ORIGINAL RESEARCH ARTICLE

Outcome-based assessment in India: A method for quantifying course outcome attainment

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ABSTRACT

The National Board of Accreditation (NBA), India was established by the AICTE (All India Council of Technical Education) to assess the qualitative competence of the programs offered by engineering institutions. NBA focuses on outcome-based education (OBE). The main principles of OBE are to provide concluding significant outcomes, to expand the opportunities for success, to set high expectations to succeed. Each course is defined with a set of course outcomes. One of the key aspects of OBE is the attainment of course outcomes (CO). At the end of each course, the CO needs to be calculated and evaluated, to verify whether outcome expected has been attained or not. The attainment of the CO proves the efficiency of the teaching and learning process of the course. The course outcome attainment enables the faculties to plan and develop appropriate tools, materials and methodologies to improve the teaching learning process as well as to provide a measure for quality assurance. This paper shows the method to quantify the course outcomes with their target level. Assessment methods and tools are used to identify, collect and prepare data to evaluate the attainment of CO. This method can be applicable to all engineering programs in the line of accrediting their program to the NBA.

Keywords: outcome-based education; CO attainment; course outcomes; continuous improvement; NBA

1. Introduction

Outcome based education (OBE) is the system that has been adopted in education system around the world as it focusses on outcomes, performance and correct measures. It is an educational theory that emphasize on multiple style of teaching, assessments, opportunities to achieve students' outcomes. These outcomes could be set for the program, for the specific program, for the course and/or for the session[1]. In this paper, Engineering is considered to be the program and computer engineering is considered as specific program. OBE model is based on defining different parameters and characteristics called as graduates attributes (GA) or program outcomes (PO), program specific outcomes (PSO) and course outcomes (CO).

1.1. Program outcomes (PO)

Programme outcomes (PO) maps with the expectations from students to know and would be able to do upon the completion of the program. These relate to the skills, knowledge, and behaviour that students obtained via the program and are defined and listed by NBA.

1.2. Program specific outcomes (PSO)

Program specific outcomes (PSO) summarizes what the students should be able to perform at the end of the specific program or specialisation. Three PSOs have to be outlined by the department in consultation with all stakeholders of the department that includes students, faculty, alumni, industry experts. The outlined PSOs are generally reviewed by the head of the department (HOD) and are approved by the department advisory board (DAB) or department academic council (DAC). Sample PSOs are listed in **Table 1**.

Table 1. Program specific outcomes.

PSO	Statement
PSO1	Professional skills: the ability to understand and develop the software systems by applying the concepts and techniques in the areas related to data structures, algorithms, system software, networking, multimedia, web design and data science for efficient computer-based solutions.
PSO2	Problem-solving skills: the ability to understand the evolutionary changes in computing, apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success, real-world problems and meet the challenges of the society related to computer engineering.
PSO3	Successful career and entrepreneurship: the ability to employ modern computer languages, environments and platforms in creating innovative career paths to be an entrepreneur and a zest for higher studies.

1.3. Course outcomes (COs)

Course outcomes (CO) are outlined to help the learners to reason out the purpose of learning the course. These enables the learners to identify what learners will be able to do when successful completion of the course[2]. COs of sample course is shown in **Table 2**.

Table 2. Course outcomes.

C211—Computer graphics	
COs	**Statement**
C211.1	Define basic terminologies of computer graphics, interpret the mathematical foundation of the concepts of computer graphics and apply mathematics to develop computer programs for elementary graphic operations.
C211.2	Define the concept of windowing and clipping and apply various algorithms to fill and clip polygons.
C211.3	Explain the core concepts of computer graphics, including transformation in two and three dimensions, viewing and projection.
C211.4	Explain the concepts of color models, lighting, shading models and hidden surface elimination.
C211.5	Describe the fundamentals of curves, fractals, animation and gaming.
C211.6	Acquire the skills to integrate graphical elements with user interfaces, understand the principles of real-time rendering, and apply this knowledge in creating interactive graphics applications.

Cxyy1–Cxyy.N: Cx shows the year of study of the course; yy shows the course order number in the prescribed syllabus; N shows the CO number.

