MADANAPALLE INSTITUTE OF TECHNOLOGY & SCIENCE
(UGC-AUTONOMOUS)
Affiliated to JNTUA, Anantapuramu & Approved by AICTE, New Delhi
Recognised Research Center, Accredited by NBA for CE, CSE, ECE, EEE, ME, CST
MBA & MCA, recognised by UGC under the sections 2(f) and 12(B) of the UGC act 1956

Outcome Based Education (OBE) Manual

Preamble

MITS, Madanapalle, has embraced the principles of Outcome Based Education (OBE) wholeheartedly, placing a strong emphasis on student-centered learning and utilizing outcomes to assess student achievement. Our curriculum, academic procedures, teaching strategies, assessment and evaluation systems, and other aspects have all been meticulously restructured and designed with guidance from OBE. The aim is to ensure that our graduates possess the essential qualities expected of Engineering and Management professionals.

The OBE Manual has been developed with the primary objective of providing practical guidance to teachers of Engineering and Management at MITS, Madanapalle, on key components of OBE philosophy. The goal of this manual is to empower MITS in developing and implementing effective teaching-learning activities that lead to the attainment of program and course objectives and outcomes.

In addition to offering practical insights into OBE philosophy, the manual also provides recommendations on assessment and evaluation procedures to accurately gauge student performance and identify areas requiring further development. The ultimate intention is to establish a cycle of continuous improvement, where curriculum development, instructional strategies, and assessment procedures are all informed by the outcomes of OBE.

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1 Outcome based Education

Outcome-based education (OBE)- a performance-based approach has emerged as a major reform model in the global engineering education scenario. The country that wants to be a signatory member of a multinational agreement for the mutual recognition of engineering degrees, i.e. the Washington Accord (WA) must implement **OBE**. This will be an endorsement that the engineering education system has demonstrated a strong, long-term commitment to quality assurance in producing engineers ready for industry practice in the international scene. Being signatory to the Washington Accord, Indian accreditation agency '**National Board of Accreditation (NBA)**' has made it mandatory for engineering institutions to adapt OBE framework for their curriculum design, delivery and assessment. In OBE framework, the educational outcomes of a program are clearly and unambiguously specified. These determine the curriculum content and its organization, the teaching methods and strategies and the assessment process.

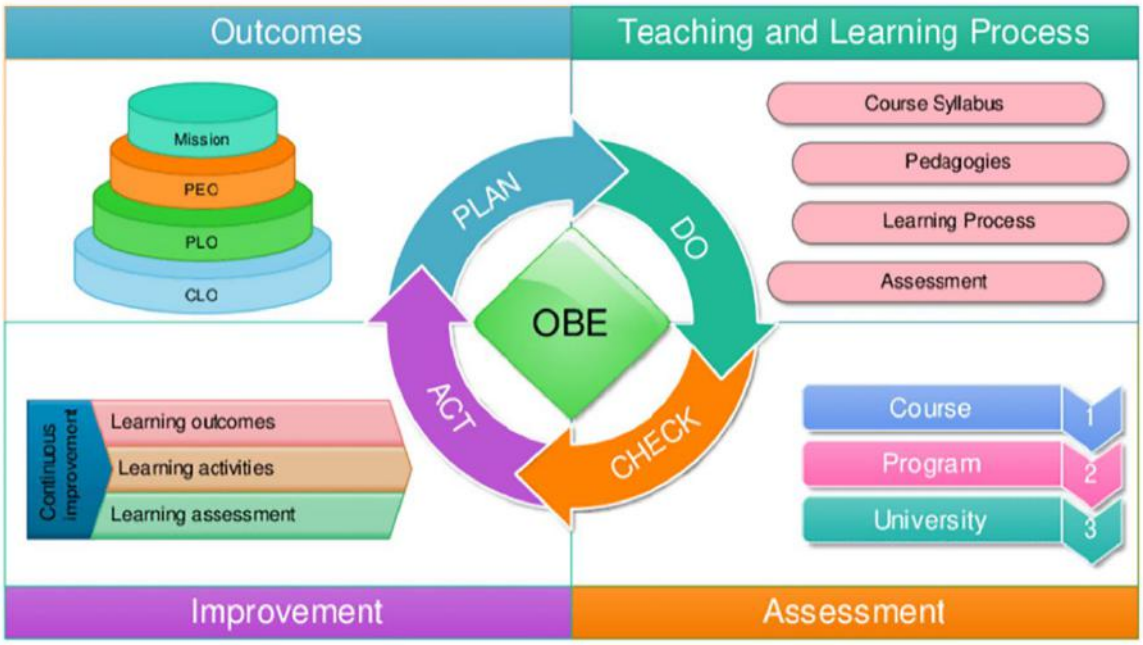


Fig. 1 Outcome based Education Process

The Fig. 1 illustrates the processes involved in Outcome-Based Education (OBE). The OBE approach begins with defining the desired outcomes, which include course outcomes, program outcomes, program educational outcomes, and the vision and mission of the institution. Once these outcomes are established, the teaching-learning process, assessment, and improvement strategies are framed and aligned to achieve them. In this regard, first step is to plan the course syllabus, relevant pedagogies, and learning processes to meet the defined outcomes. The second step is to implement well these strategies to the real scenario. Once, all these are implemented, it is required to check them whether all these are working effectively and efficiently towards the outcomes, if not then corrective measures are to be taken for achieving the outcomes.

2 Outcome based Education Implementation

Outcome-Based Education (OBE) is a **student-centric learning model** that helps teachers to plan the **course delivery and assessment**. Fig. 2 shows the implementation of the OBE, which includes the following steps:

- Define Vision statements, Mission statements for the Institute and department
- Define Program Educational Objectives (PEOs)
- GA, PO & PSO Statements
- Define Course Objectives
- Map courses with Program outcomes at suitable levels of Bloom's Taxonomy
- Define Course Outcomes with Bloom's Taxonomy for each course
- Map topics with Course outcomes
- Prepare lecture-wise Course Lesson Plan
- Define pedagogical tools for course outcomes delivery
- Define rubrics for Tutorial, Practical, seminar, Mini Project, Final year Project
- Use Learning Management Tool such as Moodle for Assignments, Quizzes, Content beyond syllabus coverage, Tests, course feedback etc.
- Measure the attainment of each CO through Direct/Indirect assessments
- Track student performance
- Identify Gaps in the Curriculum and adopt suitable measures to bridge the Gap
- Compare PO/PSO for last 3 academic years and propose remedial actions
- Assess the attainment of Program Educational Objectives

