiring 40% (or pre-set value) or more marks for each question are measured.

The attainment of the said question is obtained by using the formula.

$$\text{Attainment} = \frac{(\text{No. of students acquiring 40 \% marks})}{(\text{No. of students attempted that question})}$$

In this way, the attainment of each question is evaluated, and the attainment values are filled in the matrix prepared at step 1. and attainment of each CO is measured.

7. To calculate percentage attainment of the CO from the midterm and end-term examinations following formula is used:

$$a*x + b*y$$

Where a is the percentage of marks evaluated through continuous assessment such as assignment, midterm examination, b denotes the percentage of marks evaluated through end semester examination, x denotes midterm examinations percentage attainment, and y denotes end term examinations percentage attainment. In this way, the direct assessment of the CO for each course is carried out.

6. The attainment of each CO is calculated with respect to the target set by the course coordinator.

The target for each CO is decided based on the level of CO, and the level of questions asked related to that CO. The example below shows the method to decide the target.

3.3.2 Indirect assessment:

The course end survey is conducted at the end of each semester to collect the CO attainment data from each student. The course end survey consists of a prescribed format for all courses in the semester. The feedback/response of CO attainment is collected from the students of SY, TY, and B. Tech of the program at the end of the end term examination. The students rate the CO attainment on a scale of 1-2-3, 1- Low, 2- medium, and 3- High.

Table 5 : Justification for the expected level of attainment

Course Outcome		Expected Level	Justification
CO1	Define, compute, and describe properties of engineering material, their behavior.	90	This CO corresponds to BT1 and BT2 level in Bloom's Taxonomy. Hence it is expected that maximum students (90%) should attain the CO.
CO2	Compute stresses and strains using analytical and graphical methods.	85	This CO corresponds to BT2 and BT3 level in Bloom's Taxonomy, which expects a basic understanding of the computation of various parameters based on simple concepts and mathematical relations. Hence it is expected that 85% of students should attain the CO.
CO3	Demonstrate the knowledge of critical loads, buckling of beams, strain energy, and torsion for simple problems.	90	This CO corresponds to BT1 and BT2 level in Bloom's Taxonomy. Hence it is expected that maximum students (90%) should attain the CO.
CO4	Analyze beams and columns under different loading and supporting conditions.	65	This CO corresponds to the BT4 level in Bloom's Taxonomy, which expects a thorough understanding of basic principles and applies the knowledge to analyze real-life cases. Considering the difficulty level of the CO and cross-section of students in the class attainment level is set as 65%

3.4 Attainment of program outcome

Attainment of PO is one of the important parameters in OBE and NBA/NAAC. The direct method of assessment and indirect method of assessment is employed for measurement of program/program-specific outcomes.

3.4.1 Direct Assessment:

The data of CO attainment for all courses in the program is taken as input for evaluation of PO attainment. The method used for PO attainment is described below:

1. The target for the attainment of each CO is set by the course coordinator
2. The attainment of each CO is evaluated with respect to the target set.
3. The average of all CO attainment of the course is considered as the attainment of the respective course. The table illustrates the method for the course "Strength of Materials."
4. The mapping of course and PO is prepared in matrix form as a program articulation matrix.
5. The contribution of each course to the POs is mapped on a scale of 1-2-3 (L-M-H).

For example, if the rating of a course is 1 for a PO, then the PO attainment is 33% of the average course attainment. If the rating is 2, then the PO attainment is 66% of the average course attainment. Similarly, if the rating is 3, then the PO attainment is 100% of average course attainment. In this way, the attainment of each PO and PSO from each course in the program is determined. The average of all such attainments is considered as the attainment of that PO/PSO.

The average attainment of course outcome strength of the material is shown in table no. 6.

6. The Evaluated values of all PO/PSO attainment are measured with respect to the target value of PO/PSO, and final attainment is determined.

3.4.2 Setting of targets levels:

The following procedure is adopted for setting target levels for PO/PSO attainments.

a. Using the database of first-year (i.e., implementation of OBE), the mean of PO/PSO attainment value is calculated, which comes to be 54.50 with a standard deviation of 6.95.

b. Using the computed values of mean and standard deviation, a uniform target for all PO and PSO attainment is set using the following relation of statistics,

$$\text{Target} = \text{mean} + \text{standard deviation}$$

$$\text{Target} = 54.50 + 6.95 = 61.45 \approx 62$$

c. For an individual PO/PSO, the expected maximum attainment comes out to be 66 % under the assumption that there is an equal number of ratings (1-2-3) for mapping of course and PO/PSO.

Computation of maximum expected attainment level (66 %)

- Rating 1 corresponds to 0.33 contribution of the course for relevant PO/PSO
- Rating 2 correspond to 0.66 contributions of the course for relevant PO/PSO
- Rating 3 corresponds to 1 contribution of the course for relevant PO/PSO

Assuming an equal number of 1-2-3 ratings, the maximum expected attainment for a PO/PSO is

evaluated as,

$$\text{Maximum expected attainment} = (0.33 + 0.66 + 1.00) / 3$$

$$= 0.66 = 66 \%$$

It indicates that the set PO/PSO attainment target level is $62/66 = 93.93 \%$ of the maximum expected attainment.

d. In the future, when the majority of PO/PSO attains the existing target, it is proposed to set a new target (mean + 2*Standard deviation) to ensure continuous improvement in PO/PSO attainment.

The Attainment of PO and PSO for a particular academic year is shown in table no.7.

3.4.3 Indirect Assessment:

In the indirect mode of assessment, different surveys are conducted for the measurement of PO/PSO attainment.

- A student exit survey was conducted at the end of the academic year for passing out students.
- The survey is conducted among the employers/Alumni.

The feedback is taken on the scale of 1-2-3, 1- low rating, 2- medium rating, and 3- high rating.

Table 6 : Attainment of course outcome and course

Course Outcomes	CO Attainment	Expected Level	% Attainment	Course Attainment	PO1	PO2	PO3	PSO1	PSO3
					1	3	1	2	3
1 Define, compute, and describe properties of engineering material, their behavior.	85.41	90	94.90	95.33	31.46	95.3	31.46	62.92	95.33
2 Compute stresses and strains using analytical and graphical methods.	77.83	85	91.56						
3 Demonstrate the knowledge of critical loads, buckling of beams, strain energy, and torsion for simple problems.	86.66	90	96.28						
4 Analyze beams and columns under different loading and supporting conditions.	64.08	65	98.58						

Table 7 : Attainment of PO and PSO

PO/PSO	Average PO/PSO	Target	Attainment
1	45.4	62	73.2
2	57.7	62	93.1
3	46.7	62	75.3
4	47.2	62	76.1
5	63.7	62	TA
6	49.0	62	79.0
7	41.1	62	66.3
8	53.7	62	86.6
9	58.7	62	94.7
10	59.3	62	95.6
11	59.7	62	96.3
12	58.7	62	94.7
PSO 1	42.7	62	68.9
PSO 2	52.1	62	84.0
PSO 3	47.4	62	76.5

TA- Target Achieved

4. Conclusions

In this paper, a detailed method of assessing Course Outcome and Program Outcome in an undergraduate engineering degree program for Tier-I institutes is presented. This paper provides an attainment method that is prepared according to the direction provided by the NBA. The direct attainment is carried out for a course from examination results. Indirect attainment measurement is also done through different surveys. This analysis will help faculty to plan an effective scheme for course delivery, assessment, and student engagement in learning for betterment in the future. This would further strengthen the teaching-learning process. The method has a feature of setting new targets to ensure continuous improvement in PO/PSO attainment.

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