**Outcome Based Education, Defining PEOs, Articulation of PSOs, COs, their Assessment, and Continuous Improvement**

**Introduction**

"Outcomes Based Education (OBE) is a process which involves the restructuring of curriculum, assessment and reporting practices in education to reflect the achievement of higher order learning and mastery rather than the accumulation of course credits”.

Thus the primary aim of OBE is to facilitate desired changes within the learners, by increasing knowledge, developing skills and/or positively influencing attitudes, values and judgment. OBE embodies the idea that the best way to learn is to first determine what needs to be achieved. Once the end goal (product or outcome) has been determined the strategies, processes, techniques, and other ways and means can be put into place to achieve the goal.

Geethanjali College of Engineering and Technology has been striving hard in providing Outcome Based Education (OBE), which clearly focuses and organizes everything in an educational system around "what is essential for all students to be able to do successfully at the end of their learning experiences".

OBE based programs start with a clear picture of what is important for students to be able to do. We then organize the curriculum, instruction, and assessment to make sure this learning ultimately happens. Such an approach presupposes that we can determine what things are “essential for all students to be able to do”, and that it is possible to achieve these things through an appropriate organisation of the education system and through appropriate classroom practices.

It may please be noted that OBE requires an engineering program to address four important questions that are:

1. What do we want the students to have or able to do?
2. How can we best help the students achieve it?
3. How will we know that they have achieved it?
4. How do we close the loop?

* The first question calls for the development of program objectives, program outcomes and course outcomes.
* The second question calls for the appropriate teaching/ learning facilities and techniques to be employed in various programs or courses.
* The third question calls for appropriate assessment to demonstrate that the students have obtained the required outcomes.
* The fourth question calls for the evaluation on the effectiveness of all the plans and implementation of the learning outcomes and ascertain rooms for improvement either in learning or teaching.

**The Four Basic Principles of OBE**

OBE is based on four principles, namely,

1. Clarity of focus
2. Design down
3. High expectations
4. Expanded opportunities
5. Clarity of focus about outcomes

* Always have significant, culminating exit outcomes as the focus.
* Let the students know what they are aiming for.

There could be two types of outcomes:

1. Major ones such as the exit outcome of the course and
2. Minor ones that are developed by the instructor for achieving the instructional goals.
3. Designing backwards

* Design curriculum backward by using the major outcomes as the focus and linking all planning, teaching and assessment decisions directly to these outcomes.

1. Consistent, high expectations of success

* Set the expectation that OBE is for ALL learners.
* Expect students to succeed by providing them encouragement to engage deeply with the issues they are learning and to achieve the high challenging standard set

1. Expanded opportunity (Inclusive)

* Develop curriculum to give scope to every learner to learn in his/her own pace.

This principle is based on the idea that not all learners can learn the same thing in the same way and in the same time. However, most students can achieve high standards if they are given appropriate opportunities.

**Transformational Approach of OBE**

OBE is characterised as a systems transformation approach.

* *OBE is a transformational perspective on the curriculum*.
* It offers a dialogue between learner and the curriculum where the learner interacts with sources of knowledge, reconstructs knowledge, and takes responsibility for his or her own learning outcomes.
* In OBE, teacher becomes a facilitator in the teaching and learning situation instead of acting as a source of information transferring content to learners.

From this viewpoint the transformational character of OBE is influenced by the mastery learning and competency-based education movements.

| **OBE Principles** | **Explanation** | **Application to practice** |
| --- | --- | --- |
| Clarity of focus | Focus on what want learners be able to do successfully | * Help learners develop competencies * Enable predetermined significant outcomes * Clarify short & long term learning intentions * Focus assessments on significant outcomes |
| Design down | Begin curriculum design with a clear definition of the significant learning that learners are to achieve by the end of their formal education | * Develop systematic education curricula * Trace back from desired end results * Identity “learning building blocks” * Link planning, teaching & assessment decisions to significant learner outcomes |
| High expectations | Establish high, challenging performance standards | * Engage deeply with issues that facilitate learning * Push beyond where normally have gone |
| Expanded opportunities | Do not learn same thing in same way in same time | * Provide multiple learning opportunities matching learner’s needs with teaching techniques |

Spady identified ten key components that underlie OBE as a transformation approach, namely,

1. Outcomes-defined
2. Expanded opportunities for learners
3. Performance 'credentialing'
4. Concept integration
5. Instructional coaching
6. Culminating achievement
7. 'Inclusionary' success
8. Cooperative learning
9. Criterion validation and
10. Collaborative structures.