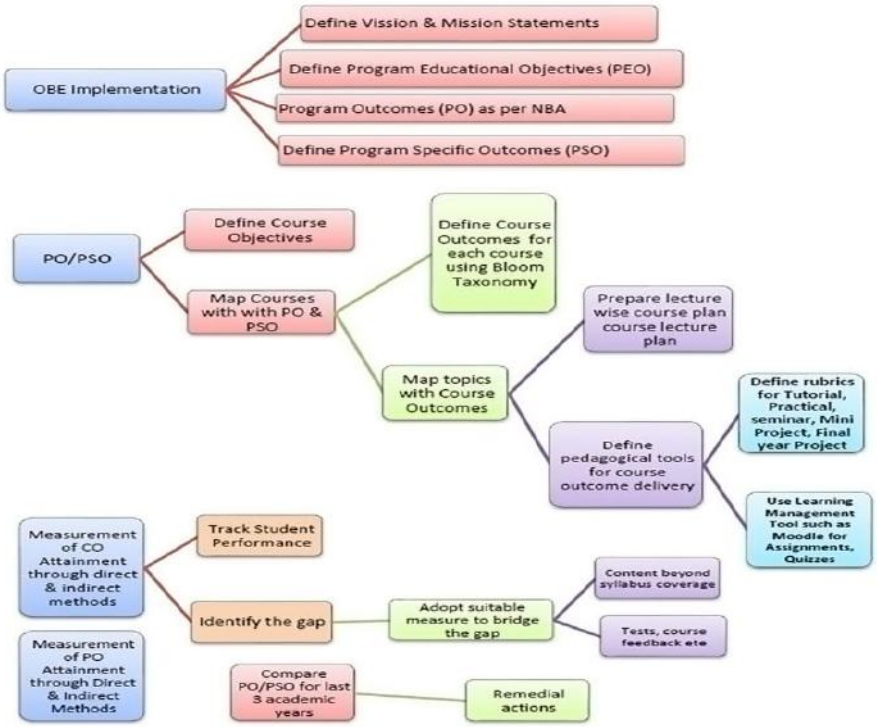


Fig. 2 Implementation of Outcome based education

2.1 Key Components and Outcome Levels

OBE comprises of four major components which cover

1. Curriculum Design
2. Teaching and Learning Methods
3. Assessment
4. Continuous Improvement

OBE defines four levels of outcomes, which are:

1. Course Outcomes (CO) - Knowledge & skills acquired via course/curriculum
2. Program Outcomes (PO) – Expertise/Skills developed at the completion of program
3. Program Specific Outcomes (PSO) - Expertise of graduates of a certain program
4. Program Educational Objectives (PEO) - Broader objectives after 4-5 years completion of the program

2.2 MITS Vision

To become a globally recognized research and academic institution and thereby contribute to technological and socio-economic development of the nation.

2.3 MITS Mission

To foster a culture of excellence in research, innovation, entrepreneurship, rational thinking and civility by providing necessary resources for generation, dissemination and utilization of knowledge and in the process create an ambience for practice-based learning to the youth for success in their careers.

2.4 MITS EOMS Quality Policy

Madanapalle Institute of Technology & Science is committed to bring out and nurture the talents and skills of youth in the fields of Engineering and Management to cater to the challenging needs of society and industry by

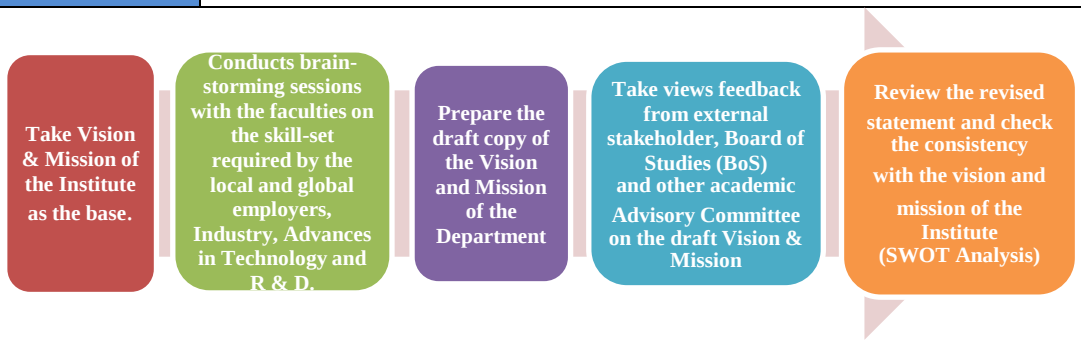
- Contributing to the academic standards and overall knowledge development of the students
- Providing excellent infrastructure and conducive learning environment.
- Enhancing the competence of faculty and promoting R & D Programs
- Collaborating with institutions and industries.
- Ensuring continual improvement of Quality Management System

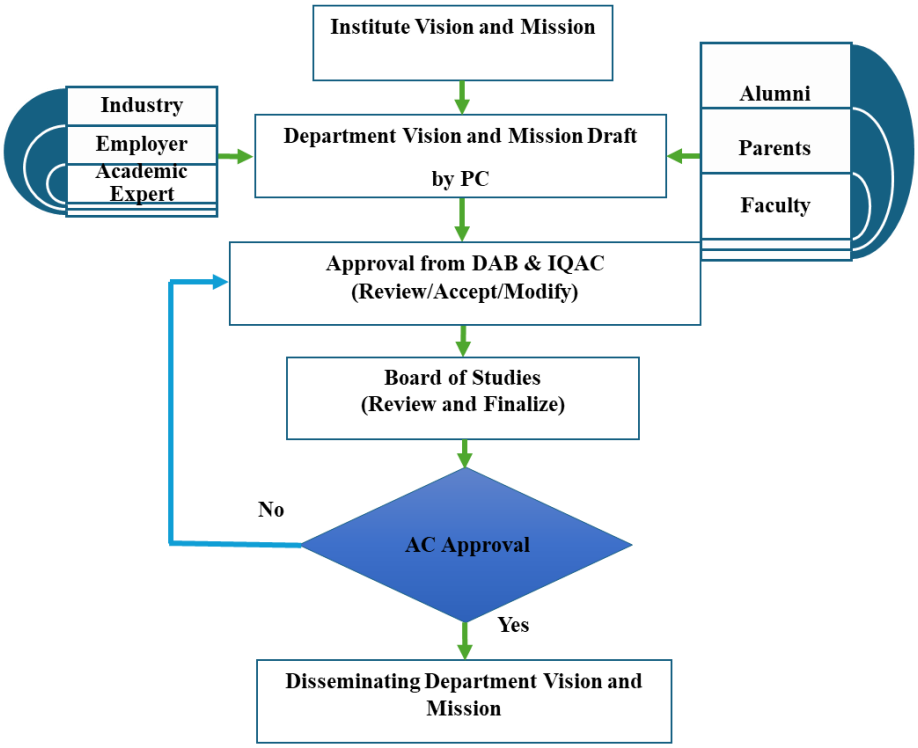
2.5 Department Vision & Mission

Vision: The vision of a department refers to the long-term aspirations and guiding principles that outline what the department seeks to achieve and become in the future. It encapsulates the department's strategic objectives and sets a direction for its growth and development.

