BRCM College Of Engineering & Technology

Outcome Based Education (OBE) Manual

Department
of
Computer Science & Engineering

CONTENTS

OVERVIEW

1. Outcome Based Education (OBE) is an educational model that forms the base of a quality education system. There is no single specified style of teaching or assessment in OBE. All educational activities carried out in OBE should help the students to achieve the set goals. The faculty may adapt the role of instructor, trainer, facilitator, and/or mentor, based on the outcomes targeted.

OBE enhances the traditional methods and focuses on what the Institute provides to students. It shows the success by making or demonstrating outcomes using statements "able to do" in favour of students. OBE provides clear standards for observable and measurable outcomes.

National Board of Accreditation (NBA) is an authorized body for the accreditation of higher education institutions in India. NBA is also a full member of the Washington Accord. NBA accredited programmes and not the institutions.

Higher Education Institutions are classified into two categories by NBA

Tier – 1: Institutions consists of all IITs, NITs, Central Universities, State Universities and Autonomous Institutions. Tier - 1 institution can also claim the benefits as per the Washington Accord.

Tier - 2 Institutions consists of affiliated colleges of universities.

What is Outcome Based Education (OBE)?

Institutions adopting OBE try to bring changes to the curriculum by dynamically adapting to the requirements of the different stakeholders like Students, Parents, Industry Personnel and Recruiters.OBE is all about feedback and outcomes.

Four levels of outcomes from OBE are:

1. Program Educational Objectives (PEOs)

2. Program Outcomes (POs)

3. Program Specific Outcomes (PSOs)

4. Course Outcomes (COs)

Why OBE?

1. International recognition and global employment opportunities.

2. More employable and innovative graduates with professional and soft skills, social responsibility and ethics.

3. Better visibility and reputation of the technical institution among stakeholders.

4. Improving the commitment and involvement of all the stakeholders.

5. Enabling graduates to excel in their profession and accomplish greater heights in their careers.

6. Preparing graduates for the leadership positions and challenging them and making them awareof the opportunities in the technology development.

Benefits of OBE

Clarity: The focus on outcome creates a clear expectation of what needs to be accomplished by theend of the course.

Flexibility: With a clear sense of what needs to be accomplished, instructors will be able to structuretheir lessons around the students' needs.

Comparison: OBE can be compared across the individual, class, batch, program and institute levels. **Involvement:** Students are expected to do their own learning. Increased student's involvement allowsthem to feel responsible for their own learning, and they should learn more through this individual learning.

• Teaching will become a far more creative and innovative career

• Faculty members will no longer feel the pressure of having to be the "source of all knowledge".

• Faculty members shape the thinking and vision of students towards a course.

India, OBE and Accreditation:

From 13 June 2014, India has become the permanent signatory member of the Washington Accord. Implementation of OBE in higher technical education also started in India. The National Assessment and Accreditation Council (NAAC) and National Board of Accreditation (NBA) are the autonomous bodies for promoting global quality standards for technical education in India. NBA has started accrediting only the programs running with OBE from 2013.

The National Board of Accreditation mandates establishing a culture of outcome-based

education in institutions that offer Engineering, Pharmacy, Management program. Reports of outcome analysis help to find gaps and carryout continuous improvements in the education system of an Institute, which is very essential.
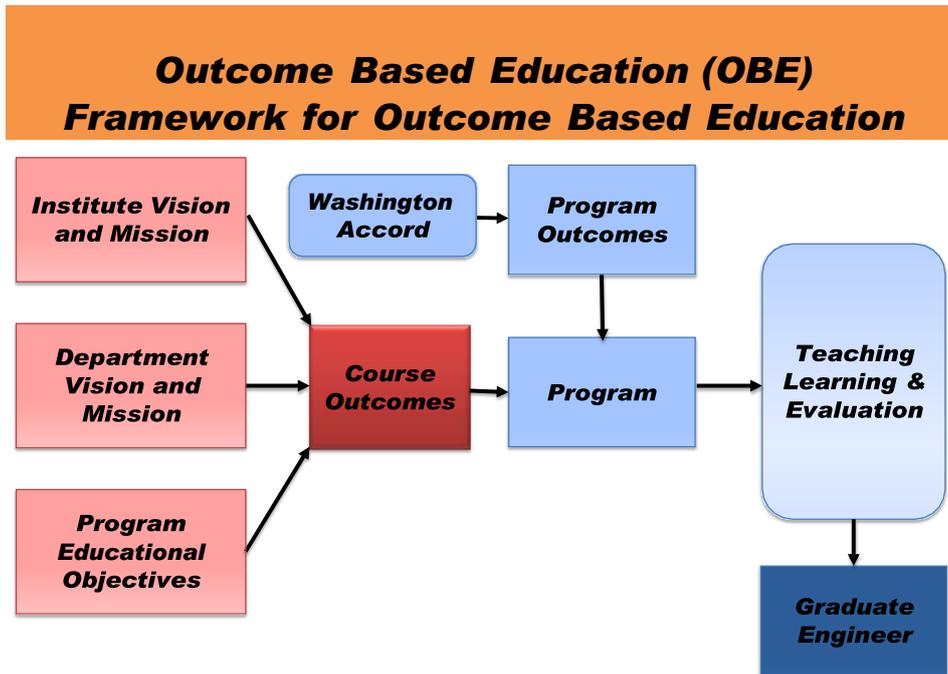
Figure 1: OBE Framework

2   Vision, Mission, Quality Policy, Philosophy & Core Values

Vision and Mission of the Institute

Institute Vision

To be a value based leading institution ensuring Academic Excellence, Research, Nurturing Innovation andEntrepreneurial Attitude to produce competent technocrats for service to Nation.