CO are written in a student-centered, measurable fashion that is concise, meaningful, and achievable. The course outcomes can be defined by the course facilitators one CO for each unit can be defined. This could be based on its significance and purpose which are mapped to the PO and PSO[3]. Generally, COs are prepared by the course faculties, coordinated by the course coordinator (CC). These COs are then brainstormed by the cohort cluster committee (CCC) and further reviewed and approved by the DAB or DAC.

The following steps are recommended for writing the course outcomes. Commonly student-centered language needs to be used. It is expected that the written CO must follow the conditions such as: (i) it must be starting with a blooms' verb[4], (ii) maximum length of each CO can be of 300–400 characters, (iii) it is necessary to avoid special characters such as &, *, %, @, etc., (iv) it is necessary to avoid special formatting such as bullets, numbering, etc. **Table 2** shows the CO defined for the subject computer graphics.

This paper is organized as follows: section 2 shows the design of CO with PO and PSO for a course.

Section 3 shows the implementation method for the attainment of CO. Section 4 shows the results obtained and the significance is discussed.

2. Design of course outcomes

The mapping between the CO and PO/PSO is the way to analyse the CO with respect to the particular PO/PSO. This analyses the framework of the program and the specific program. There is no fixed system to decide the mapping criteria. However, the NBA has given guidelines while mapping the OC with PO/PSO. The strength of correlation of COs with PO/PSO is indicated as "3" for substantial (high) correlation, "2" for moderate (medium) correlation and "1" for slight (low) correlation and "-", if there is no correlation[5]. **Table 3** aligns the program level and program specific level outcomes with each course level outcomes. This mapping mainly focusses on student centric learning experiences and the skills, knowledge and behavioural changes attained[6,7]. The advantages of theses CO-PO/PSO mapping for achieving the program outcomes are listed below:

- It helps to understand the requirement of the course.
- It helps to improve the student skills, knowledge.
- It helps to identify the gaps in the curriculum to take appropriate remedial actions.
- It helps to build the logical design of the program and its relevance for the students.

From the individual courses, Program Articulation Matrix (PAM) is formed by the strength of correlation of COs with PO and PSO[6]. The correlation mapping between CO and PO/PSO for the selected course is shown in **Table 3**.

Table 3. CO-PO matrices of courses.

C211 Computer graphics

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C211.1	3	-	3	2	-	-	-	-	-	-	-	-
C211.2	3	2	3	3	-	-	-	-	-	-	-	-
C211.3	1	3	3	-	-	-	-	-	-	-	-	-
C211.4	2	2	3	2	-	-	-	-	-	-	-	-
C211.5	3	-	2	3	-	-	-	-	-	-	-	-
C211.6	3	3	3	-	-	-	-	-	-	-	-	-

Cxyy1–Cxyy.N: Cx shows the year of study of the course; yy shows the course order number in the prescribed syllabus; N shows the CO number.

If the course outcomes are attained, the PO correlated to these CO are also attained.

3. Development of assessment tools and methodologies

The key aspects of outcome-based education (OBE) are the assessment of course outcomes.

At the end of each course, the COs needs to be assessed and evaluated, to check whether it has been attained or not. The attainment of the COs can explain the efficiency of the teaching and learning process of the course. Assessment is one or more processes, carried out by the department, to identify, collect, and prepare data to evaluate the achievement of PO and PSOs of the department. Attainment is the action or fact of achieving a standard result towards accomplishment of desired goals. The CO attainment process is described in **Figure 1**.

Attainment of the COs are measured directly and indirectly. Direct assessment basically shows the student's knowledge and skills from their performance. Indirect assessment methods such as feedbacks, surveys and interviews can provide information about learners perception of their learning and how this

3

learning is valued by different stakeholders[8,9]. The assessment processes/methods and the tools used for CO attainment; frequency/duration of the assessment methods are shown in **Table 4**.
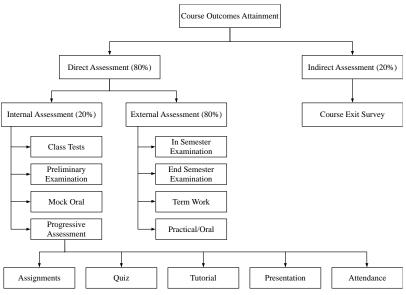

Figure 1. CO attainment process/tools.

Table 4. Assessment tools for course outcomes.

