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Development of a Framework for Assessing the Degree of Course and Program Outcome Attainment utilizing Outcome-Based Education Framework

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Abstract: Outcome-based education (OBE) has been widely adopted in technical universities due to its advantages such as providing students with clear expectations, offering flexibility in lesson plan layout, facilitating comparison for improvement, and promoting student engagement in the classroom. Assessing the degree and quality of program learning abilities obtained by students using various assessment methods is a crucial component of OBE. This study presents an assessment approach for evaluating the achievement of course outcomes (CO) and program outcomes (PO) among engineering graduates, in accordance with the guidelines outlined by the National Board of Accreditation (NBA). This research is based on analysis of the data derived from students' internal and final examination scores. The achievements are condensed and data is generated, followed by a comparative analysis that can be utilized for the ongoing enhancement of student quality. Exploring indirect instruments such as graduate exit surveys, course end surveys, alumni surveys, and employer surveys has the potential to improve the assessment procedures for COs, POs, and Program Specific Outcomes (PSOs).

Keywords : Attainment; CO; CO-PO Mapping; Engineering; NBA; NAAC; OBE; PO; PSO.

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1. Introduction

India emerged as the world's third-largest service provider of higher education during the globalization era, following the United States and China. Enhancing the professionalism and standards of technical education necessitates the critical implementation of evaluation and accreditation procedures. External bodies like the National Board of Accreditation (NBA) and National Assessment and Accreditation Council (NAAC), in alignment with criteria set by the University Grants Commission (UGC), All India Council for Technical Education (AICTE), and other accrediting agencies, play a pivotal role in examining and evaluating the quality of education and learning outcomes in India. It is of the utmost importance to design the curriculum to close the gap between industry and academics in accordance with the distinctive demands of the workforce. The aim is to ensure graduates have the information and abilities that the business needs to succeed in their careers. Due to the gap between industry and academia, it is

necessary to reform the current educational system. This involves transitioning from a teacher-centric to a student-centric approach. In a teacher-centric system, educators dictate the topic, content delivery methods, and assessment criteria. The focus is on what students need to do to pass a module or program. Conversely, in a student-centric system, the emphasis shifts to what students should be able to demonstrate by the conclusion of a module or program, reflecting their acquired skills and knowledge over the learning period (NBA, 2009).

To address these issues in India, AICTE established the NBA, a committee responsible for accrediting technological programs, and the UGC established the NAAC, which oversees institute-level accreditation. AICTE has been provided with definitions and directives for examination reforms and policies that promote improved assessment in academic studies, enabling the measurement of outcomes at both course and program levels. Model question papers have been introduced to aid in evaluating the program skills acquired by students. In this process, each institute must establish a vision, mission, as well as define Program Educational Objectives (PEO), Program Outcomes (PO), Course Outcomes (CO). The institute is required to evaluate these parameters periodically. The assessment of PEOs relies on the graduates' performance in society, where they take on various roles. At a fundamental level, it is essential to establish COs to define what students will achieve upon completing a course. These COs play a role in achieving the broader POs. The objectives may involve a combination of short-term and long-term goals. Successfully reaching these milestones and evaluating the achievement of the intended objectives and outcomes demand suitable methodologies. Institutions should possess a mission that is both achievable and innovative. Departments should come up with pertinent visions and missions that align with the institution's larger goals.

This paper introduces an assessment method for evaluating both Course and Programme Outcomes using suitable direct assessment tools. A sample assessment provided in the paper demonstrates the process of achieving COs and graduate attributes specified by the NBA, which align with the Programme Outcomes of the Washington Accord. In this study, our emphasis lies in assessing the fulfilment of COs, POs, and Program Specific Outcomes (PSOs) through the allocation of varied weights to distinct elements of OBE, such as surprise tests, experiential learning, assignments, mid-term examinations, and end-semester examinations. This paper provides a comprehensive procedure and a sample analysis for Outcome-Based Assessment, covering the process to development the vision & mission of the department to the attainment of course and program outcomes based on defined criteria.To understand the current advancements in measuring attainment in outcome-based education, we conducted an extensive review of the existing literature.

Whenever outcome-based education is implemented, it makes sure that the learner has received instruction that satisfies an appropriate standard of quality (Spady,1993). The performance-based education system referred to as outcome-based curriculum is essential in defining what sort of graduates we target. The intended objectives of instruction should be made transparent in this method. A well-defined outcome enables it easier to design the type of course that is offered, its content, and the lesson plans (Harden et. al., 1999). The OBE approach helps institution to achieve the intended outcomes through a systematic methodology (Alderson & Martin, 2007; San, 2008; Au & Kwan, 2009; Akir et al., 2012; Kaliannan & Chandran, 2012; Rasha, 2013; D'cruz, 2017; Gurukkal, 2018, 2020; Rajak et al., 2019; Rao, 2020; Shefeeque, 2020; Agrawal et al., 2021; Amirtharaj et al., 2022; Lavanya & Murthy, 2022; Prasad et al., 2023). Course Outcomes are evaluated during internal assessments and semester examinations, and Program Outcomes are appraised upon graduation.