Institute Mission

To develop BRCM College of Engineering & Technology into a "Centre of Excellence" in the field of technicaleducation by:

IM1: Providing state-of-the-art laboratories, workshops, research and instructional.
IM2: Encouraging students to delve into technical pursuits beyond the curriculum.
IM3: Promoting Post-graduate teaching and research.

IM4: Creating an environment for all round integrated personality development of students suited for the era ofconverging technologies and skills.

Quality Policy

Our policy is to nurture and build diligent and dedicated community of engineers providing a professional and unprejudiced environment, thus justifying the purpose of teaching and satisfying the stake holders. A team of well qualified and experienced professionals ensure quality education with its practical application in all areas of the Institute.

Core Values

Excellence: All activities are conducted according to the highest standards.

Integrity: Adheres to the principles of honesty, trustworthiness, reliability, transparency and account- ability.

Inclusiveness: To show respect for ethics, cultural and religious diversity and freedom of thought. **Social Responsibility:** Promotes community engagement, environmental sustainability, and global citizenship. It also promotes awareness of, and support for, the needs and challenges of the local and global communities.

Innovation: Supports creative activities that approach challenges and issues from multiple perspectives in order to find solutions and advance knowledge.

Vision and Mission of the Department

Department Vision

To be a model in Quality Education for producing highly talented and globally recognized students with sound latest knowledge, and innovative ideas in Computer Science & Engineering

Department Mission

To be a Model in Quality Education by

M1: Imparting good sound theoretical basis and wide-ranging practical experience to the Students for fulfilling the upcoming needs of the Society in the various fields of Computer Science & Engineering.

M2: Offering the Students an overall background suitable for making a Successful career in Industry Research Higher Education in India and abroad.

M3: Providing opportunity to the Students for Learning beyond Curriculum and improving Communication Skills.

M4: Engaging Students in Learning, Understanding and Applying Novel Ideas.

3. Program Educational Objectives (PEOs)

After 3-5 years our graduates will be:

PEO1: Have a successful carrier in Industry, Government, or other working environments as a Computer Engineer with an ability to solve a wide range of real life problems.

PEO2: Exhibit Good communication skills, Ethical conduct and sense of responsibility to serve the societyand protect the environment.

PEO3: Be knowledgeable, inspired and a valued professional in the different working surroundings.

Mapping of Program Educational Objectives to Program Outcomes and Program Specific Outcomes:

The following Figure 1 shows the correlation between the PEOs and the POs

PEO-I	PEO-II	PEO-III
PO: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	**PO:** 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12	**PO:** 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12
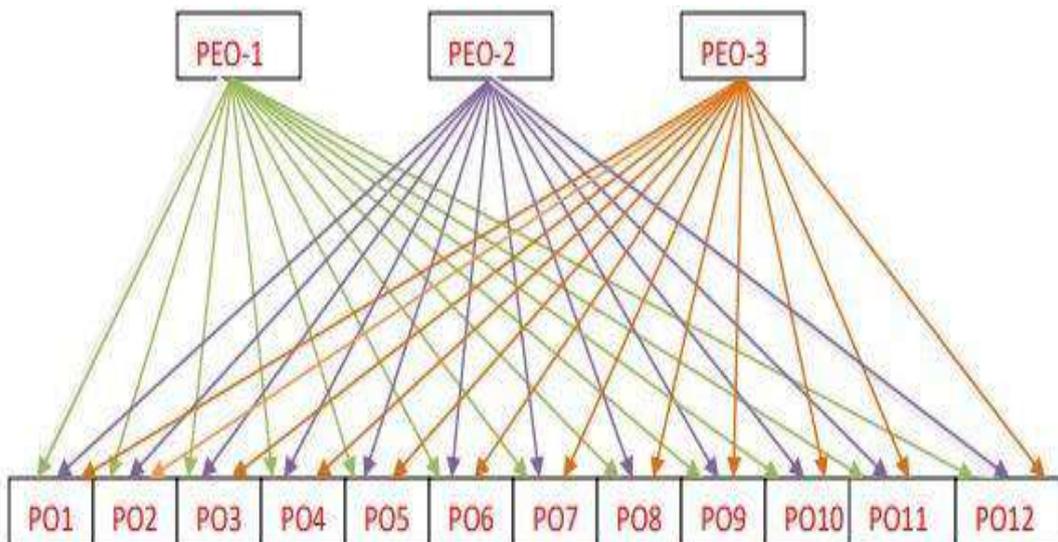
Figure 1: Correlation between the PEOs and the POs

PEO-I	PEO-II	PEO-III
PSO: 1, 2	**PSO:** 1, 2	**PSO:** 1, 2

Program Outcomes (POs)

A Program Learning Outcome is broad in scope and be able to do at the end of the programme. POs are to be in line with the graduate attributes as specified in the Washington Accord. POs are to be specific, measurable and achievable. NBA has defined 12 POs and you need not define those POs by yourself and it is common for all the institutions in India. In the syllabus book given to students, there should be clear mention of course objectives and course outcomes along with CO-PO course articulation matrix for all the courses.

B. Tech (CSE) - PROGRAM OUTCOMES (PO's)	
A graduate of the Computer Science & Engineering Program will demonstrate:	
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, review 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 re-search 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 modeling to complex engineering activities 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**.**
PO11	**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.

4. Program Specific Outcomes (PSOs)

Program Specific Outcomes (PSOs) are statements that describe what the graduates of a specific engineering program should be able to do. A list of PSOs written for the Department of Computer Science and Engineering is given below.