		Assessment type			Process/tools	COs covered	Frequency (per semester)
CO attainment	Direct Assessment (DA)	Internal test (IT) (20%)	Class test 1 (CT1)	Subjective	CO1, CO2	Once	Once
			Class test 2 (CT2)	Subjective	CO3, CO4	Once	Once
			Preliminary examination (PE)	Subjective	All COs	Preliminary examination (PE)	Once
			Progressive assessment (PA)	(Any 1 Component for each CO)	Assignments	All COs	Continuous assessment
					Presentation		
					Self-study		
					MCQ		
					Mini-projects		
					Attendance		
					Certifications		
					Online course		
					Conference		
					Workshops		
					Quiz		
			Mock oral (MO)		Oral/viva	All COs	Continuous
		External test (ET) (80%)	In-Sem (ISE)			All COs	Once
			Term work (TW)				
			Practical (PR)				
			Oral (OR)				
			Project/mini-project presentation				
			End-Sem (ESE)				
	Indirect assessment (IA)	Survey/activities			End-Sem (ESE)	All COs	Once

4

The CO attainment is calculated from direct assessment such as internal and external assessments and indirect assessment such as course exit survey. It is determined from the performance of the students in all the relevant assessment methods. These methods provide a sampling of what students know and/or can do and provide strong evidence of student learning[10]. **Table 4** shows the assessment tools used to calculate the attainment of COs. The direct assessment process takes 20% of internal assessment and 80% of external assessment.

3.1. Direct assessment (DA)

Direct assessment can be considered to be the different forms of quantitative and qualitative assessment methods that can verify the skills and knowledge of students at a specific point of time or over a period of time. This is generally considered as continuous assessment. While calculating CO direct assessment is divided in to two categories namely internal assessment and external. The methods included in the direct assessment is explained in this section.

3.1.1. Internal test (IA)

The internal assessment for theory and laboratory courses includes class tests and preliminary examinations and progressive assessments and mock orals. Students' performance in the internal assessment is evaluated as per the scheme and solution prepared by the corresponding subject faculty[11]. The internal assessment method includes the following:

Class tests (CT)

Two class tests had been planned and conducted for the theory courses in each semester. Class test 1 (CT1) was conducted for the units whereas CO1 and CO2 are covered. Class test 2 (CT2) was conducted for the units where CO3 and CO4 are covered. Question papers for the corresponding course will be prepared by the respective subject faculty and will be submitted to the internal exam coordinator well in advance. Corrected answer sheets are distributed back to the students, and results are declared after the completion of the class tests.

Preliminary examination (PE)

The preliminary examination was planned and conducted for the practice and assessment for the students before the University semester examination. All the defined COs had been covered in the preliminary examination. The subject faculties jointly prepare the question paper for the respective course and will be submitted to internal exam coordinator well in advance. The scrutiny team constituted will scrutinize the question paper with a team of members. The corrected answer sheets are distributed to the students after three days.

Progressive assessments (PA)

Progressive assessments are continuous assessments evaluates the student's presentation skills, understanding of fundamental concepts, expression of practical skills and knowledge gained. All the defined COs are covered in these assessments. Progressive assessment includes assignments, presentations, self-study, multiple choice questions (MCQ), mini-projects, practical demonstration, attendance, certifications, online courses, conferences, workshops, quiz, etc. The subject faculty selects the appropriate method for each CO to assess the students towards attainment of the COs[12–14]. The outcome of these assessments helps the students as: to guide written presentation skills, to improve the thinking capability, to test the knowledge and reasoning power and to demonstrate their practical knowledge and programming capabilities.

Mock oral/viva (MO)

Mock oral/viva is conducted to assess the students for their skills to demonstrate the practical conducted and to test the knowledge and reasoning power. This assessment covers all the COs defined and conducted once per semester before the external examinations. This helps the students to prepare for the external

examinations and provides confidence and feedback on their preparations. A team of one Internal and one external examiner is selected for each course and the team evaluates the students.

3.1.2. External assessment (EA)

The external assessment methods have been defined and structured as semester examination. At the end of each semester, as per the guidelines of controller of examination, the external assessment is conducted. The laboratory courses include term work marks and practical/oral, assignments, self-study, MCQ, viva, attendance and project/mini-project presentation marks, etc.

In semester examination (ISE)

As per the guidelines of SPPU, the in semester exam was conducted for 50 marks. This assessment is conducted as descriptive and conducted once in a semester per course.