Nordin et al., (2012) found that feedback from students indicate active engagement with the industry has a positive influence on students, aligning with the anticipated program outcomes as perceived by the students. According to Tshai et al., (2014), the essential elements contributing to student success in outcome-based education include program outcomes (POs) and educational outcomes of the program. Continuous evaluation of knowledge, skills, and competencies, as emphasized by Liew et al., (2020), is pivotal for attaining robust educational effectiveness and the successful development of programs. Jadhav et al., (2020) conducted research on the necessity of outcome-based education in Indian engineering education. They advocate the adoption of a structured process encompassing three key components: outcome-based curriculum design, outcome-based teaching-learning, and outcome-based assessment, to

yield favourable outcomes. Balaji and Karthik (2020) examined real-time data to assess the attainment of COs and POs. Banu et al. (2020) designed instructional classes based on the Process-Oriented Guided Inquiry Learning (POGIL) approach to address complex engineering problems outlined in the Program Outcomes (POs) of NBA. Kumar et al., (2021) suggested a methodology that utilizes students' performance in internal assessments, final exams, assignments, and course exit feedback to determine the achievement of course outcomes. Reddy et al. (2021) proposed a method for evaluating program quality by mapping Course Outcomes (COs) to Program Outcomes (POs) and Program Specific Outcomes (PSOs) and assessing the attainment of these outcomes at both the course and program levels. Matthews et al. (2022) characterizes it as a distinctive approach that considers the diverse weighting of individual course components. This methodology prioritizes root cause analysis and corrective measures, enabling the calculation of PO attainment levels by incorporating CO and Course Attainment Level, as well as utilizing the Program Articulation Matrix. Amirtharaj et al. (2022) explore a methodical strategy for evaluating the achievement of outcomes by graduates in a program within an autonomous engineering college that adheres to Outcome-Based Education (OBE) with Choice-Based Credit System (CBCS). The paper also delves into the details of the process and criteria used to assess the fulfilment of these outcomes. Datta (2022) has introduced a mathematical model based on rubrics to assess the direct accomplishment of COs and POs, fulfilling the essential criteria in the OBE system. Kulkarni et al. (2022) adopted Root-to-Fruit approach, emphasizing students' employability as the central focus throughout the processes of formulation, mapping, and attainment of COs and PSOs, rather than simply completing the procedural aspects of CO-PSO analysis. Thabassum et al. (2022) carried out an experimental study exploring the use of Active Learning strategies to improve the achievement of learning outcomes in undergraduate courses. Vijayakumar et al. (2023) highlight the impact of movement-based learning and assessment strategies in achieving the designated Program Specific Outcomes (PSOs) and Course Outcomes (COs) through both individual and group learning approaches. Choudhari et al. (2023) outline a process for calculating course outcome attainment and program outcome attainment using the average method. Prasad et al., (2023) introduced an approach that provides a perspective on measuring POs and PSOs through rubrics, aligning them with students' co-curricular activities like paper and project presentations, as well as internships and industrial projects.

2. Methodology Followed

OBE's primary purpose is to deliver results that are favorable in terms of a student's knowledge, capacities, attitudes, and competency upon program completion. OBE is an outcome of teaching fueled by this goal and persistent efforts. A systematic approach