B. Tech (CSE) - PROGRAM SPECIFIC OUTCOMES (PSO's)	
A graduate of the Computer Science and Engineering Program:	
PSO1	Should be able to apply the Concepts of Mathematics, Algorithms, Data Structures, Programming Languages, Databases, Multimedia, Operating Systems, Computer Networks, Computer Architecture, Big Data Analysis, Artificial Intelligence and Machine Learning to solve computation tasks and develop applications of varying complexity.
PSO2	Should be able to understand and make a contribution in the areas of Computer Science & Engineering through the design & planning of Software based real-world applications and also demonstrate professional ethics & concern for social well-being.

5. Relation between the Program Educational Objectives and the POs

Broad relationship between the program objectives and the program outcomes is given in the following Table below:

PEOs→ ↓POs	(1) Industry, Government or other working environments	(2) Good communication skills, Ethical conduct and sense of responsibility toserve the societyand protect the environment	(3) Knowledgeable, Inspired and a Valued Professional
Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to			

PO1	the solution of complex engineering problems.	3	3	3
PO2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	3	2
PO3	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.	3	3	2
PO4	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.	3	3	2
PO5	Create, select, and apply appropriate techniques, re-sources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an	3	3	2

	under- standing of the limitations.			
PO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineeringpractice.	2	3	3
PO7	Understand the impact of the professional engineering solutions in societal and environmental con- texts, and demonstrate the knowledge of, and need for sustainable development.	2	2	3
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	2	3
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	2	3	3
PO10	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	2	3	3

	presentations, and give and receive clear instructions.			
PO11	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.	2	3	3
PO12	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 andin multidisciplinary environments.	2	2	3

Relationship between Program Specific Outcomes and Program Educational ObjectivesKey: 3 = High; 2 = Medium; 1= Low

6. Relation between the Program Specific Outcomes and the Program Educational Objectives:

PEOs→ ↓PSOs	(1) Industry, Governmentor other working environments	(2) Good communication skills, Ethical conduct and sense of responsibility to serve the society and protect the environment	(3) Knowledge able, Inspired and a Valued Professional

PSO1	Should be able to apply the Concepts of Mathematics, Algorithms, Data Structures, Programming Languages, Databases, Multimedia, Operating Systems, Computer Networks, Computer Architecture, Big Data Analysis,Artificial Intelligence and Machine Learning to solve computation tasks and develop applications of varying complexity.	2	3	3
PSO2	Should be able to understand and make a contribution in the areas of Computer Science & Engineering through the design &planning of Software based real- world applications and also demonstrate professional ethics & concern for social well-being.	3	2	3

Relationship between Program Specific Outcomes and Program Educational ObjectivesKey: 3 = High; 2 = Medium; 1= Low

Note:

• The assessment process of POs and PSOs can be direct and indirect.

• The direct assessment will be done through internal assessment by conducting continuousinternal exam and semester end exams.

• The indirect assessment on the other hand could be done through student's Course ExitSurvey, Program exit survey, Alumni survey and Employer survey.

7. Blooms Taxonomy:

Bloom's taxonomy is considered as the global language for education. Bloom's Taxonomy is frequently used by teachers in writing the course outcomes as it provides a readymade structure and list of action verbs. The stages ascend in complexity and what they demand of students. First students need to simply remember information provided to them — but reciting something doesn't demonstrate having learned it, only memorization. With understanding comes the ability to explain the ideas and concepts to others. The students are then challenged to apply the information and use it in new ways, helping to gain a deeper understanding of previously covered material and demonstrating it moving forward. Questioning information is a vital part of learning, and both analysis and evaluation do just this. Analyzing asks a student to examine the information in a new way, and evaluation demands the student appraise the material in a way that lets them defend or argue against it as they determine. The final step in the revised taxonomy is creating, which entails a developing new product or point of view. How does this learned information impact your world? How can it be used to impact not just your education but the way you interact with your surroundings? By utilizing Bloom's Taxonomy, students are not going to forget the information as soon as the class ends - rather, they retain and apply the information as they continue to grow as a student and in their careers, staying one step ahead of the competition.

Incorporating Critical Thinking Skills into Course Outcome Statements

Many faculty members choose to incorporate words that reflect critical or higher-order thinking into their learning outcome statements. Bloom (1956) developed a taxonomy outlining the different types of thinking skills people use in the learning process. Bloom argued that people use different levels of thinking skills to process different types of information and situations. Some of these are basic cognitive skills (such as memorization) while others are complex skills (such as creating new ways to apply information). These skills are often referred to as critical thinking skills or higher-order thinking skills.

Bloom proposed the following taxonomy of thinking skills. 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. A summary of Anderson and Krathwohl's revised version of Bloom's taxonomy of critical thinking is provided in Figure 2.
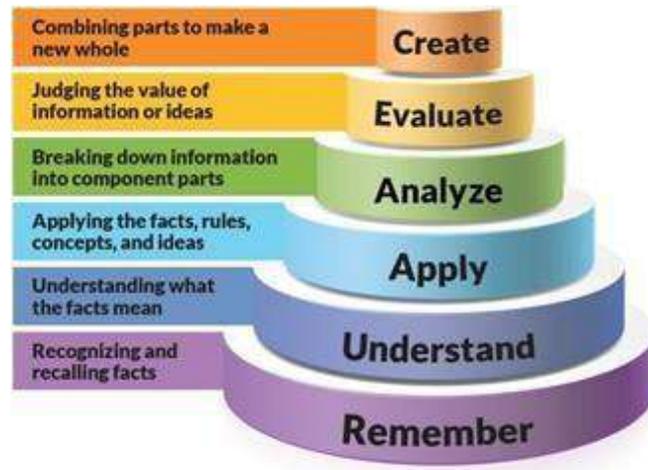

Figure 2: Revised version of Bloom's Taxonomy

Definitions of the different levels of thinking skills in Bloom's Taxonomy:

1. **Remember** –Recalling relevant terminology, specific facts, or different procedures related to information and/or course topics. At this level, a student can remember something, but may not really understand it.