Van der Horst and McDonald redefined these components as characteristics of transformational OBE. When these characteristics are analysed in terms of their foundational roots (as indicated above), the eclectic nature of OBE becomes obvious (see Table below).

The characteristics of OBE are listed in the first column, and the major roots of each characteristic are indicated in brackets. Transformational aspects that apply to each characteristic appear in the second column.

|  |  |
| --- | --- |
| **Characteristics** | **Transformational aspects** |
| 1. Outcomes define OBE   (Educational objectives, competency-based, mastery learning) | Learners are future-oriented.  They are informed about what they have to achieve and the quality of such achievement.  The process shifts from a content-based input approach to a competence-based output approach where certification validates the achieved competences.  Attaining outcomes are not bound by time and calendar constraints. |
| 1. OBE allows for expanding learning opportunities beyond traditional seat time as learning time   (Competency-based, mastery learning) | The focus is on achieving outcomes according to ability.  Achievement is supported by flexible time frames and not bound by closed, structured teaching time. Learning programmes are open-ended and creative. Learners are encouraged to form own insights and create own solutions. |
| 1. Based on successful attainment of predetermined performance outcomes   (Educational objectives, competency-based, mastery learning) | Learners advance through the system when they are able to demonstrate attainment of the desired outcomes. They are assessed continuously and facilitated to attain these desired outcomes. |
| 1. Aided by instructional guidance where learners receive continuous learning support   (Competency-based, mastery learning) | Teaching is no longer aimed at covering the curriculum (content-driven), but instead at learners discovering new knowledge, skills and attitudes by reconstructing content for themselves with creative guidance by the teacher. |
| 1. Builds on a culminating achievement of desired learning outcomes (Competency-based, mastery learning) | Attaining outcomes provides the foundation for applying acquired knowledge, skills and attitudes, leading to the attainment of ultimate desired outcomes. |
| 1. Geared towards integrating concepts across the curriculum and learning areas   (New. Not a main feature of previous approaches) | The focus shifts from atomistic mastering of content as an end in itself to using content as a vehicle towards holistic conceptual frameworks across the curriculum. |
| 1. Success-oriented allowing for individual learners to succeed according to own abilities.   (Mastery learning) | Capacity building according to learners' own abilities is paramount.  The selection-oriented approach of pass or fail is reduced. All learners progress according to ability. |
| 1. OBE is characterised by cooperative learning   (Not a main feature in mentioned approaches, but cooperative or collaborative learning as such is not new | Individual contest and competition decrease and teamwork is encouraged. |
| 1. Attainment of outcomes is confirmed by criterion assessment   (Competency-based, with roots in criterion referenced instruction) | The emphasis shifts from attaining a pass mark or distinction to a demonstration of competence at predetermined levels.  Criterion-referenced assessment focuses on assessing outcomes and not grading as such. |
| 1. Based on collaborative structures allowing for democratic input from the community   (New. Not a main feature of previous approaches) | The OBE curriculum is open to the environment. The curriculum is democratised and is the result of negotiation, not fixed and changeable (i.e. a socio constructivist approach). |

OBE is based on the following convictions:

* All students have talent and it is the job of college to nurture it.
* The role of college is to find ways for students to succeed, rather than finding reasons why students fail.
* Mutual trust among faculty and students drives outcomes based education.
* Excellence is for every student and not just a few.
* By preparing students every day for success, the next day, the need for correctives will be reduced.
* Students should collaborate in learning rather than compete.
* As far as possible, no student should be excluded from any activity in the college.
* A positive attitude is essential. (If we believe that we can get every student to learn well then they will).

It is, therefore, the responsibility of the faculty to meticulously adhere to the above.

**OBE's Accent on Promoting Thinking Process**

All faculty should appreciate the aspect that whatever approach to teaching one may use, it is important to keep the following points in mind:

* Faculty main focus should be on ensuring LEARNING rather than teaching.
* Students cannot learn if they do not THINK. Any learning that doesn't involve thinking is absolutely of "NO USE".
* Thinking must be facilitated and encouraged by the PROCESSES that faculty use to engage students with the content, as well as by the CONTENT itself.
* The subject/course the faculty teach "DOES NOT EXIST IN ISOLATION": Faculty have to help students make LINKS to other subjects/courses.
* Faculty have a responsibility to help students "LEARN HOW TO LEARN".