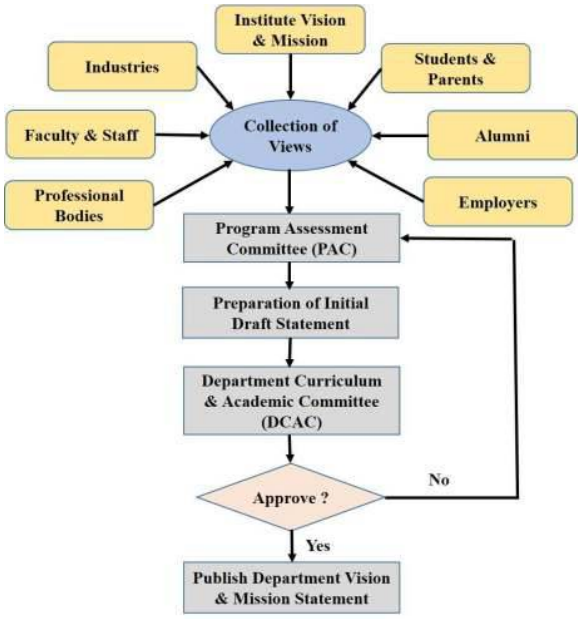

Fig.1 : Flow chart showing the process of defining vision and mission

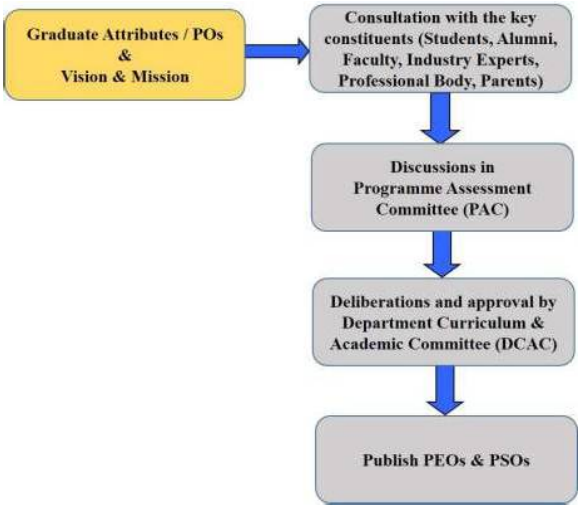

Fig. 2 : Establishment of PEOs and PSOs.

comprising the benchmarking of COs against POs is required to assure the fulfilment of these outcomes. Higher education institutions are required to implement an accreditation-focused strategy, assessing educational quality on the basis of outcomes rather than inputs. This shift is essential since excellent results do not necessarily correlate with inputs. The attainment of results depends not just on inputs but also on the procedures that an organization uses to convert inputs into clearly defined outcomes. In this context, this section deals with the development and improvement of different measures or outcomes.

A. Establishment of Vision and Mission

The formulation or enhancement of the department's vision and mission should incorporate input from diverse stakeholders, including professional bodies, faculty members, staff, industry experts, students, parents, alumni, and employers. This iterative process should align with the institute's overarching vision and mission. Fig.1 illustrates the steps involved in shaping the vision and mission through engagement with pertinent forums.

B. Establishment of PEO and PSO

The considerations for establishing or enhancing the PEOs and PSOs closely resemble those in the formulation of the vision and mission. The procedures for setting up the PEOs and PSOs by duly appointed committees are outlined in Fig. 2.

C. Process Followed to Improve the Quality of Teaching and Learning

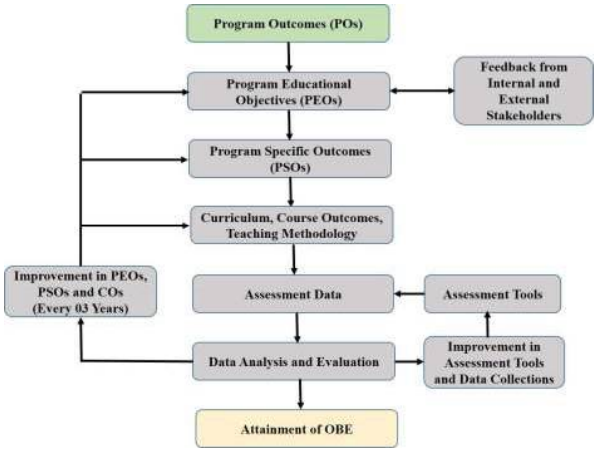

Fig. 3 : Processes followed to improve quality of Teaching & Learning

Table 1:
Consistency of Peos With Departmental Mission

PEOs / Mission Statement	M1	M2	M3	M4
PEO 1	03	03	02	02
PEO 2	03	02	03	01
PEO 3	02	02	03	03

Note: High: 03; Medium: 02; Low: 01

The attainment of academic success relies significantly on an efficient teaching-learning process. The engineering institution in question advocates for outcome-based education to guarantee the acquisition of essential skills, habits, attitudes, and knowledge by students. The teaching-learning approach of the institute prioritizes the needs of the students, actively promoting student-centric learning. The institution endeavors to foster an environment where each student is encouraged to take responsibility for their own learning and engage in reflective practices throughout the learning process. Each student is motivated to take the ownership of his or her learning and reflect on the learning process.