2. **Understand** –the ability to grasp the meaning of information (facts, definitions, concepts, etc.) thathas been presented.

3. **Apply** –being able to use previously learned information in different situations or in problem solving.

4. **Analyze** –the ability to break information down into its component parts. Analysis also refers to the process of examining information in order to make conclusions regarding cause and effect, interpreting motives, making inferences, or finding evidence to support statements/arguments.

5. **Evaluate** –being able to judge the value of information and/or sources of information based on personal values or opinions.

6. **Create** –the ability to creatively or uniquely apply prior knowledge and/or skills to produce new and original thoughts, ideas, processes, etc. At this level, students are involved in creating their ownthoughts and ideas.

List of Action Words Related to Critical Thinking Skills

Here is a list of action words that can be used when creating the expected student learning outcomes related to critical thinking skills in a course. These terms are organized according to the different levels of higher-order thinking skills contained in Anderson and Krathwohl's (2001) revised version of Bloom's taxonomy.

Here is the revised Bloom's document with action verbs, which we frequently refer to while writingCOs for our courses.

The cognitive process dimensions- categories:

Lower Order of Thinking (LOT)			Higher Order of Thinking (HOT)		
Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Interpreting Illustrating Classifying Summarizing Inferring (concluding) comparing explaining	Recognizing (identifying) Recalling (retrieving)	Executing Implementing	Differentiating Organizing Attributing	Checking (coordinating, detecting, testing, monitoring) Critiquing (judging)	Planning Generating Producing (constructing)

The Knowledge Dimension			
Concrete Knowledge →Abstract knowledge			
Factual	**Conceptual**	**Procedural**	**Met cognitive**
• Knowledge of terminologies • Knowledge of specific details and elements	• Knowledge of classifications and categories • Knowledge of Principles and generalizations • Knowledge of theories, models and structures	• Knowledge of subject specific Skills and algori-thms • Knowledge of subject specific techniques and methods • Knowledge of criteria for determining when to use appropriate procedures	• Strategic Knowledge • Knowledge about cognitive task, including appropriate contextual and conditional Knowledge • Self- Knowledge

Table 1: Action Verbs for Course Outcomes

Definitions	Lower Order of Thinking (LOT)			Higher Order of Thinking (HOT)		
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Bloom's Definition	Exhibit memory of previously learned material by recallingfacts, terms, basic concepts, and answers.	Demonstrate understanding of factsand ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.	Solve problems tonew situations by applying acquired knowledge, facts,techniques and rules in a differentway.	Examine and break information into parts by identifying motivesor causes. Make inferences and findevidence 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 differentway by combining elements in a new pattern or proposing alternative solution.
Verbs	• Choose • Define • Find • How • Label • List • Match • Extend	• Classify • Compare • Contrast • Demonstrate • Explain • Illustrate • Infer • Interpret	• Apply • Build • Choose • Construct • Develop • Interview • Make use of • Model	• Analyze • Assume • Categorize • Classify • Compare • Discover • Dissect • Distinguish	• Agree • Appraise • Assess • Award • Choose • Criticize • Decide • Deduct • Importance	• Adapt • Build • Solve • Choose • Combine • Invent • Compile • Compose • Construct

Table 1: Action Verbs for Course Outcomes

	Lower Order of Thinking (LOT)			Higher Order of Thinking (HOT)		
Definitions	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Verbs	• Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Outline • Relate • Rephrase • Show • Summarize • Translate • Experiment with • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate • Experiment with	• Organize • Plan • Select • Solve • Utilize • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize • Identify	• Divide • Examine • Function • Inference • Inspect • List Motive • Simplify • Survey • Take part in • Test for Theme • Conclusion • Contrast	• Defend • Determine • Disprove • Estimate • Evaluate • Influence • Interpret • Judge • Justify Mark • Measure • Opinion • Perceive • Prioritize • Prove • Criteria • Criticize • Compare • Conclude	• Create • Design • Develop • Estimate • Formulate • Happen • Imagine • Improve • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution

8. Guidelines for writing Course Outcome Statements:

Well-written course outcomes involve the following parts:

1. Action verb

2. Subject content

3. Level of achievement as per RBTL

4. Modes of performing task (if applicable)

Course Outcomes (COs)

A Course Outcome is a formal statement of what students are expected to learn in a course. When creating Course Outcomes remember that the outcomes should clearly state what students will do or produce to determine and/or demonstrate their learning. Course learning outcome statements refer to specific knowledge, practical skills, areas of professional development, attitudes, higher- order thinking skills, etc. that faculty members expect students to develop, learn, or master during a course.

A well-formulated set of Course Outcomes will describe what a faculty member hopes to successfully accomplish in offering their particular course(s) to prospective students, or what specific skills, competencies, and knowledge the faculty member believes that students will have attained once the course is completed. The learning outcomes need to be concise descriptions of what learning is expected to take place by course completion.