Faculty must strive hard and ensure students appreciate "thinking process" and "enjoy learning" thereby students become self explorers who ultimately contribute to "Technological Advancements" for "Societal Development".

For successful learning to take place, students must be encouraged to take some responsibility for their own learning, and continued support from the teacher becomes contingent upon the students’ acceptance of this responsibility. Faculty must continuously mentor and nurture the students about the necessity for students to take responsibility for learning.

Based on OBE, our outcomes based programs should include the following:

1. A clear set of outcomes that all students will achieve (if one likes, a minimum set of outcomes). Teachers must select, from all the possible outcomes, those that should be given top priority. These are the learning outcomes that will be of most value to the students and are written in a way that the students can comprehend. We should provide examples to students of what they will be able to do when they have achieved those outcomes.
2. A clear set of suitably categorized outcomes for all students. Few additional extension outcomes provide some students with a much more deeper understanding of the issues being studied.
3. A detailed specification of the prerequisites that students must master before attempting to achieve each new outcome.
4. Plans for several different teaching strategies that can be used to help students achieve the desired learning outcomes.
5. A variety of tests, assignments, homework problems, tutorial sessions, guided practice/laboratory sessions, etc provide both the teacher and the students with feedback on their progress towards the learning outcomes achieved.
6. Resources and teaching techniques to assist students who do not master the required outcomes as quickly as other students.

Because of its focus on student success, our outcomes based approach education should place much more importance on individual learning than many other approaches to education. One of the key questions in our outcomes based program is “What are reasonable and attainable outcomes for *each* student?”

Once that question has been answered, teachers should consider how they may keep records of individual students’ progress towards these outcomes. Record keeping becomes much more important than it might be in situations where testing is a necessary evil rather than an integral part of student learning. We should involve students also in this record keeping so that they are reminded continually of the goals towards which they are working, and of the need for them to accept some of the responsibility for achieving those goals.

In implementing OBE,

* Faculty should start by assessing the students’ prerequisite knowledge and skills; if students do not understand essential prior knowledge or if they do not have the skills on which one wants to build; faculty must provide instruction on the prerequisites.
* Next, faculty prepare the students by explaining the outcomes that they are to achieve (what they will be able to do when they have completed the unit satisfactorily). To be meaningful, each outcome is placed within an appropriate context and it should be related to one or more of the Key Competencies.
* Then faculty provide whatever forms of whole class instruction or individual/group work they consider will have the best chance of enabling all the students to achieve mastery of the unit.
* Next, faculty organise guided practice for the students so that they can be evaluated informally and provided with feedback to enhance their learning. The emphasis here is on *successful* guided practice through careful selection of examples and problems.
* When most students seem to be ready to demonstrate mastery, assess their learning, or have the students assess their own learning through an appropriate form of self-assessment or peer assessment. This assessment should take into account the context in which outcomes should be demonstrated.
* Students who have achieved mastery then work on enrichment activities while those who have not achieved mastery receive additional instruction and practice.
* All students then take a summative test. Those who do not demonstrate mastery on this test receive an “incomplete” grade that they are required to convert to a mastery level through additional effort.

To be useful in an OBE system, assessment should conform to the following principles:

Our assessment procedures must be

1. Valid and useful - they should facilitate faculty to assess what they intend the assessment procedures to assess.
2. Reliable - they give consistent results.
3. Fair and just - they are not influenced by any irrelevant factors such as the learner’s cultural background.
4. Able to reflect the knowledge and skills that are most important for students to learn.
5. Able to tell teachers and individual students something that they do not already know. That is, they have stretched students to the limits of their understanding and ability to apply their knowledge.
6. Both comprehensive and explicit.
7. Able to support every student’s opportunity to learn things that are important; and,
8. Able to allow individuality to be demonstrated because learners are individuals.

For OBE to be implemented successfully, a program must have educational objectives and outcomes, which are measurable. Many colleges offer several programs. We also offer same/similar programs.

* How our programs are different from other colleges' programs?
* What is it that our programs offer value addition to the students and a value addition to other stake holders?
* What is the unique nature of our program that makes it distinct from other colleges' program(s)?
* What do we want our graduates to be able to do at the end of the program vis-à-vis other graduates of other colleges' offering same/similar programs.