Each program incorporates mechanisms to ensure learning assurance. This includes the development of rubrics based on course outcomes and the creation of various assessment tools to gauge the level of student learning. The institute's assessment system is characterized by openness and fairness. The assurance of learning ultimately contributes to enhancements in the teaching-learning process. The institute follows a system of continuous evaluation of learning, making efforts to assess both cognitive and applied aspects. Components of overall assessment encompass project work, quizzes, problem-solving exercises, classroom assessments, and end-semester examinations. Furthermore, students receive feedback on their work to enhance their academic performance. The continuous process of curriculum and course upgrading is driven by the fundamental goal of improving student learning. Based on data analysis and evaluation, improvements in PSOs, PEOs, and COs are implemented every three years, if necessary as shown in Fig.3.

D. Mapping of PEOs with Mission of the Department

The mapping table demonstrates how the PEOs contribute to the overall mission of the department. Table I illustrates the alignment between the department's mission and the specific PEOs,

Table 2 :
Course Articulation Matrix

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1															
CO 2															
CO 3															
CO 4															
CO 5															

showcasing the correlation between the objectives and the overarching goals of the department.

E. Justification for PEOs Mapping with Department Mission

PEO 1: This is providing students with a sound foundation in fundamentals areas such as scientific, application & mathematics. Which, they learn during their graduate and under graduate. Hence, this PEO1 is maps substantially with mission 1 & 2. These mission statements focus on providing the students with strong and clear fundamentals of mechanical engineering and related field. Also PEO 1 maps slightly with mission 3 & 4 as it is concerned with the professional and responsible behavior of a student.

Table 3 :
Correlation Level Rubrics

Percentage of classroom sessions addressing a particular PO	Correlation level	
>=40%	3	Substantial (High)
25 to 40 %	2	Moderate (Medium)
5 t0 25 %	1	Slight (Low)
< 5%	-	No correlation

Table 4 :
Calculation of Correlation Level For Pos

POs	Number of hours devoted to PO (H)	Total hour of lesson plan (TH)	Percentage of hour of PO (H/TH)*100	Mapping strength
PO 1	27	52	51.92	3
PO 2	7	52	13.46	1

F. Course Articulation Matrix

Not every CO is required to address all 12 POs outlined by the NBA for engineering students. A comprehensive mapping, known as global mapping or overall CO-PO-PSO mapping, is developed, taking into account the significance of each course in contributing to each PO as given in Table II. The weightage of the contribution of each course to each PO is considered in preparing the global mapping. An example of this mapping is provided in Table III and IV.

G. Assessment of CO Attainment

This section provides an overview of the methods employed to assess the degree of attainment of COs. The utilization of a multidimensional analytics approach is considered to be more efficacious, since it allows for the evaluation of CO achievement from two unique perspectives: student-centric and course-centric assessments. The evaluation of each student's achievement in each CO is conducted on an individual

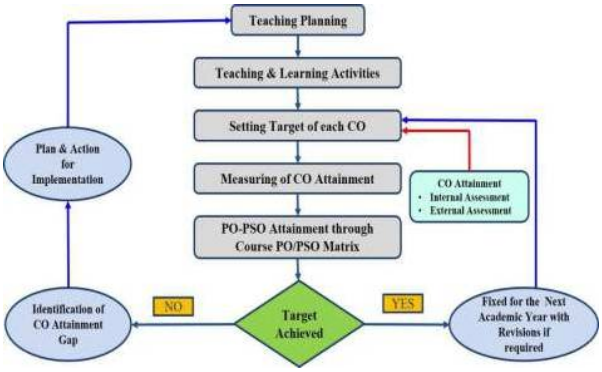

Fig. 4 : Process to identify the extent of compliance of the curriculum.

Table 5 :
Tools Used For Course Outcomes (cos) Assessment Processes

Sl. No	Categories	Assessment Tools	Full Marks	Weightage	Frequency in a Semester
1	External Assessment	ESE	100	60%	01
2	Internal Assessment	ST	20	10%	05
3		EL	20	10%	01
4		Assig	10	13%	05
5		MT	20	7%	01

basis in the student-wise assessment. This evaluation takes into account both the internal assessment scores gained through internal tests and the external marks obtained from end-semester examinations. Conversely, the course-wise approach entails evaluating the proportion of CO achievement for all students registered in a specific course. Fig. 4 shows that CO evaluation involves carefully gathering and looking at data to see how well teaching and learning materials were used to help engineering students reach their goals. This information can be used for:

H. Improving teaching learning method.

- Improving the syllabus by fine tuning it.
- Introducing additional training programs.
- Redefining the CO for a course to align with the course contents and objective.
- Setting new target for attainment.

The assessment of outcomes should commence with the gathering of data related to the achievements and outputs generated by students. This may encompass various deliverables like internal assessment and external assessment. Various tools considered, weightages for CO attainment are outlined in Table V.