Developing Course Outcomes

When creating course outcomes consider the following guidelines as you develop them eitherindividually or as part of a multi-section group:

*   Limit the course outcomes to 4-6 statements for the entire course [more detailed outcomes can bedeveloped for individual units, assignments, chapters, etc.

*   Focus on overarching knowledge and/or skills rather than small or trivial details

*   Focus on knowledge and skills that are central to the course topic and/or discipline.

*   Focus on the learning that results from the course rather than describing activities or lessons thatare in the course.

*   Incorporate and/or reflect the institutional and departmental missions.

When developing learning outcomes, here are the core questions to ask yourself:

• What do we want students in the course to learn?

• What do we want the students to be able to do?

• Are the outcomes observable, measurable and are they able to be performed by the students?

Course outcome statements on the course level describe:

• What faculty members want students to know at the end of the course AND

• What faculty members want students to be able to do at the end of the course?

Course outcomes have three major characteristics

• They specify an action by the students/learners that is observable

• They specify an action by the students/learners that is measurable

• They specify an action that is done by the students/learners rather than the faculty members.

Effectively developed expected learning outcome statements should possess all three of these characteristics. When this is done, the expected learning outcomes for a course are designed so that they can be assessed. When stating expected learning outcomes, it is important to use verbs that describe exactly what the student(s) / learner(s) will be able to do upon completion of the course.

Relationship of Course Outcome to Program Outcome

Learning outcomes formula:
STUDENTS SHOULD BE ABLE TO + BEHAVIOR + RESULTING EVIDENCE

The Course Outcomes need to link to the Program Outcomes.

For example, you can use the following template to help you write an appropriate course level learning outcome.

"Upon completion of this course students will be able to (knowledge, concept, rule or skill you expect them to acquire) by (how will they apply the knowledge or skill/how will you assess the learning)."

Characteristics of Effective Course Outcomes

Well written course outcomes:

• Describe what you want your students to learn in your course.

• Are aligned with program goals and objectives.

• Tell how you will know an instructional goal has been achieved.

• Use action words that specify definite, observable behaviors.

• Are assessable through one or more indicators (papers, quizzes, projects, presentations,journals, portfolios, etc.)

• Are realistic and achievable.

• Use simple language

Examples of Effective Course Outcomes

Course Outcomes (COs)

Course: Database Management Systems

Course Code: PCC-CSE-201G

	CO (Course Outcomes)	RBT*- Revised Bloom's Taxonomy
CO1	To **Describe** the concepts of DBMS Architecture and database objects and their Applications.	L1 (Remember)
CO2	To **Summarize** transaction processing, concurrency control and database recovery protocols in databases.	L2 (Understand)
CO3	To **Apply** Relational algebra operation & Structured Query Language (SQL) for database manipulation.	L3 (Apply)
CO4	To **Apply** normalization algorithms using database design theory for different applications.	L3 (Apply)
CO5	To **Design** Relational database systems for different applications to interact with databases.	L6 (Create)

Write Your Course Outcomes!

One of the first steps you take in identifying the expected learning outcomes for your course is identifying the purpose of teaching the course. By clarifying and specifying the purpose of the course, you will be able to discover the main topics or themes related to students' learning. Once discovered, these themes will help you to outline the expected learning outcomes for the course. Ask yourself:

• What role does this course play within the program?

- How is the course unique or different from other courses?

- Why should/do students take this course? What essential knowledge or skills should they gainfrom this experience?

- What knowledge or skills from this course will students need to have mastered to perform wellin future classes or jobs?

- Why is this course important for students to take?

CO-PO Course Articulation Matrix (CAM) Mapping

Course Articulation Matrix shows the educational relationship (Level of Learning achieved) between course outcomes and program outcomes for a course. This matrix strongly indicates whether the students are able to achieve the course learning objectives. The matrix can be used for any course andis a good way to evaluate a course syllabus.

CO PO-PSO Articulation Matrices

Course: Database Management Systems

Course Code: PCC-CSE-201G

Course Outcomes (COs)	(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2										1	2	1
CO2	2	3	2									1	3	2
CO3	2	2	3	2								1	2	1
CO4	2	2		2								1	2	2
CO5	1	2	3	2								1	1	1

Observations:

1. The first five POs are purely of technical in nature, while the other POs are non-technical.

2. 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.

3. For the laboratory courses, while composing COs, you need to restrict yourself

between Blooms Level 1 to Level 5.

4. Only for Mini-project and Main project, you may extend up to Blooms Level 6 while composing COs.

5. For a given course, the course in-charge has to involve all the other Professors 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.

6. If you want to match your COs with non-technical POs, then correlate the action verbs used in the course COs with the thumb rule given in the table and map the values. (Applies only for mapping COs to non-technical POs).

Tips for Assigning the values while mapping COs to POs.

1. Select action verbs for a CO from different Bloom's levels based on the importance of the particular CO for the given course.

2. Stick on to single action verbs while composing COs but you may go for multiple action verbs if the need arises.

3. You need to justify for marking of the values in CO-PO articulation matrix. Use a combination of words found in the COs, POs and your course syllabus for writing the justification. Restrict yourself to one or two lines.

4. Values to CO-PO (technical POs in particular) matrix can be assigned by

(a) Judging the importance of the particular CO in relation to the POs. If the CO matches strongly with a particular PO criterion then assign 3, if it matches moderately then assign 2 or if the match is low then assign 1 else mark with " - " symbol.

(b) If an action verb used in a CO is repeated at multiple Bloom's levels, then you need to judge which Bloom's level is the best fit for that action verb.

Method for Articulation

1. Identify the key competencies 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 vital 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 competencies for CO – PO/PSO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.