The outlining philosophy of our programs should be to ensure our programs carve a niche for themselves and graduates churned out from our programs must be sought after by industry and society as they would be capable to contribute significantly for technological advancements and breakthroughs benefiting society immensely.

Keeping these aspects in view we must develop PEOs.

**Writing Program Educational Objectives (PEOs)**

**Definition of PEOs and their Validation**

Developing educational objectives for any program is usually a demanding task due to the multitude of stakeholders that the program serves. Direct stakeholders include students, parents, alumni, employers, professionals, and society at large. To develop program educational objectives to meet the needs of such a diverse and large number of stakeholders, program designers should focus on the required performance attributes of a practicing individual graduating from such a program.

To design, refine, or continuously improve an educational program, a set of clear objectives and outcomes must be defined. In addition, all learning experiences, courses, and activities should be aligned to deliver these outcomes and ultimately achieve the program objectives.

However, we have not taken into account inputs from parents in the definition of our PEOs

**Definition of PEOs and their Validation**

The definition of the PEOs are to be provided. The process employed to define as well as validate the PEOs in association with all stakeholders of the program needs to be articulated.

* PEOs are defined with inputs from all stake holders of program constituents and describe the expected accomplishments of graduates during the first several years following graduation.
* POs, and PSOs on the other hand, describe what students are expected to know or be able to do by the time of graduation from the program.
* A systematic process must be in place to assess the achievement of both the POs – before students graduate – and the PEOs – after graduates leave the program. This process is an ongoing that ensures continuous improvement of the program.
* The relationship between PEOs, POs, PSOs, and Course Outcomes (COs) is illustrated in Figure 1.

Program Educational Objectives (PEOs)

Program Outcomes POs)

Course Outcomes (COs)

Figure 1: Relationship between COs, POs, and PEOs

* Following the process of engineering design, one may view PEOs as a set of mission requirements (specifications).
* Alumni will be able to meet the expectations set for them in the PEOs, if students have the skills described in the Program Specific Criteria (PSC), i.e. Program Specific Outcomes (PSOs) at the time they graduate, which are acquired mostly through the curriculum of each program.
* Thus, learning objectives in each course represent a subset of skills described in the PSOs.
* PEOs reflect the career and professional accomplishments of graduates during the first several years after graduation.
* The process of definition and assessment of the PEOs is illustrated in Figure 2.

Employer

Inputs

Yes

No

Define PEOs

Assess PEOs

Student

Inputs

Experts

from

Professional

Bodies

Inputs

PEOs

met?

Program

Satisfactory

Design and Implement Curriculum Changes

Faculty Inputs

Alumni

Inputs

Faculty

Inputs

Figure 2: Definition and Assessment process for PEOs.

* Inputs from students, faculty, alumni, employers, and experts from professional bodies are used to validate the definition of our PEOs, as well as to assess their achievement.
* PEOs are revisited periodically to ensure that they continue to reflect current industrial trends.
* Program is designed to fulfil the University, College, and Department mission.
* They provide students with a broad understanding of basic concepts, as well as the contemporary skills required by industry.
* The coursework includes extensive laboratory experiences and many opportunities for students to work on hands-on, design projects.
* The foundation courses provide a basis for professional competence and the required knowledge to focus on a particular specialization upon graduation, in the work environment or in subsequent higher education.

PEOs and POs are designed keeping in mind the characteristics a professional engineer should have. A professional engineer must have the following traits consisting codes of ethics, attributes valued by employers, and core competencies valued by professional societies. Synthesis of these traits produces a set of ten holistic behaviours of an engineer, which are further categorized in to three groups given below.

* Technical roles include the roles of analyst, problem solver, designer, and researcher.
* Interpersonal roles include communicator, collaborator, and leader.
* Professional roles include being a self-grower, achiever, and practitioner.
* Improve the quality, effectiveness, efficiency and relevance of Engineering courses offered Engineering Colleges.
* Identifying changes in technical engineer manpower job profiles for selecting programme offerings and modifying the existing programmes

Faculty of the college have been involved in an open discussion (Dept.-wise) with regard to the qualities / characteristics of a graduate engineer based on the various career options / roles open for a graduate engineer. They have been informed of the following roles an engineer is likely to assume after graduation. Based on the discussions, the faculty members have felt an engineer is likely to perform the following in the first four to five years after graduation:

* Analyst
* Problem Solver
* Designer
* Researcher
* Communicator
* Collaborator
* Leader
* Self-grower
* Achiever
* Practitioner

Characteristics of each of the roles is briefly described hereunder:

**Analyst**

When conducting engineering analysis, the engineer adeptly applies principles and tools of mathematics and science to develop understanding, explore possibilities, and produce credible conclusions. Observable actions that support this role include:

1. Searching strategically to identify all conditions, phenomena, and assumptions influencing the situation
2. Identifying applicable governing principles of mathematics, natural sciences, and engineering sciences
3. Selecting tools for analysis that are efficient, and consistent with governing principles, desired results, and assumptions
4. Producing and validating results through the skilful use of contemporary engineering tools and models
5. Extracting desired understanding and conclusions consistent with the objectives and limitations of the analysis

**Problem Solver**

When facing an engineering problem, the engineer produces solutions that properly address critical issues and assumptions, and that are conceptually and contextually valid. Observable actions that support this role include:

1. Examining the problem setting to understand critical issues, assumptions, limitations, and solution requirements
2. Considering all relevant perspectives, solution models, and alternative solution paths
3. Selecting models for obtaining solutions consistent with problem type, assumptions, and solution quality
4. Using selected models, methods, and data to produce a desired solution
5. Validating results, and interpreting and extending the solution for wider application

**Designer**

When facing an engineering design challenge, the engineer develops designs that satisfy stakeholder needs while complying with important constraints of implementation and societal need. Observable actions that support this role include:

1. Searching widely to determine stakeholder needs, existing solutions, and constraints on solutions
2. Formulating clear design goals, solution specifications (including cost, performance, manufacturability, sustainability, and social impact), and constraints that must be satisfied to yield a valuable design solution
3. Thinking independently, cooperatively, and creatively to identify relevant existing ideas, and to generate original solution ideas
4. Synthesizing, evaluating, selecting, and defending alternatives that result in products (components, systems, processes, or plans) that satisfy established design criteria and constraints to meet stakeholder needs
5. Reviewing and refining design processes for improved efficiency and product (solution) quality

**Researcher**

When conducting applied research, the engineer designs and conducts studies that yield defensible results and answer important applicable research questions. Observable actions that support this role include:

1. Formulating research questions that identify relevant hypotheses or other new knowledge sought
2. Planning experiments or other data gathering strategies to address questions posed and to control error
3. Conducting experiments or other procedures carefully to obtain reliable data for answering questions
4. Using accepted data analysis procedures to infer trends, parameters, and data error
5. Interpreting and validating results to offer answers to posed questions and to make useful application

**Communicator**

When exchanging information with others, the engineer prepares, delivers, and receives messages that achieve desired outcomes. Observable actions that support this role include:

1. Listening, observing, and questioning to assess audience background and information needs
2. Documenting and mining available information and differing perspectives for understanding and application
3. Preparing a message with the content, organization, format, and quality that fits the audience and purpose
4. Delivering a message in a timely, credible, and engaging way that efficiently achieves desired outcomes
5. Assessing the communication process and responding in real time to advance its effectiveness

**Collaborator**

When working with others in joint efforts, the engineer supports a diverse, capable team and contributes to the achievement of its collective and individual goals. Observable actions that support this role include:

1. Respecting individuals with diverse backgrounds, perspectives, and skills important to the effort
2. Valuing roles, accepting role assignments, and supporting others in their roles
3. Contributing to the effective cooperation of the team in its development of consensus goals and procedures
4. Resolving conflicts and promoting enhanced creativity, perceptions, trust, and enjoyment by all
5. Contributing to and accepting feedback and change that support continuous improvement

**Leader**

When providing needed leadership, the engineer promotes a shared vision to individuals, teams, and organizations, and empowers them to achieve their individual and collective goals. Observable actions that support this role include:

1. Facilitates and articulates a shared vision valued by targeted individuals, groups, or organizations
2. Motivates others to action by crafting a compelling yet credible case for achieving individual and organizational goals
3. Provides authority and resources and removes barriers to aid others' success
4. Supports risk-taking and growth by creating trust, providing counsel, and modelling desired attributes
5. Encourages achievement by recognizing and rewarding individual and group successes

**Self-grower**

Motivated for lifelong success, the engineer plans, self-assesses, and achieves necessary personal growth in knowledge, skills, and attitudes. Observable actions that support this role include:

1. Takes ownership for one's own personal and professional status and growth
2. Defines personal professional goals that support lifelong productivity and satisfaction
3. Regularly self-assesses personal growth and challenges to achieving personal goals
4. Achieves development planned to reach personal goals
5. Seeks out mentors to support and challenge future growth and development

**Achiever**

When given an assignment, the engineer demonstrates initiative, focus, and flexibility to deliver quality results in a timely manner. Observable actions that support this role include:

1. Accepts responsibility and takes ownership in assignments
2. Maintains focus to complete tasks on time amidst multiple demands
3. Takes appropriate actions and risks to overcome obstacles and achieve objectives
4. Monitors and adapts to changing conditions to ensure success
5. Seeks help when the challenge exceeds current capability in the given time constraints

**Practitioner**

Driven by personal and professional values, the engineer demonstrates integrity and responsibility in engineering practice and contributes engineering perspectives in addressing societal issues. Observable actions that support this role include:

1. Displays integrity, consistency, ethical, and professional demeanour in engineering practice and relationships
2. Embraces and employs appropriate professional codes, standards, and regulations
3. Engages with engineering professionals and organizations to support excellence in engineering practice
4. Demonstrates citizenship through service to society on local, national and/or global scales
5. Brings responsible engineering perspectives to global and societal issues

Based on the discussions with the faculty of the department, the following PEOs have been arrived for B. Tech CSE program:.

**PEOs**

1. A strong foundation in mathematics, basic science and engineering fundamentals, to successfully compete for entry-level positions or pursue graduate studies in CSE or related fields.
2. Contemporary professional and lifelong learning skills including hands-on laboratory experience, familiarity with computers, modern software, and information technology, to successfully compete in the global engineering market with an understanding of the ethical choices inherent in the engineering profession to deal with societal issues such as public safety, honest product marketing, and respect for intellectual property.
3. Strong communication and interpersonal skills, broad knowledge, and an understanding of multicultural and global perspectives to work effectively in multidisciplinary teams, both as team members and as leaders.

**Program Outcomes**

Program outcomes are narrower statements that describe what students are expected to know and be able to do by the time of graduation.

These are essentially a range of the knowledge, skills, and attitudes (behavior) that students acquire during their matriculation through the program by the time of graduation

Knowledge:

* Facts students know and concepts they understand

Skills:

* Skills students use in managing and applying their knowledge such as computation, experimentation, analysis, synthesis/design, evaluation, communication, leadership, and teamwork.

Attitudes:

* Attitudes that dictate the goals toward which their knowledge and skills will be directed – personal values, concerns, preferences, and biases.

Program Outcomes (a-l) are to written from NBA SAR document annexure I (June 2015), which are as follows:

1. Engineering Knowledge: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. Problem Analysis: Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences
3. Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
4. Conduct investigations of complex problems: Conduct investigation of Complex Problems using research based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.
5. Modern Tool Usage: Create, select, and study appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of limitations.
6. 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.
7. 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.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. 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.
11. 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.
12. 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 those program outcomes pertaining to the program offered unlike the program outcomes, which are more generic in nature.

Program specific outcomes should clearly specify the outcomes pertaining to the program (major discipline) the student undergone and will be able to do immediately after the completion of the program.

For example, some of the PSOs for CSE graduate could be written as follows:

* be able to read and write program code in a variety of programming languages and have extensive experience with at least one high-level language;
* has the knowledge to produce effective conceptual and physical database systems;
* design and develop algorithm skills;
* have experience in programming for and using a variety of computer operating systems;
* an ability to design, implement, and evaluate a software or a software/hardware system, component, or process to meet desired needs within realistic constraints such as memory, runtime efficiency, as well as appropriate constraints related to economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability considerations;

Some of the PSOs for ECE graduate could be written as follows:

* An ability to use modern Electronic Design Automation (EDA) tools, software and electronic equipment to analyze, synthesize and evaluate Electronic / Communication systems for multidisciplinary tasks.
* An ability to model, simulate, and design Electronics and Communication Engineering systems, conduct experiments, as well as analyze and interpret data and prepare a report with conclusions.
* An ability to design, implement, and evaluate Electronics and Communication Engineering system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

After having written the PEOs, POs, and PSOs, the faculty must write course outcomes for the courses that they intend to teach.

**Course Outcomes (COs)**

Course Outcomes are narrower statements that describe what students are expected to know and be able to do at the end of each course.