H. Direct CO Attainment of the Course

- External or Summative Assessment Method (SAM) of maximum marks 100 is conducted and evaluated and Maximum mark has been scaled down to 60 marks.
- SAM of each student in individual COs is available. So the attainment percentage has been calculated for each CO of the subject.
- Internal of Formative Assessment Method (FAM) includes attainment of surprise test, experiential learning, assignment and midterm examination conducted by the subject teacher and total maximum mark has been scaled down to 40 marks.
- Direct attainment of a course = (0.4xFAM)+(0.6xSAM)
- A sample copy of attainment of COs using FAM & SAM is shown in Fig. 5 and Table VI.

I. Assessment of PO Attainment

Assessing program outcomes involves systematically gathering and analysing information, ultimately leading to the implementation of corrective actions, both within the curriculum and through extracurricular means, to enhance student learning and achieve the intended results. The assessment process is guided by fundamental principles, including:

- Effectiveness in PO Assessment is maximized when it demonstrates an awareness that learning is multi-faceted, interconnected, and becomes evident through performance across various dimensions over an extended period.
- Evaluation is most effective when applied to programs with well-defined and explicitly stated objectives.
- Evaluation necessitates focus not only on the outcomes but also on the experiences that contribute to the achievement of those outcomes.
- Continuous assessment is more effective than sporadic or intermittent evaluation.
- The involvement of representatives from different areas of the educational community in assessment facilitates broader enhancements.
- The likelihood of improvement through assessment is higher when it is integrated within a broader framework of conditions that facilitate transformative processes.

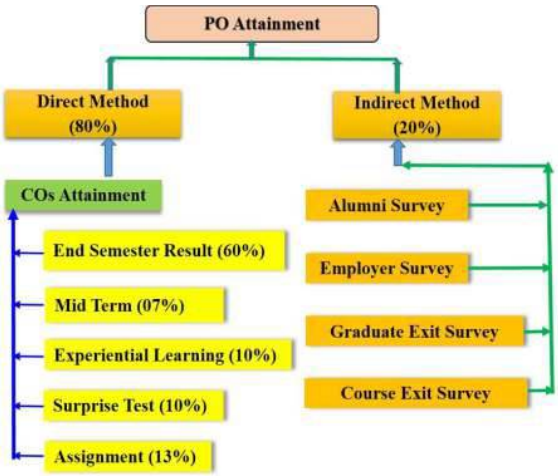

Fig. 5: Different components to assess attainment of POs.

Table 6 :
Attainment Of Cos Of Courses Using Fam & Sam

	Surprise Test					Experiential Learning					Assignments					Mid Term					End Semester Examination				
	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5
Student List / Marks																									
S1																									
S2																									
S3																									
S4																									
S5																									

Set Value (60% of the surprise test, experiential learning, mid - term, 70% for assignment, & 75% End Semester)																									
No. of students attend the set values																									
% of student securing equal or more than the set value																									
Attainment levels of individual CO (if $0.6 \leq X < 0.7$ then X =1, else $0.7 \leq X < 0.8$ then X=2, else $0.8 \leq X$ 1 then X=3)																									
Attainment of individual CO (Considering weightage) 10% Surprise Test, + 10% Experiential Learning +13% Assignment + 7% Mid Term + 60% End Semester Exam																									
Average CO Attainment																									

Case Study

A. Calculation of CO Attainment

This section presents some sample reports that have been developed for a group of students in a typical program that our institution offers employing the methodologies mentioned in the previous sections. Each course individually contributes to the achievement of a set of Programme Outcomes and Program Specific Outcomes. Every course specifies a set of Course Outcomes that are aligned with the Programme Outcomes and Program Specific Outcomes (PSOs). Course Outcomes are directly linked to the Programme Outcomes & Program Specific Outcomes and detail the skills, performance, and knowledge that students are expected to exhibit upon completing the course. These outcomes are articulated in terms of measurable behaviors that students should demonstrate as a result of the course. Essentially, Course Outcomes outline the abilities students will possess after completing the respective course. The typical regulations outlined by the NBA specify 12 POs for an undergraduate program. Table VII displays the COs for a standard course "Kinematics & Dynamics of Machines (KDM)" as outlined in the curriculum of the aforementioned program and PSOs for mechanical engineering department. The COs of a specific subject is designed to align with certain POs and PSOs, based on how the course assists students in demonstrating their knowledge, skills, or behaviors. Faculty provides the department with a matrix that illustrates the mapping between each CO and the corresponding POs and PSOs. The course assessment matrix or mapping of COs to POs and PSOs for the subject KDM is presented in Table VIII. The provided matrix depicts the competency level that is catered to by each CO in