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

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.

9. Key Competencies for Assessing Program Outcomes:

PO	NBA statement / Vital features	No. of vital features
PO1	**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems (Engineering Knowledge). Knowledge, under-standing and application of** 1. Scientific principles and methodology 2. Mathematical principles 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline	3
	Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural	

PO2	sciences, and Engineering sciences (Problem Analysis). 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO3	**Design solutions for complex Engineering problems and design sys-tem 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).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health andsafety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem includingproduction, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes 7. Knowledge and understanding of commercial and economic con-text of engineering processes	**10**

	8. Knowledge of management techniques which may be used to achieve engineering objectives within that context	
	9. Understanding of the requirement for engineering activities to pro- mote sustainable development	
	10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk issues	
PO4	**Use research-based knowledge and research methods including de- sign of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions (Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or product 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty. 8. Understanding of engineering principles and the ability to apply them to analyze key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques	**11**

	10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	
PO5	**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).** 1. Computer software / simulation packages / diagnostic equipment /technical library resources / literature search tools.	**1**
PO6	**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).** 1. Knowledge and understanding of commercial and economic con- text of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to pro- mote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering	**5**
PO7	**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 Sustain- ability). Impact of the**	**3**

	professional Engineering solutions (Not technical) 1. Socio economic 2. Political and 3. Environmental	
PO8	**Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO9	**Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (Individual and Team- work).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive theirperformance 3. Self-direction (take a vaguely defined problem and systematicallywork to resolution) 4. Teams are used during the classroom periods, in the hands-on labs,and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project,and for the seventeen - week design project. 6. Instruction on effective teamwork and project management is pro-vided along with an appropriate textbook for reference. 7. Teamwork is important not only for helping the students know theirclassmates but also in completing assignments.	**12**

	8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Ability to work with all levels of people in an organization 10. Ability to get along with others 11. Demonstrated ability to work well with a team 12. Subjective evidence from senior students shows that the friendships and teamwork extend into the junior years, and for some of those students, the friendships continue into the workplace after graduation.	
PO10	**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). "Students should demonstrate the ability to communicate effectively in writing / Orally."** 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO11	**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).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables	12

	4. Work Breakdown Structure	
	5. Schedule	
	6. Budget	
	7. Quality	
	8. Human Resources Plan	
	9. Stakeholder List	
	10. Communication	
	11. Risk Register	
	12. Procurement Plan	
PO12	**Recognize the need for and have the preparation and ability to en- gage in independent and life-long learning in the broadest context oftechnological change (Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	8

10. Key Competencies for Assessing Program Specific Outcomes:

PSO	NBA statement / Vital features	No. of vital features
PSO1	**Apply the Concepts of Mathematics, Algorithms, Data Structures, Programming Languages, Databases, Multimedia, Operating Systems, Computer Networks, Computer Architecture, Big Data Analysis, Artificial Intelligence and Machine Learning to solve computation tasks and develop applications of varying complexity.** 1. Identify the need and problem specific constraints 2. Develop computer programs related to Algorithms for specific problem / project. 3. Develop data centric applications using the concepts of Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking. 4. Design and analyze algorithms for problems. 5. Use data structures for developing solutions. 6. Apply appropriate algorithms for data processing.	6
PSO2	**Understand and make a contribution in the areas of Computer Science & Engineering through the design & planning of Software based real-world applications and also demonstrate professional ethics & concern for social well-being.** 1. Design and develop software applications. 2. To show professional ethics & concern for social well being.	2

11. Methods for measuring Learning Outcomes and Value Addition:

There are many different ways to assess student learning. In this section, we present the different types of assessment approaches available and the different frame works to interpret the results.

i)   Continuous Internal Evaluation (CIE)

ii)   Semester End Examination (SEE)

iii) Laboratory and Project work

iv)   Course Exit Survey

v)   Program Exit Survey

vi)   Alumni Survey

vii) Employer Survey

viii) Department Academic Committee (DAC)

The above assessment indicators are detailed below.

Continuous Internal Evaluation (CIE)

Two Internal Examinations (CIEs) are conducted for all courses by the department. All students must participate in this evaluation process. These evaluations are critically reviewed by HOD and senior faculty and the essence is communicated to the faculty concerned to analyze, improve and practice so as to improve the performance of the student

Semester End Examination (SEE)

The semester end examination is conducted for all the courses in the department. Before the Semester end examinations course reviews are conducted, feedback taken from students and remedial measures will be taken up such that the student gets benefited before going for end exams. The positive and negative comments made by the students about the course are recorded and submitted to the department Academic Committee (DAC) and to the principal for taking necessary actions to better the course for subsequent semesters.

Laboratory and Project Works

The laboratory work is continuously monitored and assessed to suit the present

demands of the industry. Students are advised and guided to do project works giving solutions to research industrial problems to the extent possible by the capabilities and limitations of the student. The results of the assessment of the individual projects and laboratory work can easily be conflated in order to provide the students with periodic reviews of their overall progress and to produce terminal marks and grading.

Course Exit Surveys

Students are encouraged to fill-out a brief survey on the fulfillment of course objectives. The data is reviewed by the concerned course faculty and the results are kept open for the entire faculty. Based on this, alterations or changes to the course objectives are undertaken by thorough discussions in faculty and DAC meetings.

Program Exit Survey

The program exist questionnaire form is to be filled by all the students leaving the institution. The questionnaire is designed in such a way to gather information from the students regarding the program educational objectives, solicit about program experiences, carrier choices, as well as any suggestions and comments for the improvement of the program. The opinions expressed in exit interview forms are reviewed by the DAC for implementation purposes.