Each course must have about six (6) to eight (8) course outcomes. Further, each course divided into five or six modules/units. Each unit must have several learning outcomes which usually consist of eight (8) to ten (10) Learning Outcomes (LOs).

Before writing Instructional Learning Outcomes or simply Learning Outcomes (LOs), one should provide basic information related to

1. Course purpose;
2. Expected learning outcomes (LOs);
3. Methods for assessing expected learning outcomes;
4. Criteria for grade determination; and
5. A course outline

* Prepare a description of the course mentioning what the course is all about. We may as well provide a written statement regarding the course’s purpose; i.e. by clarifying the purpose of the course, faculty can help discover the main topics or themes related to students’ learning.

The course purpose involves the following:

* What role does this course play within the Program?
* How is the course unique or different from other courses of the Program?
* What essential knowledge or skills should they gain from this experience?
* What knowledge or skills from this course will students need to have mastered to perform well in future classes or later (Higher Education / Jobs)?
* Why is this course important for students to take?
* What is/are the prerequisite(s) for this course?
* When students complete this course, what do they need know or be able to do?
* Is there specific knowledge that the students will need to know in the future?
* Are there certain practical or professional skills that students will need to apply in the future?
* Five years from now, what do you hope students will remember from this course?
* What is it about this course that makes it unique or special?
* Why does the program offer this course?
* Why can’t this course be “covered” as a sub-section of another course?
* What unique contributions to students’ learning experience does this course make?
* What is the value of taking this course? How exactly does it enrich the program?

The “Course Purpose” should describe how the course fits into the student's educational experience in the program and how it helps in his/her professional career.

**Construct/develop expected learning outcomes for the course**;

**Expected Learning Outcome (definition)**

An expected learning outcome is a formal statement of what students are expected to learn in a course.

Expected 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.

Expected learning outcomes are also often referred to as “learning outcomes”, “student learning outcomes”, or “learning outcome statements”.

When beginning to construct expected learning outcome statements, it is always good to think about the learners and please consider the following questions:

* What are the most essential things the students need to know or be able to do at the end of this course?
* What knowledge and skills are required to do this course?
* What knowledge and skills should they learn from the course?

When you begin thinking about the expected learning outcomes for a course, it is a good idea to think broadly.

Course-level expected learning outcomes do not need to focus on small details; rather, they address entire classes/lectures of theories, skill sets, topics, etc.

*Simply stated, expected learning outcome statements describe:*

1. What faculty members want students to *know* at the end of the course *AND*
2. What faculty members want students *to be able to do* at the end of the course.

**Characteristics of Learning Outcomes (LOs)**

1. They specify an action by the students/learners that is ***observable***
2. They specify an action by the students/learners that is ***measurable***
3. They specify an action that is done by the ***students/learners*** (rather than the faculty members)

When expected learning outcomes for a course are designed then they can be assessed.

**Writing Effective Learning Outcome Statements**

When stating expected learning outcomes, it is important to use verbs that describe exactly what the learner(s) will be able to *do* upon completion of the course.

**Examples of good action verbs (words) to include in expected learning outcome statements:**

*Compile identify create, plan*

*revise, analyze design select*

*utilize apply demonstrate prepare*

*use compute discuss explain*

*predict assess compare rate*

*critique outline evaluate*

* Verbs that are unclear in the context of an expected learning outcome statement (*e.g. know, be aware of, appreciate, learn, understand, comprehend, become familiar with*).
* These words are often vague, have multiple interpretations, or are simply difficult to observe or measure.

It is suggested to avoid using these terms when creating expected learning outcome statements.

For example, please look at the following learning outcomes statements:

* *The students will understand basic human development theory.*
* *The students will appreciate music from other cultures.*

Both of these learning outcomes are stated in a manner that will make them difficult to assess. Consider the following:

* How do you observe someone “understanding” a theory or “appreciating” other cultures?
* How easy will it be to measure “understanding” or “appreciation”?

**These expected learning outcomes are more effectively stated the following way:**

* *The students will be able to identify and describe the major theories of human development.*
* *The students will be able to identify the characteristics of music from other cultures.*

**Incorporating different levels of Thinking Skills into Expected Learning Outcome Statements**

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.

A revised version of Bloom’s taxonomy of critical thinking is provided below.