End semester examination (ESE)

As per the guidelines of SPPU, the end semester exam was conducted for 50 marks which covers the whole syllabus prescribed by the university. The in semester and end semester examinations for each semester together considered which would be the metric for assessing whether the COs are attained or not. Examinations are focused on attainment of COs using a descriptive. Theory marks are considered as the sum of ISE and ESE.

Term work (TW)

As per the guidelines of SPPU, the term work marks are given to the students as per the evaluations of students based on the progressive assessments, tutorial/lab participation and attendance, etc. To evaluate student's practical knowledge with their programming level capabilities, evaluation is done for every lab session[2]. The evaluation of courses is done by the laboratory in-charge(s) based on predefined rubrics.

Practical (PR)

As per the guidelines of SPPU, practical exam is conducted at the end of the semester. An external faculty from different institution is called for the evaluation of student's performance for the problem-solving skill in lab experiments. The strength of the students in using their skills and tools in the laboratory is also evaluated. The evaluation is done by the laboratory in-charge(s) based on predefined rubrics.

Oral (OR)

As per the guidelines of SPPU, oral exam is conducted at the end of the semester. An external faculty from different institution is called for the evaluation to assess the knowledge and reasoning power of students based on the course.

3.2. Indirect assessment

Indirect assessment tools used in calculating the attainment of COs. In the indirect assessment of CO attainment, course exit survey method is used for assessing the percentage of attainment. In the overall attainment, a weight of 80% is given to direct assessment while 20% is assigned to indirect assessment.

3.2.1. Course exit survey

Course exit survey conducted among the students after completing around 75% of syllabus is covered. The students are given questionaries about the course outcomes and the course satisfaction. This is conducted by the course coordinator once in a semester. Scores, feedbacks and comments received from the survey are considered for the attainment of COs and for the continuous improvement process for the current and upcoming academic sessions[15,16]. Course exit survey data is analyzed to identify the attainment level and gaps[1,15]. Necessary actions and processes like mentoring, revision sessions, guest lectures and tutorial sessions are planned and executed based on the course requirements.

4. Attainment of course outcomes

The attainment of each CO is evaluated using Internal and External assessment. Attainment level of each assessment is determined by grouping the students into three levels of attainment according to their performance in each assessment. Target level for attainment of COs had been set based on the attainment of the courses in the previous academic years, and based on the pandemic situation arouse. The courses are grouped in to three and the targets for each group is set between 1% to 3% increment of their previous academic year CO attainment[17–19]. The target for the course computer graphics is set to be 81%.

Let us consider

N = The total number of students

A = Number of students scoring 55% to 100%

B = Number of students scoring 50% to 54%

C = Number of students scoring 40% to 49%

D = Number of students scoring below 40% + absent

T = Number of students attended

$X1$ = Number of internal assessments

$X2$ = Number of external assessments

Step 1: The internal assessments and external assessments are considered for the attainment of COs. Individual assessment score (AS) is calculated using Equation (1).

$$AS_i \text{ in \%} = \frac{(A_i \times 3) + (B_i \times 2) + (C_i \times 1) + (D_i \times 0)}{T_i \times 3} \tag{1}$$

where $i \in \{CT1, CT2, PE, PA, MO, TM, TW, PR, OR\}$.

Step 2: Here, the internal score (IS) percentage is obtained from all the internal assessment methods and are calculated as Equation (2).

$$CO_{i\_IS} \text{ in \%} = \frac{\sum_{j=1}^{X1} AS_x}{j} \tag{2}$$

where $1 \leq i \leq$ number of COs, $x \in \{CT1, CT2, PE, PA, MO\}$ and $1 \leq j \leq X1$.

Step 3: Similarly, the external score (ES) percentage is obtained from all the external assessment methods and are calculated as Equation (3).

$$CO_{i\_ES} \text{ in \%} = \frac{\sum_{j=1}^{X2} AS_y}{j} \tag{3}$$

where $y \in \{TM, TW, PR, OR, PA\}$ and $1 \leq j \leq X2$.