Table 7 :
Cos Fora Typical Course

COs	Course Outcome Description
CO 1	Analyze various mechanisms, which can be used under different situations in different machines.
CO 2	Analyze and plot displacement, velocity and acceleration of different components of machines.
CO 3	Analyze and decide the type of gear mechanisms to be used for different machinery applications.
CO 4	Identify and analyze different cam -follower mechanisms for motion control.
CO 5	Analyze and decide the type of drives to be used for different machinery applications.
PSO 1	Students will be able to employ their grasp of mathematics, science, and engineering fundamentals to develop, evaluate, and propose solutions to mechanical engineering challenges. Additionally, they will effectively communicate these solutions to the relevant stakeholders.
PSO 2	Utilizing various engineering and technological resources, design mechanical systems across diverse domains, including machine components, thermal applications, manufacturing processes, industrial operations, and interdisciplinary sectors. These designs aim to meet the evolving demands of both industry and society.
PSO 3	The ability to grasp the latest advancements in Mechanical Engineering methodologies and acquiring a thorough understanding of the design process, practical skills, and competencies relevant to the field. This includes proficiency in program-specific skills and knowledge, along with the capacity to devise collaborative, multidisciplinary research concepts within a team framework.

respect to each PO and PSO, hence illustrating the extent to which each CO contributes to the attainment of the designated POs and PSOs for a standard course.

The course coordinator establishes individual targets for each CO, which are subsequently reviewed and confirmed by the department's Program Assessment Committee (PAC). For this course the target level for each CO is determined at 60% of the attainment level, equating to 1.8. Table IX shows the sample calculation of the COs by considering

Table 10 :
Co Gap Analysis

	Final	CO Target	Gap
CO 1	1.1	1.8	0.7
CO 2	1.39	1.8	0.41
CO 3	0.83	1.8	0.97
CO 4	1.49	1.8	0.31
CO 5	1.86	1.8	-0.06

different weightages to different components. These weightages are finalized in the PAC by considering the difficulty level of the specific subjects. Table X

Table 11:
Closure of the Quality Loop

COs	Target	CO Attainment Gap	Action Proposed to Bridge the Gap	Modification of Target where Achieved
CO 1	1.8	0.7	The class will incorporate various instructional methods such as presentations, animations, and videos created using information and communication technology (ICT) tools. Additionally, there will be additional practice exercises for each module, comprising more examples, as well as assignments for the students to solve during tutorial sessions.	
CO 2	1.8	0.41	Same as CO 1	
CO 3	1.8	0.97	Same as CO 1	
CO 4	1.8	0.31	Same as CO 1	
CO 5	1.8	-0.06		1.96

Table 8 : Co-po-pso Mapping For A Standard Course

CO	Statement	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1		3	3	2	2	2	-	1	-	-	-	-	3	3	-	2
CO 2		3	2	2	1	1	-	-	-	-	-	-	2	-	2	1
CO 3		3	3	3	3	-	-	1	-	-	-	-	2	3	1	-
CO 4		3	3	2	1	-	-	-	-	-	-	-	2	-	3	-
CO 5		3	2	3	2	-	-	-	-	-	-	-	2	1	-	2
Average Mapping Strength		3	2.6	2.4	1.8	0.6	0	0.4	0	0	0	0	2.2	1.4	1.2	1

Note: High: 03; Medium: 02; Low: 01

Table 9 :
A Sample Co Attainment For A Standard Course

COs	CO 1					CO 2					CO 3					CO 4					CO 5				
Components	ST	EL	Assig	MT	ESE	ST	EL	Assig	MT	ESE	ST	EL	Assig	MT	ESE	ST	EL	Assig	MT	ESE	ST	EL	Assig	MT	ESE
Student List / Marks	4	4	2	7	22	4	4	2	7	20	4	4	2	6	20	4	4	2	NA	20	4	4	2	NA	18
S1	3	4	2	5	16	3	4	2	7	16	2	4	2	4	15	2	4	2		16	3	4	2		14
S2	2	3	1	4	14	2	2	2	6	15	2	4	2	2	14	2	2	2		12	2	4	1.5		14
S3	3	4	2	5	16	3	4	2	5	15	3	2	1	4	12	4	4	2		10	4	4	2		14
S4	4	4	2	5	17	3	2	2	5	10	2	4	2	4	17	2	4	2		18	3	4	1		16
S5	2	4	2	7	18	2	4	2	4	16	3	4	2	4	14	3	4	2		16	3	3	2		14
S6	3	4	2	7	17	3	1	2	4	11	3	4	2	4	12	3	4	2		14	4	3	2		13
S7	3	4	2	7	15	3	4	2	4	14	2	4	2	4	13	3	4	2		11	2	3	1		14
S8	3	3	1	6	15	3	2	2	4	13	2	4	2	3	12	3	4	2		16	3	4	2		15
S9	3	4	2	5	16	3	4	2	5	13	1	2	2	4	11	2	4	2		16	3	3	2		14
S10	3	3	2	3	16	3	4	2	4	13	3	3	1	3	11	3	2	1		12	1	1	2		8
S11	2	4	2	5	16	2	3	2	5	18	2	4	2	4	10	3	4	2		15	3	4	2		12
S12	3	4	2	5	16	3	4	2	3	16	2	1	2	3	7	4	4	2		16	3	3	1		14
S13	2	3	2	7	17	3	4	2	4	18	3	4	2	4	13	3	4	2		18	2	2	2		8
S14	3	3	1	5	14	4	4	2	5	18	3	4	2	4	13	4	4	2		17	3	3	2		14
S15	3	4	2	7	15	3	2	2	4	15	4	4	2	4	15	4	4	2		12	2	3	1		15