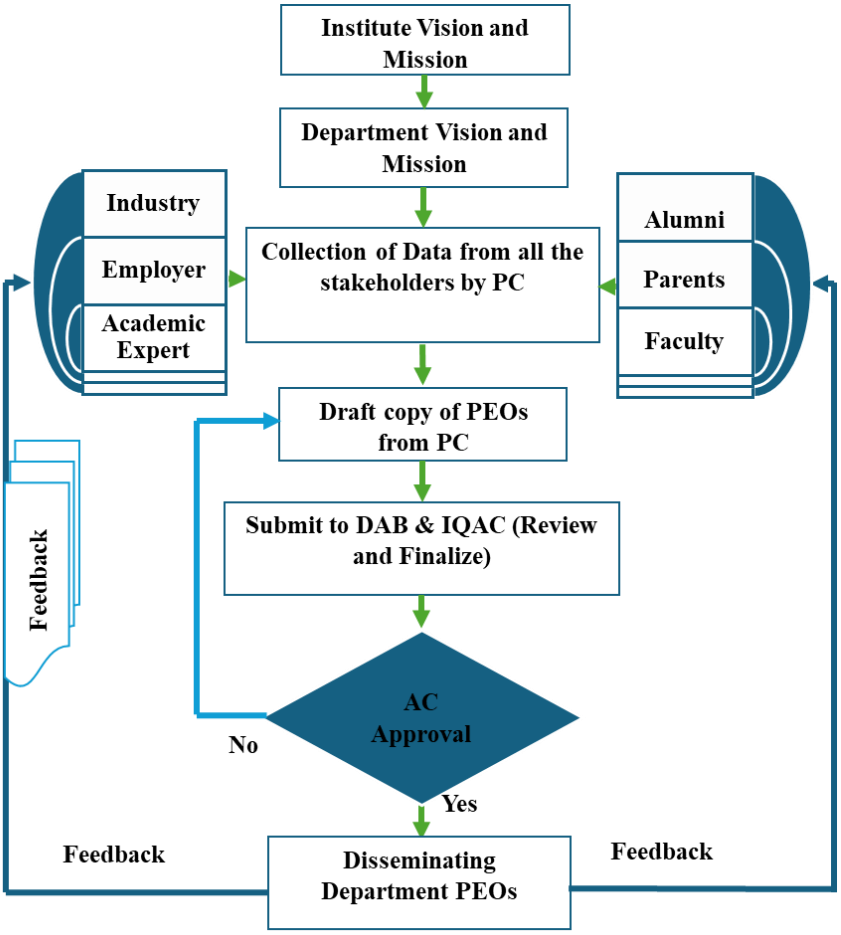
Mission: Mission statements are actionable statements that guide the stake holders to act and achieve the vision

Formation	• Brainstorming sessions with stake holders including experts & experienced faculty of the department • Discussion with industry professionals, employers, students, parents and alumni batches • Accepted views are analysed and reviewed to check the consistency with the vision and mission of the institute
Dissemination	• Academy website, display in the various class rooms and laboratories, Departmental office and notice board and course file and lab manual
Correlation with Institute Vision	High (3)





2.6 Programme Education Objective	
Program educational objectives (PEOs) specify the expected outcomes of students once they graduate, mostly the way they conduct their behaviour & ethics and excel in their careers after 4-5 years of graduation. It is supposed to define minimum 3-5 PEOs.	
Formation	• The Program Coordinator consults with the senior faculty members and prepares a draft mentioning the POs. • The Program Coordinator also speaks to the students that belong to the Alumni batch, industry representatives, and various employers to understand the requirement of current industry & trends. On analyzing the views, he/she edits the draft and sends it to the Program Assessment Committee. • The Program Assessment Committee reviews the draft and sends it to the Department Advisory Board to get the final approval. • Department Advisory Board and IQAC makes the final decision by moderating the draft and get approved by BOS. • PEOs should be measurable, appropriate, realistic, and achievable.



2.6.1 Mapping Mission statements with Program Educational Objectives

- The program educational objectives (PEOs) should fall in line with the Mission statements. The BoS of the department is to establish consistency of the PEOs with the mission of the department.
- There are distinct elements of the mission statements such as academic development, industrial & social needs, human potential development etc.
- These key elements capture some key aspects of the PEO statements. On the basis of this, the correlation is established between PEOs and such distinct elements of mission statements, the correlation is quantized the correlation levels need to be entered as 1 or 2 or 3.
- **"1"** means that the correlation is low or slight, **"2"** means that the correlation is moderate or medium and **"3"** means that the correlation is substantial or is very high.

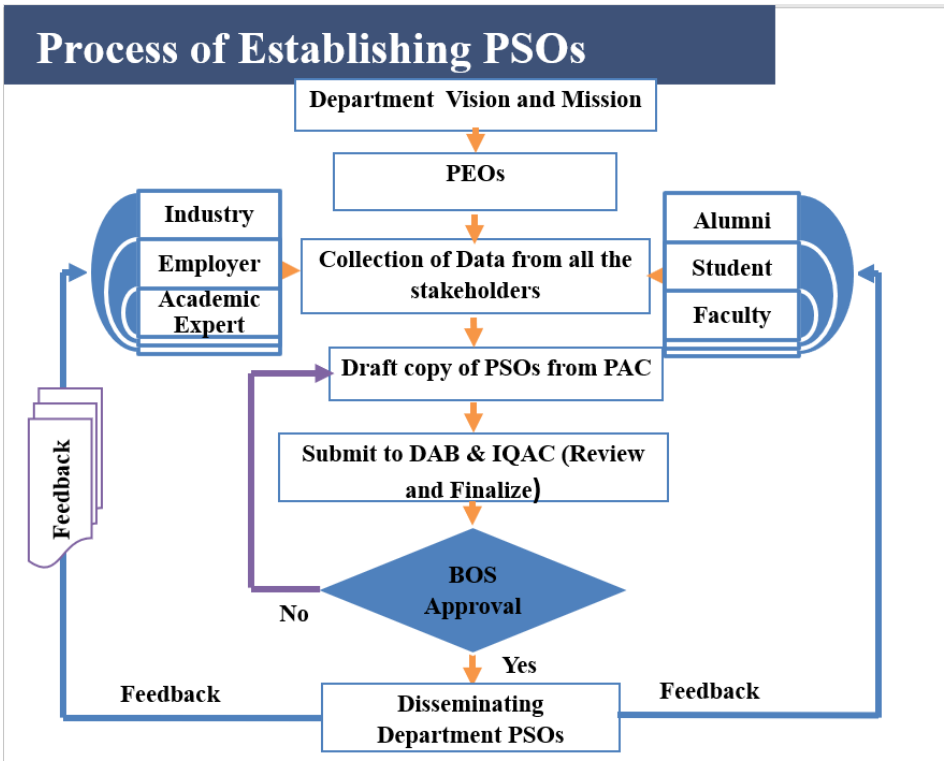
2.7 Programme Outcome and Programme Specific Outcome		
Description		• Program outcomes are statements that describe what students are expected to know and be able to do upon graduating from the program. • These relate to the skills, knowledge, analytical ability, attitude, and behavior that students acquire through the **program at the end of 4 years**. • The POs essentially indicate what the students can do from the knowledge acquired by them during the program. • As such, POs define the professional profile of an engineering graduate. NBA has defined the following 11 POs for an engineering graduate and are applicable to all engineering programs:
PO1	**Engineering Knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the **solution** of **complex engineering problems.**
PO2	**Problem Analysis**	Identify, formulate, research literature, and **analyze complex engineering problems** reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**	**Design solutions** for **complex engineering problems** and **design** system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**	Use research-based knowledge and research methods including **design of experiments**, **analysis and interpretation of data**, and **synthesis** of the information to provide valid conclusions.
PO5	**Modern Tool Usage**	Create, select, and apply appropriate techniques, resources, and **modern engineering and IT tools** including prediction and modelling to **complex engineering activitie**s with an understanding of the limitations.