Step 4: Direct attainment (DA) in any course consists of the internal tests and the external tests conducted for the students and is calculated using Equation (4).

$$DA_i \text{ in \%} = \frac{20 \times CO_{1\_IT}}{100} + \frac{80 \times CO_{1\_ET}}{100} \tag{4}$$

Step 5: To calculate the indirect attainment (IA) of the CO attainment, the course exit survey is conducted and is calculated using Equation (5).

$$IA_i \text{ in \%} = \frac{(A_i \times 3) + (B_i \times 2) + (C_i \times 1) + (D_i \times 0)}{T_i \times 3} \tag{5}$$

Step 6: To calculate the attainment for each COs, DA is considered with 80% weightage and indirect attainment is considered 20% of weightage. CO attainment is calculated for the maximum level out of 3. Each CO attainment is calculated using Equations (6) and (7).

$$CO_i \text{ in } \% = 80\% \text{ of } DA_i + 20\% \text{ of } IA_i \tag{6}$$

$$CO_i = \left(\frac{0.8 \times DA_i + 0.2 \times IA_i}{100}\right) \times 3 \tag{7}$$

Step 7: The average CO attainment for the course is calculated using Equation (8).

$$CO = \frac{\sum_1^n CO_n}{n} \tag{8}$$

where n is the number of COs defined for the course.

Step 8: To verify whether each CO of the course has attained its target level, The average CO_i is calculated using Equation (9).

$$\text{Average } CO_i = \frac{\sum_{i=1}^{12} PO_i + \sum_{j=1}^{3} PSO_j}{x + y} \quad \begin{array}{l} \text{where } PO_i > 0, PSO_j > 0 \\ x = \text{number of } PO_i > 0 \\ y = \text{number of } PSO_i > 0 \end{array} \tag{9}$$

where $\sum_{i=1}^{12} PO_i$ represents the sum values of POs with respect to the CO from **Table 3**. Similarly, $\sum_{j=1}^{3} PSO_j$ represents the sum values of PSOs with respect to the CO from **Table 3**.

Step 9: To verify the attainment of COs, the target is set to be 81% for the course C211 by the DAB and the attainment of individual COs are verified as shown below. CO_i target is calculated for defined COs using Equation (10).

$$CO_i \text{ target} = 81\% \text{ of average } CO_i \tag{10}$$

Step 10: Now CO attainment is calculated for every CO for the average CO and it is compared with the CO_i target to check whether the CO_i is attained or not. The CO_i out of average CO_i is calculated using Equation (11).

$$CO_i \text{ out of average } CO_i = \frac{CO_i \times \text{average } CO_i}{3} \tag{11}$$

Step 11: The calculated CO_i out of average CO_i is compared with the CO_i target and the COs are verified whether it is attained or not using Equation (12).

$$CO_i \text{ attained (yes/no)} = \begin{cases} \text{Yes} & CO_i \text{ out of average } CO_i \geq CO_i \text{ target} \\ \text{No} & \text{otherwise} \end{cases} \tag{12}$$

Using Equations (1)–(12), the CO attainment value is calculated[5–7]. The following sections shows the calculation of CO1 for the subject computer graphics and further calculates the CO of the course.

5. Experimental results and discussion

Sample CO attainment process for the course C211—computer graphics is shown below:

Step 1: AS for the preliminary examination (AS_{PE}) is calculated using Equation (7).

$$\begin{aligned} AS_{PE} \text{ in } \% \quad &= \quad \frac{(165 \times 3) + (14 \times 2) + (19 \times 1)}{204 \times 3} \times 100 \\ &= \quad \frac{495 + 28 + 19}{612} \times 100 \\ &= \quad \frac{595}{615} \times 100 \\ &= \quad 88.56 \end{aligned}$$

Similarly, all the internal and external assessments attainment scores in percentage are calculated. As mentioned in section 3.2.1., the mappings of the assessments and the COs are mention such as (i) CT1 is mapped with CO_1 and CO_2, (ii) CT2 is mapped with CO_3 and CO_4, (iii) PE is mapped with all the COs, (iv) ISE and ESE are considered together as theory marks and are mapped with all the COs.

Step 2: *IS* for the CO_1 is calculated as follows:

$$CO_{1\_IS} \text{ in \%} = \frac{AS_{PE} + AS_{CT1} + PA}{3}$$

$$= \frac{88.56 + 87.91 + 90.69}{3}$$

$$= 89.05$$

Step 3: Similarly, the ES for the CO_1 is calculated as follows:

$$CO_{1\_ES} \text{ in \%} = \frac{AS_{TM}}{1}$$

$$= 77.8$$

Similarly for all the defined COs the *IS* and *ES* scores are calculated.