Alumni Survey

The survey asks former students of the department about the status of their employment and further education, perceptions of institutional emphasis, estimated gains in knowledge and skills, involvement as under graduate student, and continuing involvement with BRCM College of Engineering. The data obtained will be analyzed and used in continuous improvement.

Employer Survey

The main purpose of this employer questionnaire is to know employer's views about the skills they require of employees compared to the skills actually possessed by them. The purpose is also to identify gaps in technical and vocational skills, need for required training practices to fill these gaps and criteria for hiring new employees. These employer surveys are reviewed by the Training & Placement and CSE Department to affect the present curriculum to suit the requirement so the employer.

Department Academic Committee (DAC)

Departmental Academic Committee plays an important role in the development of the department. Department level Advisory Board will be established for providing guidance and direction for qualitative growth of the department. The Board interacts and maintains liaison with key stakeholders. DAC will Monitor the progress of the program and develop or recommend the new or revised goals and objectives for the program. Also, the DAC will review and analyze the gaps between curriculum and Industry requirement and gives necessary feedback or advices to be taken toimprove the curriculum.

12. CO - Assessment Processes and Tools

Course outcomes are evaluated based on two approaches namely direct and indirect assessment methods. The direct assessment methods are based on the Continuous Internal Assessment (CIA) and Semester End Examination (SEE) whereas the indirect assessment methods are based on the course end survey and program exit survey provided by the students, Alumni and Employer. The weightage in CO attainment of Direct and Indirect assessments are illustrated in Figure below.
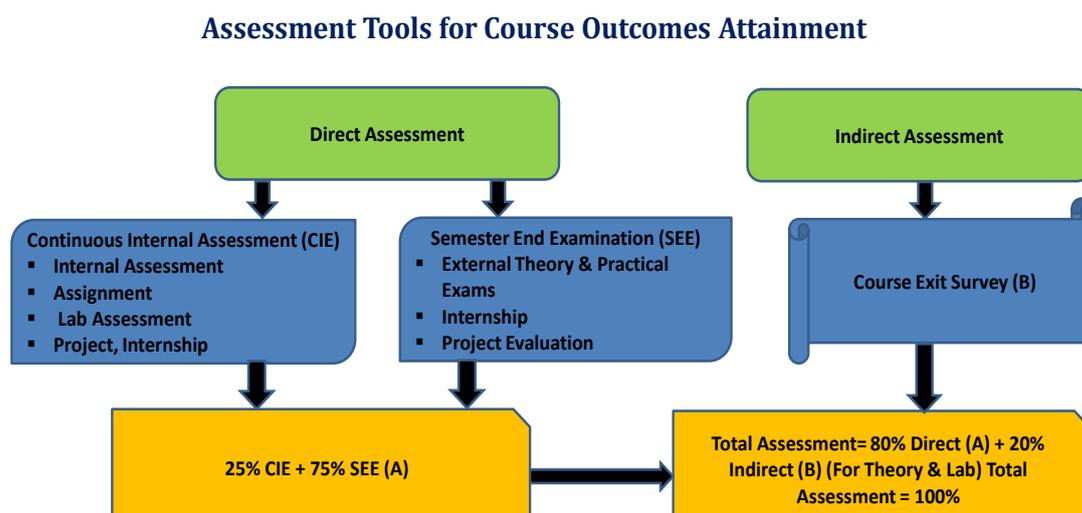
Assessment Tools for Course Outcomes Attainment

Figure 3: Assessment Tools for Course Outcomes Attainment

Direct Assessment

Direct assessment methods are based on the student's knowledge and performance in the various assessments and examinations. These assessment methods provide evidence

that a student has command over a specific course, content, or skill, or that the students work demonstrates a specific qualitysuch as creativity, analysis, or synthesis.

The various direct assessment tools used to assess the impact of delivery of course content is listed inTable.

- Continuous internal examination, semester end examinations, assignment, Quiz, etc. are used for CO calculation.

- The attainment values are calculated for individual courses and are formulated and summed forassessing the POs.

☐ **Theory Courses:**

Rubrics for CO Attainment					
Assessment Types	**Assessment component**		**Marks**	**Total Marks**	**Weightage**
Direct (80%)	External Assessment	Semester Examination (SE)	75 Marks	75 Marks	75%
	Internal Assessment	First Sessional	10 Marks	25 Marks	25%
		Second Sessional	10 Marks		
		Assignment (A)	5 Marks		
		Test/Quizzes(Q)			
Indirect (20%)	Course Exit Survey (CES)		On the Scale of 3		20%
CO	**CO=0.8*(0.75*SE+0.25*(0.8*Average of Sessional and 0.2*AQ))+0.2*CES**				

☐ **Laboratory / Practical Courses:**

☐ **Project Courses:**

Rubrics for CO Attainment

Assessment Types	Assessment component			Marks	Total Marks	Weightage
Direct (80%)	External Assessment		Semester Examination(SE)	50Marks	50 Marks	100%
	Internal Assessment	Continuous Project Evaluation	R1	10 Marks	50 Marks	100%
			R2	10 Marks		
			R3	10 Marks		
			R4	10 Marks		
			R5	10 Marks		

Rubrics for Project Evaluation

Project ContinuousEvolution	R1	Synopsis Submission
	R2	1st Midterm Presentation
	R3	2nd Midterm Presentation
	R4	Execution / VIVA-VOCE
	R5	WEEKLY PROGRESS REPORT

Indirect Assessment:

Course End Survey - In this survey, questionnaires are prepared based on the level of understanding of the course and the questions are mapped to Course Outcomes. The tools and processes used in indirect assessment are shown in Table below.