PO6	**The Engineer and Society**	**Apply reasoning informed** by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**	**Understand** the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**	**Apply ethical principles** and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**	**Function effectively** as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO10	**Communication**	**Communicate effectively** on **complex engineering activities** with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
P011	**Project Management and Finance**	**Demonstrate knowledge** and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-Long Learning**	**Recognize** the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Program Specific Outcomes (PSOs)

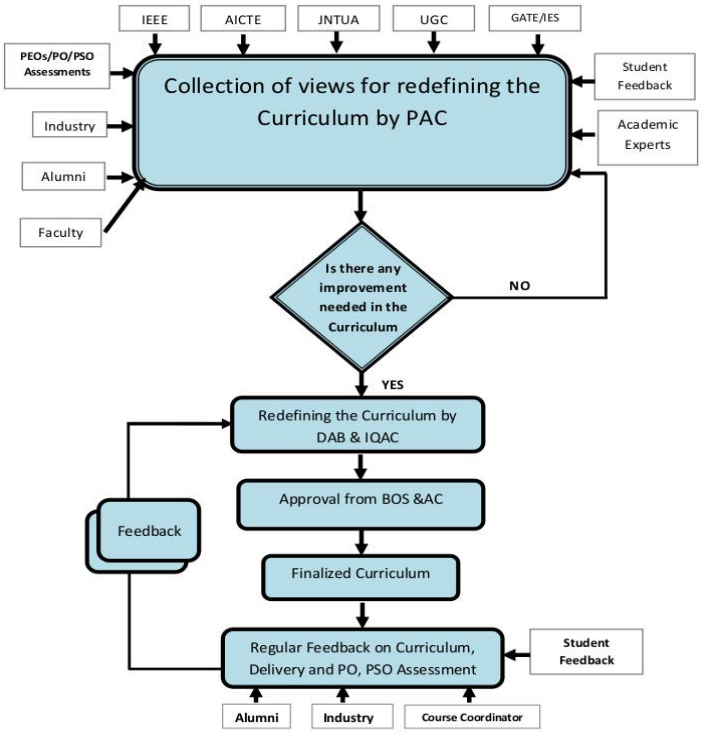
Program Specific Outcomes are statements that describe what the graduates of a specific engineering program should be able to do.

- PSOs characterize the specificity of the core courses of a program.
- Like POs, the PSOs are important as a guideline while developing or revising the course outcomes and curriculum.
- PSOs are defined based on the **Centre of Excellence** of the Department.
- Generally, **2 to 3** Program Specific Outcomes (PSOs) that the graduates of the program will attain should be defined for each department.



3 OBE Course Design and Delivery

The efficiency of an OBE system to a greater extent depends on how well the curriculum is managed and delivered. Drilling down to the course level, it is mandatory that a curricular framework or a course design is needed to assist the teacher and students to navigate through the curricular activities along the right track. The cardinal principle behind an OBE course design is the principle of **constructive alignment**, i.e. streamlining the learning experiences and assessments to the **intended course outcome**. The flow chart to design the curriculum is presented below.



Curriculum design procedure

3.1 OBE-enabled course development

- Gather information about the course content, available resources related to the content, the respective course outcomes, course expectations, and students learning needs.
- Divide the module into functional units or frames and decide upon the intended learning outcomes and performance indicators for the course units.
- Select content, fundamental concepts related to the content, appropriate learning activities, instructional method, support system (media) relevant for the learning environment, and constructive align it to the intended course outcome
- Develop suitable performance indicators (assessment methods) that directly reflect the attainment of the intended learning outcomes.
- Implement the course plan as per the design creating a learning environment for the community of learners (students of the course).
- Revise the plan periodically after the assessment and evaluation based on intended learning outcomes and actual learning outcomes, feedback from the students, peers, and self-reflection.

3.2 Elements for effective development of OBE-enabled Course

- What the students should learn and be able to do on completion of each subunit must be clearly identified.
- Formative assessment tools should be based on demonstrated achievement of the students. Hence proper indicators for the assessment must be identified.
- Diversified instructional and assessment strategies should be formulated to meet the needs of the students.
- Ensure the learning strategies and assessment techniques to be aligned with the learning outcomes.

- Each student should be made to reach the maximum potential by providing suffi-cient assistance.

3.3 Course Outcomes (COs):

- It is a detailed description of what **a student** must be able to do at the end of a course.
- COs are the statements of **Knowledge/ Skills/ Attitude** that students are expected to know, understand and perform, as a result of learning experiences.
- Course Outcome remains the **base of the hierarchy of outcomes** and is the tools that can be used to measure student performance in each course.
- The course outcomes need to be **concise descriptions** of what learning is expected to take place by course completion.
- It should be **Specific, Achievable** and **Measurable** statements
- Well-written COs facilitate the faculty to **determine the depth of knowledge** required for specific content associated with each CO. It also helps the faculty in designing suitable delivery and assessment methods to achieve the designed COs.
- New COs are developed when a new course is offered.

3.3.1 Preparation and writing COs

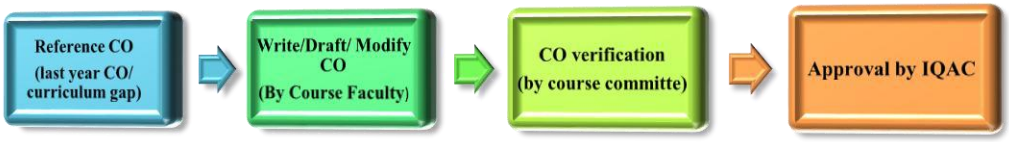
Well-written CO facilitates the faculty in measuring the achievement of the CO at the end of the semester. To prepare the COs, the points given below are to be supposed to follow.

- Define the CO considering the course content covered in each module of a course.
- Focus on the **learning skills** that results from the course rather than describing activities or lessons that are in the course.
- Create CO that is **student-cantered** rather than an instructor cantered.
- For every course there may be **5 or 6** Course Outcomes depending **total hours of syllabus.**
- Write a CO with **performance indicator (based on blooms taxonomy), condition indicator** and **criteria indictor**.

  CO: Write a customer reply letter with no spelling mistakes by using a word processor.

  Performance component: Write a customer reply letter
  Conditions component: using a word processor
  Criteria component: with no spelling mistakes
- To develop COs, follow the **SMART** rules.
  - **Specific**: Students can state what they should be able to achieve from reading the outcomes.
  - **Measurable**: Students can be able to recognize when they have achieved the outcomes.
  - **Achievable**: It is genuinely possible to complete the outcomes in the time and with the resources available.
  - **Realistic**: Outcomes are appropriate for the student.
  - **Time bounded**: Outcomes have a time limit for completion

- The keywords used to define CO are based on Bloom's Taxonomy and **map each CO with Bloom's Taxonomy.** The **intended Blooms Level of CO** should be aligned with the corresponding **PO blooms level** for which the **particular course** was mapped.
- For the theory courses, while writing the COs, you need to restrict yourself between Blooms Level 1 to Level 4. Again, if it is a programming course, restrict yourself between Blooms Level 1 to Level 3 but for the other courses, you can go up to Blooms Level 4.
- For the laboratory courses, while composing COs, you need to restrict yourself between Blooms Level 1 to Level 5.
- Only for Mini-project and Main project, you may extend up to Blooms Level 6 while composing COs.
- Existing COs are revised upon feedback from stakeholders or during the cycle of Curriculum review.