Step 4: The direct attainment for the CO_1 is calculated as follows:

$$DA_1 \text{ in \%} = 0.20 \times 89.05 + 0.80 \times 77.8$$

$$= 17.81 + 62.22$$

$$= 80.03$$

Similarly for all the defined COs the DA scores are calculated.

Step 5: The IA for the CO_1 is calculated as follows:

$$IA_1 \text{ in \%} = \frac{(169 \times 3) + (28 \times 2) + (7 \times 1)}{205 \times 3} \times 100$$

$$= \frac{507 + 56 + 7}{615} \times 100$$

$$= \frac{570}{615} \times 100$$

$$= 92.68$$

Step 6: Hence the final CO_1 attainment from the direct attainment using internal assessments and external assessments is calculated as follows:

$$CO_1 \text{ in \%} = 80\% \text{ of } 80.03 + 20\% \text{ of } 92.68$$

$$= 82.65$$

$$= \frac{82.65}{100} \times 3$$

$$= 2.48$$

Similarly, all the CO attainments are calculated.

Step 7: The values of $CO_1, CO_2, CO_3, CO_4, CO_5, CO_6$ for the course C204 is measured as 2.61, 2.61, 2.62, 2.62, 2.61 and 2.61 respectively and the final CO attainment is calculated as follows:

$$CO = \frac{CO_1 + CO_2 + CO_3 + CO_4 + CO_5 + CO_6}{6}$$

$$= \frac{2.48 + 2.48 + 2.48 + 2.48 + 2.48 + 2.48}{6}$$

$$CO = 2.48$$

Step 8: The average CO_1 is calculated using Equation (9).

$$\text{Average CO}_1 = \frac{PO_1 + PO_2 + PO_3 + PO_{12} + PSO_1}{4 + 1}$$

$$= \frac{3 + 3 + 2 + 3 + 2 + 2}{6}$$

$$= 2.50$$

Similarly, all average CO_i are calculated using Equation (9).

Step 9: To verify the attainment of COs, the target is set to be 81% for the course C211 by the DAB and the attainment of individual COs are verified as shown below. For example, the CO_1 target is calculated as follows:

$$CO_1 \text{ target} = 0.81 \times \text{Average CO}_1$$

$$= 0.81 \times 2.50$$

$$= 2.03$$

Step 10: CO_1 out of average CO_1 is calculated as follows:

$$CO_1 \text{ out of average CO}_1 = \frac{CO_1 \times \text{Average CO}_1}{3}$$

$$= \frac{2.48 \times 2.50}{3}$$

$$= 2.07$$

Similarly for all COs the values are calculated.

Step 11: Now the calculated CO_1 out of average CO_1 is compared with the CO_1 target and the COs are verified whether it is attained or not using Equation (12).

The CO_1 attained (yes/no) is calculated as follows:

$$CO_1 \text{ attained (yes/no)} = \begin{cases} \text{Yes} & CO_1 \text{ out of average CO}_1 \geq CO_1 \text{ target} \\ \text{No} & \text{otherwise} \end{cases}$$

$$= \text{Yes}$$

Similarly for all COs the values are calculated to check the attainment status. The detail process of the CO attainment for the course C211 is shown in **Figure 2**.

The CO attainment status for individual COs is calculated as shown in **Figure 3**.

Figure 3 shows that the attainment of CO can be efficiently calculated and are mapped with the individual PO. CO attained status shows whether the CO_1 to CO_6 has achieved its target or not. In this course all the CO are attained with respect to the target set.

Code	C211	Subject Name & Subject Code	Computer Graphics (210251)		Class	Second Year Engineering
Academic Year	2018-2019	Subject Faculty	Mrs.Megha Kadam		Semester	II