Tools Used in Indirect Assessment

Tools	Process	Frequency
Course Exitsurvey	• Taken for every course at the end of the semester • Gives an overall view that helps to assess the extent of coverage/ compliance of COs • Helps the faculty to improve upon the variousteaching methodologies	Once in a semester

Direct Tools: (Measurable in terms of marks and w.r.t. CO) Assessment done by faculty at department level

Indirect Tools: (Non measurable (surveys) in terms of marks and w.r.t. CO) Assessment done at institute level.

13. PO/PSO - Assessment tools and Processes

Assessment Tools used for PO & PSO Attainment Calculation
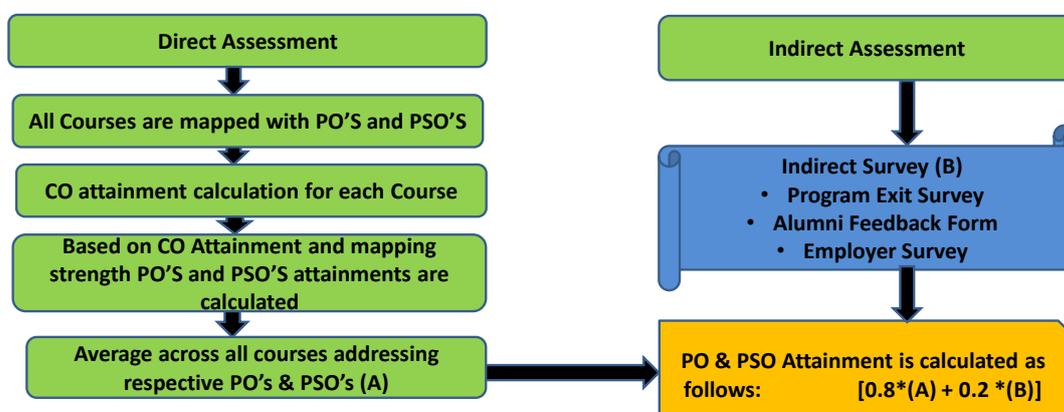

Figure 4: Assessment Tools for PO & PSO Attainment

The institute has the following methods for assessing attainment of POs/PSOs.

1. Direct method

2. Indirect method

The attainment levels of course outcomes help in computing the PO/PSO based upon the mapping done.

Table: Attainment of Po/Psos

|	Assessment	Tools	Weight
POs/PSOs Attainment	Direct Assessment	CO attainment of courses	80%
	Indirect Assessment	Student exit survey	
		Alumni survey	
		Employer survey	20%

The CO values of both theory and laboratory courses with appropriate weightage as per CO-PO mapping, as per Program Articulation Matrix are considered for calculation of direct attainment of PO/PSOs.

PO Direct Attainment is calculated using the following rubric:

PO Direct Attainment = (Strength of CO-PO)*CO attainment / Sum of CO-PO strength.

Following figure represents the evaluation process of POs/PSOs attainment through course outcomeAttainment.
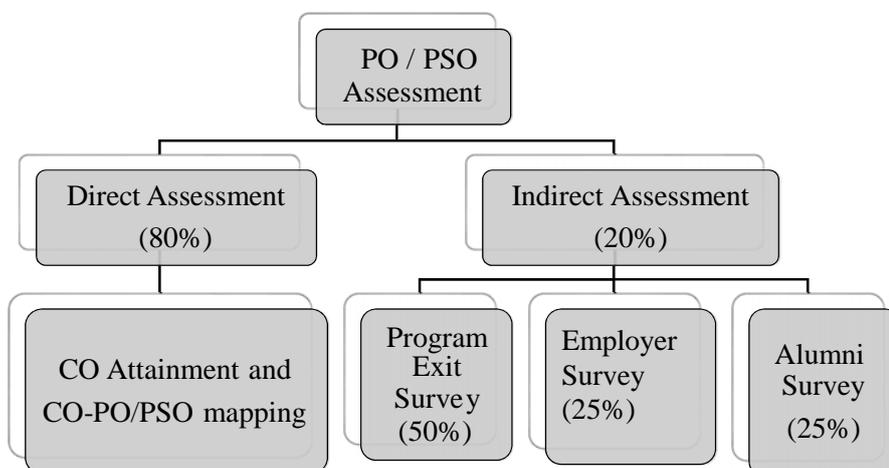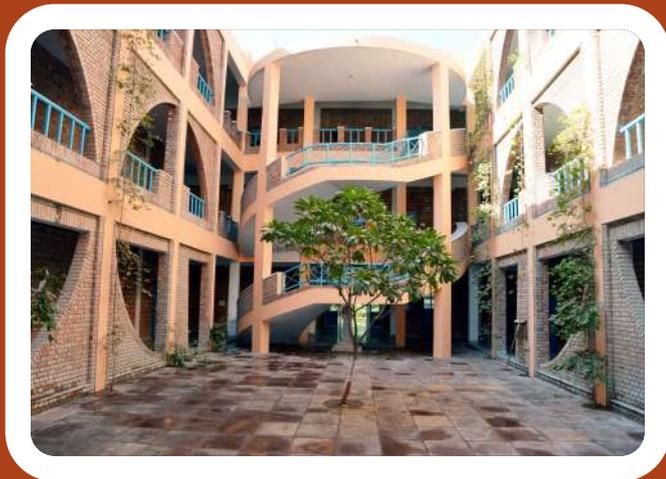
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