- Table 1 depicts the blooms levels of POs, which are supposed to be incorporated while preparing the COs of a course. A **course coordinator/ instructor** is supposed to prepare a table as shown by last two column in **Table 1** with the corresponding **benchmark** blooms level of each CO.

Table 1: Benchmark Blooms Level for PO and CO

PO	Action verbs keyword in PO	Blooms Level	CO	Benchmark Blooms Level as per the Course Curriculum
PO1	Apply	L3	CO1	
PO2	Identify, formulate, and analyse	L2, L6 and L4	CO2	
PO3	Design and develop	L6 and L3	CO3	
PO4	Analyse, Interpret and design	L4, L3 and L6	CO4	
PO5	Create, select and apply	L6, L1, L5 and L3	CO5	

3.4 Outcome Based Course Outline

An outcome-based course outline includes the four steps, which are introduction, content, assessment, and resources. Every step consists of a number of components that needs to be prepared and followed by the concerned faculty.

3.4.1 Introduction

This step also includes five components a. Course information, b. Academic session, c. Course objective, d. Learning outcome, and e. CO-PO mapping and attainment.

- **Course Information** is all about the course itself such as, (i) Course no./code, (ii) Course name/title, (iii) Section/Student group, (iv) Pre-requisite, (v) Credit value, and (vi) Total marks.
- **Academic session** includes other academic information such as, (i) Semester (ii) Course level, and (iii) Course type.
- **Instructor profile** includes short biography of the course instructor who is the developer of the course outline as well.
- **Course objective** includes the description of the course through the following points: (i) Rationale of the course, (ii) Course synopsis, and (iii) Overall and specific objectives.
- **Course outcome** is the list of students' learning outcomes aligned with the course objectives mentioned earlier. These learning outcomes are called Course Outcomes (CO) of the course.
- **CO-PO-PSO mapping and attainment** includes the mapping of each CO with one or more program outcomes (PO) and PSO listed for the program for which this course is required. This is called course articulation matrix. Every program has a list of PO's that needs to be achieved by every student at the program completion. Student's attainment level from each course, as the course grade point, contributes to the cumulative grade point of the program. The guidelines to prepare the course articulation matrix and attainment are discussed later on.

3.4.2 Content

This step includes the components a. Topic selection and its alignment with CO, b. Teaching-learning strategy, and c. Class schedule and Lesson Plan.

- **Topic selection and alignment with CO** is about the subject contents that are planned to teach during the semester. Each and every selected topic must the aligned with the course objectives and learning outcomes of the course. This process in outcome-based course outline is exactly opposite to that of the traditional course outline. Here, subject topics are selected as required according to pre-defined POs of the program and COs of a course.
- **Teaching-learning strategy** is a wide area of considerations of variety of suitable methods for effective teaching and learning. Some effective methods, suitably classified as Andragogy, are accepted for tertiary education. This component in the course outline

gives an outline of the teaching methods to be used and process of students' learning. (Teaching learning strategies are discussed in the next article of this series of write-ups.)

- **Class schedule and Lesson Plan** includes the dates and times of lectures during the semester. Lesson plan is the plan of every class/lecture by day or lecture hours by week. All classes are planned in the lesson plans by a standard format practiced in the institution. (**Format of Lesson Plan and course files are attached on IQAC website.)**

3.4.3 Assessment

This step includes the components a. Assessment strategy, b. Assessment tool selection, and c. Evaluation policy and grading.

- **Assessment strategy** is the selection of an appropriate method of evaluating students' performance for the course. There are various methods of students' performance evaluation, which are independently effective for different courses. Usually, Two MID semester exams and assignment are conducted as the part of formative assessment. Similarly, end semester exam for each course at the end of semester is considered as summative assessment. The Project and internship reviews are conducted as per the rubrics.
- **Assessment tool selection** includes the list of assessment tools that are intended to use for this course during its time period. The assessment tolls can be quiz, class test, assignment, report writing, group task, project work etc. There is no wrong or right in this selection of tools. Instructor identifies variety of selected tools for the course to evaluate the students' performance and mention the evaluation tools in the course outline. **However, MITS has predefined tools for evaluation of student performance.**
- **Evaluation policy and Grading** is about the institutional policy of examination and grading system. Policies also include the law of being absent in an exam, course retake, course withdrawal, incomplete grade, individual or group work standard, field trip design, project work formation etc. Grading system shows the range of marks for different grades, and the calculation methods of course grade, semester grade and program grade points.

3.5 Resources

This step includes the components a. Text book and reference, and b. Other resources.

- **Text book and reference** includes the names of one or more text books that will cover all of the topics selected for the course. Some more reference books are also to be mentioned here for student's learning support and extra knowledge for the course.
- **Other resources** are the list of all other resources that the students need to follow during the semester. These resources can be professional journal, research article, company report, conference proceedings, website, video/audio clip, or any other online resources.

3.6 Activity-based learning

In an OBE environment, the role of the teacher is to design an environment for learning. The student must get actively involved in the learning process for the attainment of the intended learning outcomes. Henceforth, for designing an effective environment for learning a sound knowledge of activity-based learning strategies are essential. A list of few activities beyond the classroom-board teaching are MOOC, Flipped Classroom, Supervised Learning, Think Pair Share, Think Pair Solo, Round Robin, Collaborative Learning, Puzzles, Programmed Instructions, Matrix Method, Peer Learning, Work-Based Learning, Problem-Based Learning, Personalized Learning, Group Discussion, Debate, Case Studies, Fishbowl, Reciprocal Teaching, etc.

4 OBE Assessment

Outcome-based assessment (OBA) asks us to first identify what it is, we expect students to be able to do once they have completed a course or program. It then asks us to provide evidence that they are able to do so. In other words, how will each learning outcome be assessed? What evidence of student learning is most relevant for each learning outcome and what standard or criteria will be used to evaluate that evidence? Assessment is therefore a key part of outcome-based education and used to determine whether or not a qualification has been achieved. In this regard, attainment of each learning outcome for a course or program is calculated with respect to each PO and PSO. OBE assessment tools include the direct and indirect attainment calculation of the CO-PO-PSO. The direct assessment tools are the internal and end semester examination, assignments, Lab evaluations, etc. These are divided into two categories: Continuous Internal Evaluation (CIE) and Semester End Evaluation (SEE). The indirect assessment is obtained from Course Exit Survey, alumni survey and employee survey etc. First, direct attainment calculation guidelines are discussed, then indirect attainment.

4.1 CO-PO Course Articulation Matrix Mapping

The first step for the direct attainment calculation is to prepare the course articulation matrix, which shows the educational relationship (Level of Learning achieved) between Course Outcomes and Program Outcomes (defined by NBA) for a Course. This matrix strongly indicates whether the students are able to achieve the course learning objectives or not. The matrix can be used for any course and is a good way to evaluate a course syllabus. Following are frequently used rules to frame this matrix.