Set Value	2.4	2.4	1.4	4.2	16.5	2.4	2.4	1.4	4.2	15	2.4	2.4	1.4	3.6	15	2.4	2.4	1.4	0	15	2.4	2.4	1.4	0	13.5
No. of students attend the set values	11	15	12	13	4	12	10	15	7	9	7	12	13	11	3	11	13	14	0	9	10	13	11	0	11
% of student securing equal or more than the set value	73.3	100	80	86.7	26.7	80	66.6	100	46.6	60	46.6	80	86.6	73.3	20	73.3	86.(	93.3	0	60	66.6	86.6	73.3	0	73.3
Attainment levels of individual CO	2	3	3	3	0	3	1	3	0	1	0	3	3	2	0	2	3	3	0	1	1	3	2	0	2
Attainment of individual CO (Considering Weightages)	1.1					1.39					0.83					1.49					1.86				
Average CO Attainment											**1.334**														

displays the target levels and gap analysis for each CO within a specific subject. It's important to note that this percentage may vary based on the difficulty level of each CO. Successful achievement of these targets indicates successful attainment of the courses for the year. As part of continuous improvement, the program is encouraged to set higher targets in subsequent years. In instances where the targets are not met, the program is required to develop an action plan to ensure the attainment of targets in the following years, as outlined in Table XI.

B. Calculation of PO-PSO Attainment

PO-PSO attainment value = (Average mapping strength of the subject x Average CO attainment) /3

For example: PO1= (3 x 1.334)/3 = 1.334.

After evaluating the achieved results, in order to enhance the attainment of CO and PO in the upcoming academic year/semester, it is recommended to modify the teaching-learning approaches. Embrace innovative methodologies such as crossover learning, argumentation-based learning, incidental learning, context-based learning, computational thinking, and adaptive teaching. These approaches should be designed to be easily comprehensible for students, ensuring a more effective educational experience.

In Fig.6, the X-axis represents POs, and the Y-axis represents the attainment values, graded on a 3-point scale. PO1 exhibits the highest attainment with a value of 1.334, while PO7 has the lowest attainment at 0.178. Analyzing the COs mappings, it is evident that PO6, PO8, PO9, PO10, and PO11 are not achieved, suggesting that these specific program outcomes may not align well with the course objectives as per the mappings. Table XII represents the calculation of PO-PSO attainment for a standard course. PO 9 and 10 for this specific theory subject can be achieved by introducing the flip class, where some topics may be assigned to the students in a group to present in the class room.

4. Implications

This study holds significant implications for practitioners, theoretical frameworks, and policy-making. The proposed framework in this research can assist teachers in assessing the level of achievement in PO and CO. This framework can help teachers identify the outcomes of their course and focus on enhancing their teaching pedagogy. Additionally, it can help improve assessment rubrics to improve the degree of CO attainment for their course. In a similar vein, institutions have the ability to assess their attainment of POs and make comparisons with other universities that offer similar programs. This can prove beneficial for educators in identifying the specific areas in which they can concentrate their efforts to enhance student learning. This will also prove beneficial for universities in identifying regions requiring improvement and those that can be maintained in their current state during periods of resource scarcity. While this study was conducted in India, it is worth noting that the research framework presented herein holds potential applicability to institutions in other developing nations that are now undergoing program accreditation in accordance with the Washington Accord. The results of this study will also provide valuable insights for policymakers. They have the ability to assess the level of proficiency in both the theoretical and practical aspects of specific programs and courses provided by top universities. They can then create guidelines and policies that will guide other universities in enhancing the quality and effectiveness of their teaching and assessment methods.