S.No	Seat No	Name of the student	Preliminary Examination	Class Test 1	Class Test 2	Mock Practical	Progressive Assessment	Theory Exam Marks	Term Work Marks	Practical Exam Marks	Feedback
		Max.Marks	50.00	30.00	30.00		25	100			30
1	ADARSH KUMAR	S150244202	25	20	29		13	49			29
2	ADHAV PRATIK GANESH	S150244203	24	13	15		13	28			29
3	ADITYA KUMAR	S150244204	35	16	16		20	68			22
4	ADITYA KUMAR	S150244205	32	22	15		22	63			18
5	AIUSHMAN SUVABROTO ROY	S150244206	30	13	16		18	43			20
6	AJIT KUMAR	S150244207	27	18	12		15	34			15
7	AKSHAY SHIVAJI KURKUTE	S150244208	30	15	11		23	50			24
8	ALTE AARTI BALASAHEB	S150244209	32	11	17		22	46			26
9	AMRUTKAR DHIRAJ PRAKASH	S150244210	30	11	18		21	63			30
10	ANJALI KUMARI	S150244211	31	12	18		21	68			19
11	:	:	:	:	:	:	:	:			:
12	:	:	:	:	:	:	:	:			:
13	:	:	:	:	:	:	:	:			:

Note: Mark "AB" for Absent Students

Marks >=55%	(A)		165	158	149		161	123			169
Marks 50% to 54%	(B)		14	23	31		29	38			28
Marks 40% to 49%	(C)		19	18	19		14	31			7
Marks < 40 %(failed)+ Absent	(D)		7	6	6		1	13			1
Total Attendance	(T)		204	204	204		204	204			204
Total Students	(N)		205								

Assessment Type	Internal Test (IT)					External Test (ET)			Feedback (FB)	Distribution in %				CO Score
Attainments	Preliminary Exam (PE)	Class Test 1 (CT1)	Class Test 2 (CT2)	Mock Practical Oral (MP)	Progressive Assessment (PA)	Theory (TH)	Term Work (TW)	Practical (PR)	Feedback (FB)	Internal Score (IS)	External Score (ES)	Direct attainment (DA)	Indirect Attainment (IA)	
Assessment Scores = ((A*3+B*2+C*1)/(T*3))*100	88.56	87.91	86.27		90.69	77.78			93.14	20%	80%	80%	20%	Out of 3
CO1	88.56	87.91			90.69	77.78			93.14	89.05	77.78	80.03	93.1	2.48
CO2	88.56	87.91			90.69	77.78			93.14	89.05	77.78	80.03	93.1	2.48
CO3	88.56		86.27		90.69	77.78			93.14	88.51	77.78	79.92	93.1	2.48
CO4	88.56		86.27		90.69	77.78			93.14	88.51	77.78	79.92	93.1	2.48
CO5	88.56				90.69	77.78			93.14	89.62	77.78	80.15	93.1	2.48
CO6	88.56				90.69	77.78			93.14	89.62	77.78	80.15	93.1	2.48
CO Attainment														2.48

IS = average of Internal Test   DA = 20% of IS + 80% ES   CO = 80% DA + 20% IA
ES = average of External Test   IA = 100% of FB

Figure 2. Sample CO attainment process.

Outcome	Attainment Out of 3	Program Outcomes (PO)												Program Specific Outcomes (PSO)			Average CO	CO Target = 81% of CO average	CO Attained out of average CO	CO Attained (Yes/No)
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3				
CO1	2.48	3		3	2									3	2	2	2.50	2.03	2.07	Yes
CO2	2.48	3	2	3	3									3	3	3	2.86	2.31	2.36	Yes
CO3	2.48	1	3	3										3	3	3	2.67	2.16	2.20	Yes
CO4	2.48	2	2	3	2									3	3	3	2.57	2.08	2.12	Yes
CO5	2.48	3		2	3									2	3	2	2.50	2.03	2.07	Yes
CO6	2.48	3	3	3										2	1		2.40	1.94	1.99	Yes

CO Attainment   CO Target   81%

Figure 3. CO Attainment Status for individual COs.

6. Conclusion

A quality OBE expects attainment of all the CO. If any of the CO is not attained with expected target level, OBE expects an action plan for continuous improvement process to achieve the same. The objective of the OBE is, the skills and knowledge and behavioural changes in students to become a globally competent

professionals. Quantitative and qualitative assessments can also be adopted to assess students and grades can be given. OBE provides clarity in expected outcomes and this paper quantifies the course outcomes to ensure if the potential students have the skills necessary for the career.

Author contributions

Conceptualization, SM and JB; methodology, SM; validation, MA, SK and SS; formal analysis, SS; investigation, SK; data curation, SM; writing—original draft preparation, SM; writing—review and editing, MA; visualization, JB; supervision, JB. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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