- The Course Outcomes (CO) should be mapped with at least one of the PO i.e. all POs can be adequately addressed through the selection of core courses and their COs
- When designing the COs, faculty handling the course should map their COs to the appropriate PO in order to ensure that all POs are delivered throughout the period of study.
- Write the COs for a course and see to what extent each of those CO's correlate with the POs.
- For a given course, if in case more than one faculty are involved, the course in-charge has to involve all the other faculties who teach that course and ask them to come up

with the CO-PO mapping. The course in-charge has to take the average value of all of these CO-PO mappings and finalize the values or the course in-charge can go with what the majority of the faculty members prefer for. Ensure that none of the Professors who are handling the particular course discuss with each other while marking the CO-PO values.

4.1.1 Revised Bloom's Taxonomy

The bloom taxonomy is a set of three hierarchal models used to classify educational objectives. These models include cognitive, affective and psychometer. After attaining the OBE every student shall be evaluated with their performance in different domains by various levels of model. The revised Bloom's Taxonomy is shown in Figure 3. There are six levels of cognitive learning according to the revised version of Bloom's Taxonomy. Each level is conceptually different. The six levels are remembering, understanding, applying, analyzing, evaluating, and creating. Bloom's Taxonomy is frequently used in writing the course outcomes as it provides a readymade structure and list of action verbs. All levels of Bloom's taxonomy of thinking skills can be incorporated into expected learning outcome statements. Recently, Anderson and Krathwohl (2001) adapted Bloom's model to include language that is oriented towards the language used in expected learning outcome statements.

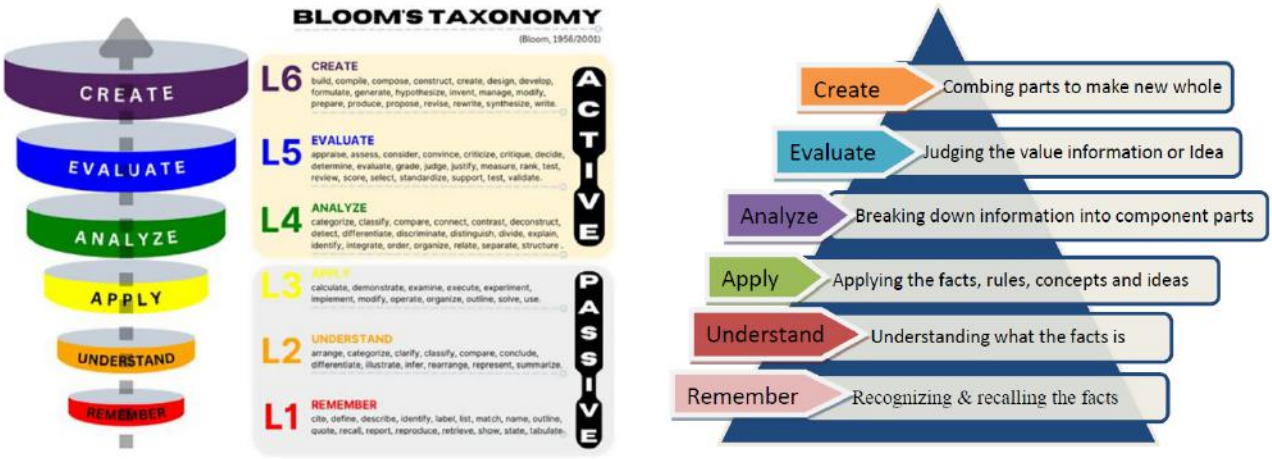
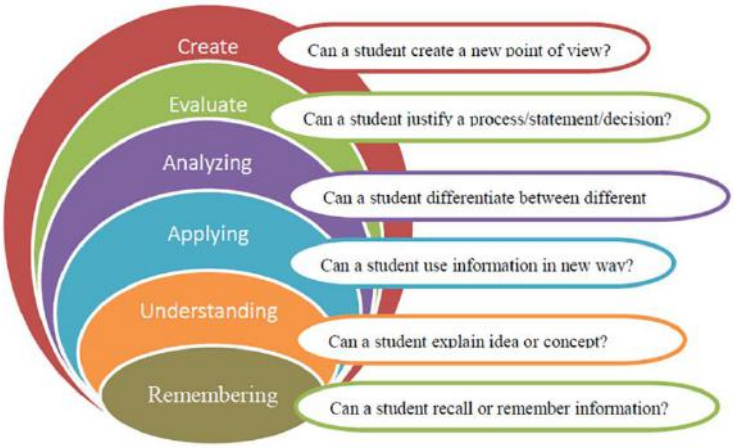


Fig. 3 Revised Blooms Taxonomy



Lower Order Thinking Skills

Based on Bloom's taxonomy of critical thinking, Lower Order Thinking Skills have three levels. They are Remembering, Understanding and Applying.

Higher-order thinking skills

The higher-order thinking skills include Analyzing, Evaluating, and Creating. It consist of complex thinking that achieves more than the basic recall of facts. Higher-order thinking skills enable students to retain information learned, and apply problem-solving solutions to real world problems.

The sample list of action words that can be used when creating the expected student learning outcomes related to critical thinking skills in a course. A details list is attached in Annexure.

Lower Order of Thinking (LOT)			Higher Order of Thinking (HOT)		
Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Define	Explain	Solve	Analyse	Reframe	Design
Describe	Describe	Apply	Compare	Criticize	Create
List	Interpret	Illustrate	Classify	Judge	Plan
State	Summarise	Calculate	Distinguish	Recommend	Formulate
Match	Compare	Sketch	Explain	Grade	Invent
Tabulate	Discuss	Prepare	Differentiate	Measure	Develop
Record	Estimate	Chart	Appraise	Test	Organize
Label	Express	Choose	Conclude	Evaluate	Produce
Choose	Illustrate	Make use of	Discover	Choose	Compile

4.1.2 Method for preparing Articulation Matrix

In OBE, a "design down" process is used which moves from POs to course outcomes (COs) and outcomes for individual learning experiences. Outcomes at each successive level need to be aligned with the program outcomes. Moreover, courses are the building blocks of a program. Teaching strategies, learning activities, assessments and resources should all be designed and organized to help students to achieve the learning outcomes at the course level. In the assessment activities, students demonstrate their level of achievement of the course learning outcomes. In a constructively aligned program, the courses are carefully coordinated to ensure steady development or scaffolding from the introduction to mastery of the learning outcomes and leading to achievement of the intended POs. For the effectiveness of the program, the achievement of POs is crucial which needs to be proven through accurate and reliable assessments.The articulation matrix is used for the CO-PO attainment calculation. In this process, the relationship among CO-PO-PSO is established as per the OBE guidelines, which are as follows.