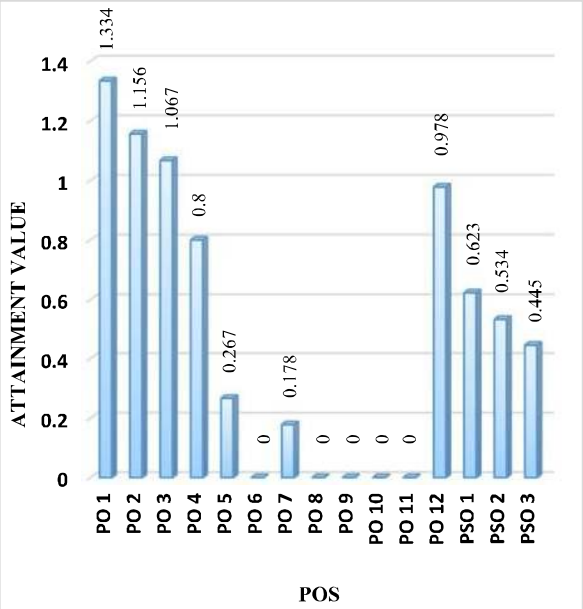

Fig. 6 : Program Outcome Attainment for a standard course

Conclusion

The suggested system offers a thorough evaluation of OBE in an engineering college using Microsoft Excel data. Curriculum, Assessment, and Evaluation serve as primary tools for achieving POs, and their attainment is assessed solely through the direct method. In this paper, we analyze real-time data to assess the achievement of COs and POs. The key indicator of program performance lies in the attainment of COs and POs. If the attainment is deemed satisfactory, the teaching-learning process continues; otherwise, adjustments in the learning approach may be necessary to enhance attainment levels. In cases of high attainment, it becomes straightforward to elevate the level further by adjusting the attainment formula. The assessment of course results involves systematically gathering data and utilizing student learning information for improvement purposes. This paper proposes a simplified approach utilizing different weightages for attainment calculation, aligned with the formulation of COs, CO-PO-PSO Mapping, and justifications.

Abbreviations

OBE	:	Outcome -Based Education
CO	:	Course Outcome
PO	:	Program O utcome
PSO	:	Program Specific Outcome
PEO	:	Program Educational Objective
NBA	:	National Board of Accreditation
NAAC	:	National Assessment and Accreditation Council
UGC	:	University Grants Commission
AICTE	:	All India Council for Technical Education
ST	:	Surprise Test
EL	:	Experiential Learning
Assig	:	Assignment
MT	:	Mid Term
ESE	:	End Semester Examination

Table 12 :
Attainment Of Po-pso For A Standard Course

	PO 1 Engg. Knowledge	PO 2 Problem Analysis	PO 3 Design/development of Solutions	PO 4 Conduct investigation of complex problem	PO 5 Modern tool Usage	PO 6 The Engineer & Society	PO 7 Environment & Sustainability	PO 8 Ethics	PO 9 Individual & Team Work	PO 10 Communication	PO 11 Project Management & Finance	PO 12 Life Long Learning	PSO 1	PSO 2	PSO 3
Average Mapping Strength of the subject (Table 8)	3	2.6	2.4	1.8	0.6	0	0.4	0	0	0	0	2.2	1.4	1.2	1
Average CO Attainment (Table 9)	1.334														
Attainment of PO & PSO	1.334	1.056	1.067	0.800	0.267	0	0.178	0	0	0	0	0.978	0.623	0.534	0.445

Analyzing these attainment values can guide the implementation of innovative methodologies to enhance student performance, contributing to continuous improvement in subsequent years. It is recommended that institutions establish a standardized process for CO-PO-PSO attainment to streamline the OBE process. The efficacy of the OBE process is contingent upon the practices of relevant academic members. Effective planning is crucial in meeting additional requirements imposed by accreditation bodies, ensuring a favorable outcome. The approaches suggested in this study are beneficial for researchers aiming to investigate teaching and learning in both traditional and online classroom settings, particularly in alignment with the NBA and NAAC Accreditation process under OBE. Additionally, researchers could build upon this work to develop new and emerging technologies for assessment and capturing student feedback in online learning environments. There is an opportunity to improve the evaluation methods for COs, POs, and PSOs by considering indirect approaches like course-end surveys, graduate exit surveys, alumni surveys, and employer surveys in future study. We are continuing to work on enhancing the assessment method to identify the optimal approach for directly evaluating both COs and POs simultaneously by combining both direct and indirect method.

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