4.1.2.1 Two-step Process for Bringing Clarity to POs

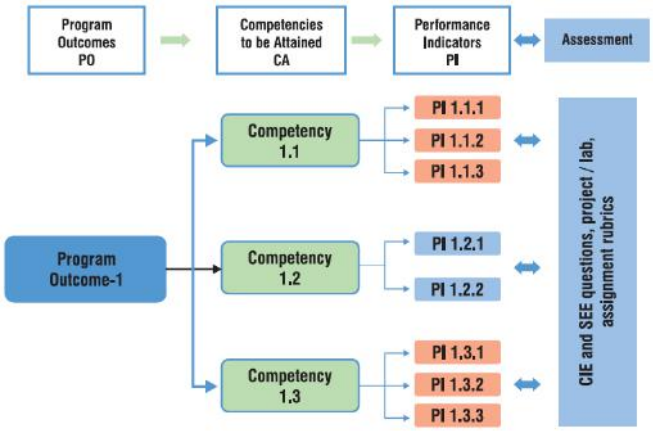
POs give useful guidance at the program level for the curriculum design, delivery and assessment of student learning. However, they represent fairly high-level generic goals that are not directly measurable. Real observability and measurability of the POs at course level is very difficult. To connect high-level learning outcomes (POs) with course content, course outcomes and assessment, there is a necessity to bring further clarity and specificity to the program

outcomes. This can be achieved through the following two-step process of identifying Competencies and Performance Indicators (PI).

1) Identify Competencies to be attained: AICTE has already been defined competencies for each PO, which relate to the different abilities implied by program outcome statement that would generally require different assessment measures. This helps us to create a shared understanding of the competencies we want students to achieve. They serve as an intermediate step to the creation of measurable indicators. **The competencies and PI defined by AICTE for each engineering program are given in Annexure.**

2) Define Performance Indicators: For each of the competencies, AICTE has identified the defined performance Indicators (PIs) that are explicit statements of expectations of the student learning. They can act as measuring tools in assessment to understand the extent of attainment of outcomes. They can also be designed to determine the appropriate achievement level or competency of each indicator so that instructors can target and students can achieve the acceptable level of proficiency.

Once the above process is completed for the program, the assessment of COs for all the courses is designed by connecting assessment questions (used in various assessment tools) to the PIs. By following this process, where examination questions map with PIs **(Fig. 4),** we get clarity and better resolution for the assessment of COs and POs. The pictorial representation of the process is given below.



Q. No	Question	Marks	BL	CO	PO	PI Code
	Section-A					
1.	a. What is an algorithm? Explain the characteristics of an algorithm.	2+6	1,2	2	1	1.4.1
	b. Write an algorithm to find angle between hour and minute hands of a clock at a given time.	7	3	3	1	1.4.1
	c. Is it mandatory to declare main() function with return type as void or int. What will be the effect if there is no return type declared for main() function?	3+2	4	3	1	1.4.1
	OR					
2.	a. What is the difference between definition and declaration in C? When a user writes "int x;" is it treated as declaration or definition in C.	3+2	2,4	3	1	1.4.1
	b. Write a program in C to find largest of 3 positive integer numbers using conditional operators.	7	3	3	1,2	1.4.1, 2.2.4
	c. What is meant by iterative statements? What are the different types of iterative statements in C?	8	1,2	3	1	1.4.1
	Section-B					

Fig. 4 Sample question paper format

4.1.2.2 Preparation of CO-PO-PSO articulation matrix

1. Identify the key PI of POs/PSOs to each CO and make a corresponding mapping table with assigning √ mark at the corresponding cell. One observation to be noted is that the first five POs are purely of technical in nature, while the other POs are non-technical.
2. Justify each CO - PO/PSO mapping with a justification statement and recognize the number of **Key PI (KPI) features** mentioned in the justification statement that are matching with the given Key Attributes for Assessing Program Outcomes. Use a combination of words found in the COs, POs//PSOs and your course syllabus for writing the justification.
3. Make a table with number of key performance indicators for CO – PO/PSO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.

Course Outcomes	Program Outcomes/ No. of key performance indicator (KPI)												Program specific outcomes/ No. of KPI		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	5	13	13	10	6	2	4	3	7	7	5	6	1	2	2
CO1	3	5			3										
CO2	3	5					3								
CO3	3														
CO4	3	5	5					3			5		1		
CO5	3			5								4			1

4. Make a table with percentage of key performance indicators for CO-PO/PSO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.

Course Outcomes	Program Outcomes/ No. of key performance indicator (KPI)												Program specific outcomes/ No. of KPI		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	5	13	13	10	6	2	4	3	7	7	5	6	1	2	2
CO1	60	38	0	0	50	0	0	0	0	0	0	0	0	0	0
CO2	60	38	0	0	0	0	75	0	0	0	0	0	0	0	0
CO3	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO4	60	38	38	0	0	0	0	100	0	0	100	0	100	0	0
CO5	60	0	0	50	0	0	0	0	0	0	0	66	0	0	50

5. Finally, Course Articulation Matrix (CO - PO / PSO Mapping) is prepared with COs and POs and COs and PSOs on the scale of 0 to 3, 0 being no correlation (marked with "-"), 1 being the low/slight correlation, 2 being medium/moderate correlation and 3 being substantial/high correlation based on the following strategy.

0 ≤ PI ≤ 5% – No correlation (0)
5 < PI ≤ 40% – Low / Slight (1).
40 % < PI < 60% – Moderate (2)
60% ≤ PI < 100% – Substantial / High (3)

Course Articulation Matrix (CO - PO / PSO Mapping)

Course Outcomes	Program Outcomes												Program specific outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	0	0	2	0	0	0	0	0	0	0	0	0	0
CO2	3	1	0	0	0	0	3	0	0	0	0	0	0	0	0
CO3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO4	3	1	1	0	0	0	0	3	0	0	3	3	3	0	0
CO5	3	0	0	2	0	0	0	0	0	0	0	0	0	0	2

The performance indicator for each program is presented in Table 2. The details are attached in Annexure.

Table 2: PO and corresponding performance indicator

PO	NBA Statement	No. of PI	
		Core Branches	Computer Science Engg / Allied branches.
1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).**	5	5
2	Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences **(Problem Analysis).**	13	14
3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).**	13	14
4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions **(Conduct Investigations of Complex Problems).**	10	8
5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).**	6	6
6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice **(The Engineer and Society).**	2	2
7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development **(Environment and Sustainability).**	4	4
8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice **(Ethics).**	3	3
9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **(Individual and Teamwork).**	7	7
10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions **(Communication).**	7	7
11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments **(Project Management and Finance).**	5	5
12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change **(Life - Long Learning).**	6	6

4.2 CO – PO/PSO Attainment Calculation

A common format of programmed excel sheet, prepared in the Institute, is being used for finding the CO-PO attainment. The concerned course faculty computes the attainment as per the appropriate assessment tools considered. Once the marks of each student for Mid examination, assignment and End semester examination are entered, the direct CO attainment can be measured for each student.

4.2.1 CO Attainment

Setting Target for CO Attainment

At the beginning of each semester, the course coordinator should establish the target level for each Course Outcome (CO) of the specific course.

- Target level for attainment of COs can be set initially based on average marks of a course in the last three previous academic years.
- However, it can also be based on some threshold (minimum passing criteria or some other threshold level) i.e. 60 % or Level-1/2/3 or maximum marks allocated to CO etc.
- The benchmark target is level-3; however, it may vary depending on the level of students and course.

Target Level	CO1	CO2	CO3	CO4	CO5
	2	2	2	2	2

- Course coordinator can set the same target level for all the COs of a course or different for each.
- CO target should be revised for every academic year, once it is achieved; remember the benchmark target is level-3.

S. N.	Average % result in last three	Target (in terms of percentage)	Target (in terms of Level)
1	Above 60% but less than 69%	60%	Level-1
2	Above 70% but less than 79%	70%	Level-2
3	Above 80 %	80%	Level-3

Level of attainment

Here three levels of attainment are taken as 1-Low; 2- Medium; 3- High. These levels of attainment can be defined as

- Attainment Level-3: >= 80% Student scoring above 60% of max marks allocated to CO.
- Attainment Level-2:70-79% Student scoring above 60% of max marks allocated to CO.
- Attainment Level-1: 60-69% Student scoring above 60% of max marks allocated to CO.

Procedure for computation of CO attainment

- CO attainment can be measured based on direct assessment and indirect assessment method, as shown in Fig. 4.

- Direct attainment of COs can be determined from the performances of students in all the relevant assessment instruments (CIE, SEE).
- Indirect attainment of COs can be determined from the course exit survey (Graduate survey, Alumni survey and Employer survey).
- The exit survey form should permit receiving feedback from students on all the COs.

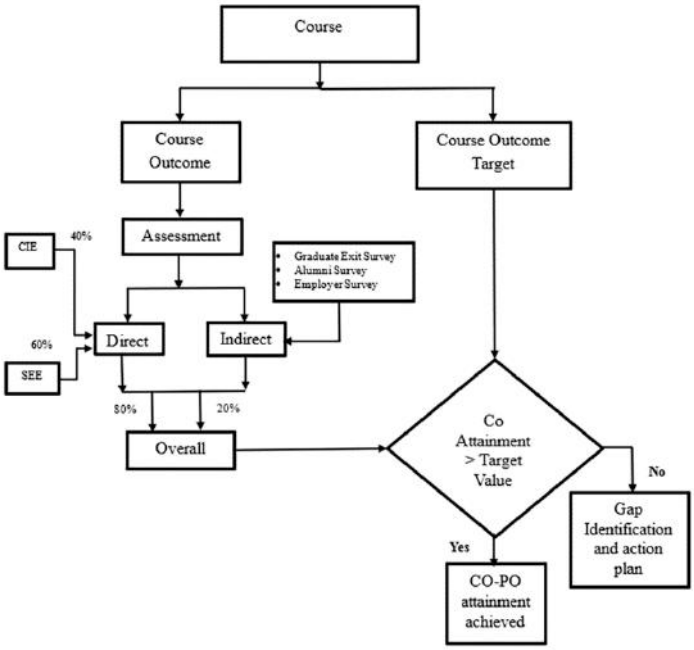


Fig. 4 Assessment of course outcome

4.2.1.1 Direct Attainment:

The following criteria are considered in the direct attainment:

- The direct attainment of Course Outcomes (COs) is determined based on student performance in Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE). The proportional weightages assigned to CIE and SEE are in accordance with the prevailing academic regulations. For instance, under the R20 regulations, the weightages are 40% for CIE and 60% for SEE.
- Continuous Internal Evaluation (CIE) is carried out by two mid-term Examinations and Two Assignments.
- Direct attainment of a specific COs is determined from the performances of students to all the assessment items related to that particular CO.
- Hence, every assessment item needs to be tagged with the relevant CO (Mid-term exam, assignment, End-semester exam).

Direct CO attainment from CIE

- Continuous Internal Evaluation (CIE) in the form of two Mid examination and assignments is conducted and evaluated by the department itself for the theory course.

- When questions are mapped with relevant Cos and bloom levels, the department can access performance of students with respect to each CO.
- Day to day evaluation is conducted for attainment calculation for laboratory course.
- Internal reviews are conducted for both project and internship work. The assessment process adheres to established rubrics specifically designed for evaluating project and internship outcomes.

Direct CO attainment from SEE

- Semester End Examination (SEE) for theory course, laboratory, project and internship is conducted and evaluated by the Institute policies and guidelines (internal examiner and external examiner).
- Each question should be tagged with the relevant Course Outcomes (COs) and Bloom's Taxonomy levels. This tagging allows for the detailed assessment of student performance relative to each CO. Additionally, the attainment score for each CO will indicate the specific Bloom's skill level that has been developed for the corresponding CO. This ensures a comprehensive understanding of both the students' proficiency in the course material and their cognitive skill development.

4.2.1.2 Indirect CO Attainment

The course exit survey is used as the indirect assessment tool for CO attainment. In the overall attainment, it is formulated with 20% weightage for every course and collected at the end of every semester.

4.2.2 PO Attainment

Program Outcome (PO) attainment is categorized into direct and indirect methods to assess the Program Outcomes and Program Specific Outcomes (PSO).

4.2.2.1 Direct PO/PSO Attainment

The direct attainment of POs and PSOs is computed from the COs attainment The CIE, SEE and Rubrics used for COs calculation helps to assess PO/PSO attainment. Once the direct attainment of each CO and Course Articulation Matrix is achieved, Direct PO/ PSO can be calculated as per the Excel sheet Template. The Direct PO attainment is the average of POs for all the courses. It carries a 80% weightage for every course.

4.2.2.2 Indirect PO/PSO Attainment

Indirect assessment is carried out using simple average of the graduates, employers, and alumni survey. It carries a 20% weightage for every course.

***Detailed guidelines for assessing the CIE and SEE for theory course, laboratory course, projects, and internships are available on the institute's website.**

Annexure

AICTE Examination Reform Policy

chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.aicte-india.org/sites/default/files/ExaminationReforms.pdf

REVISED Bloom's Taxonomy Action Verbs

Definitions	I. Remembering Level 1 (L1)	II. Understanding Level 2 (L2)	III. Applying Level 3 (L3)	IV. Analyzing Level 4 (L4)	V. Evaluating Level 5 (L5)	VI. Creating Level 6 (L6)
Bloom's Definition	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.	Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.	Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria.	Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions.
Verbs	• Choose • Define • Find • How • Label • List • Match • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Classify • Compare • Contrast • Demonstrate • Explain • Extend • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate	• Apply • Build • Choose • Construct • Develop • Experiment with • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize	• Analyze • Assume • Categorize • Classify • Compare • Conclusion • Contrast • Discover • Dissect • Distinguish • Divide • Examine • Function • Inference • Inspect • List • Motive • Relationships • Simplify • Survey • Take part in • Test for • Theme	• Agree • Appraise • Assess • Award • Choose • Compare • Conclude • Criteria • Criticize • Decide • Deduct • Defend • Determine • Disprove • Estimate • Evaluate • Explain • Importance • Influence • Interpret • Judge • Justify • Mark • Measure • Opinion • Perceive • Prioritize • Prove • Rate • Recommend • Rule on • Select • Support • Value	• Adapt • Build • Change • Choose • Combine • Compile • Compose • Construct • Create • Delete • Design • Develop • Discuss • Elaborate • Estimate • Formulate • Happen • Imagine • Improve • Invent • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution • Solve • Suppose • Test • Theory

Anderson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing, Abridged Edition. Boston, MA: Allyn and Bacon.