***Definitions of the different levels of thinking skills in Bloom’s taxonomy***

**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.

**Comprehend/Explain** – the ability to grasp the meaning of information (facts, definitions, concepts, etc.) that has been presented.

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

**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.

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

**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 own thoughts and ideas.

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.

**List of Action words related to Critical Thinking Skills**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Remember** | **Comprehension** | **Apply** | **Analyze** | **Evaluate** | **Create** |
| Count Define Describe Draw Identify Label  List  Match Name Outline Point  Quote  Read  Recall Recite Recognize Record Repeat Reproduce Select  State  Write | Associate Compute  Convert  Defend  Discuss  Distinguish Estimate  Explain  Extend  Extrapolate Generalize  Give examples Infer  Paraphrase Predict  Rewrite Summarize | Add  Apply  Calculate Change Classify Complete Compute Demonstrate Discover Divide Examine Graph Interpolate Manipulate Modify Operate Prepare Produce Show  Solve Subtract Translate  Use | Analyze Arrange Breakdown Combine Design Detect Develop Diagram Differentiate Discriminate Illustrate Infer  Outline  Point out Relate  Select  Separate Subdivide Utilize | Appraise Assess Compare Conclude Contrast Criticize Critique Determine Grade  Interpret  Judge  Justify Measure  Rank  Rate  Support  Test | Categorize Combine Compile Compose Create  Drive  Design Devise Explain Generate Group Integrate Modify  Order Organize Plan Prescribe Propose Rearrange Reconstruct Related Reorganize Revise Rewrite Summarize Transform Specify |

**Tips for Developing Course Level Expected Learning Outcome Statements**

* Limit the course-level expected learning outcomes to 5 – 10 statements for the entire course (more detailed outcomes can be developed for individual units, assignments, chapters, etc.).
* Focus on overarching or general 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.
* Create statements that are student-centred rather than faculty-centred (e.g. "upon completion of this course students will be able to list the names of the 20 districts" versus "one objective of this course is to teach the names of the 20 districts").
* Focus on the learning that *results* from the course rather than describing activities or lessons in the course.
* Incorporate or reflect the institutional and departmental missions.
* Incorporate various ways for students to show success (outlining, describing, modelling, depicting, etc.) rather than using a single statement such as “at the end of the course, students will know "\_\_\_\_\_\_\_\_" as the stem for each expected outcome statement.

**Sample Expected Learning Outcomes (LOs) Statements**

**Course title: Introduction to Business**

*At the end of the course, students should be able to:*

* Identify and describe current domestic and international business trends
* Explain how proper business management benefits consumers and employees
* Define the basic rules related to human resources management
* Compare and contrast the different types of business ownership
* Evaluate and classify various marketing strategies
* Summarize how technology can help a business manage information

**Course title: Object-Oriented Analysis and Design**

**Course Outcomes**

The main objective of the course is that students will be able to analyze system requirements, and create and justify object-oriented design that meets their requirements and is robust and evolvable. In more detail, the essential outcomes for this course are that students will be able to:

* Analyze system requirements and model problem domains.
* Evaluate the quality of an analysis, and be able to explain how to improve it.
* Design and build object-oriented systems.
* Explain and justify designs based on design principles, patterns, and heuristics.
* Evaluate the quality of a design, and be able to explain how to improve it.
* Write object-oriented code to correctly implement a design.
* Be able to read and write analysis and design documentation in the Unified Modelling Language (UML).
* Be able to read and write object-oriented code, in Java, that uses subclasses, inheritance, abstract methods, subtypes, and subtype polymorphism.

**Assessment**

* Assessment involves the systematic collection, review, and use of evidence or information related to student learning.
* Assessment helps faculty know how well their students have been able to comprehend course topics/lessons in order to see what areas need to be re-addressed in order to increase the students’ learning.
* Assessment is the process of investigating
  + *What* students are learning
  + *How well* they are learning

in relation to the stated *expected learning outcomes* for the course.

This process also involves providing feedback to the students about their learning and providing new learning opportunities/strategies to increase student learning.

**What is the difference between “evaluation” and “assessment”?**

1. *Evaluation* focuses on making a judgment about student work to be used in assigning grades that express the level of student performance.
2. Evaluation is usually used in the process of *determining grades*. Evaluation typically occurs after student learning is assumed to have taken place (e.g. a final exam).
3. Evaluation is part of the assessment process.
4. Course assignments that are evaluated/graded (e.g. exams, papers, homework, etc.) are often seen as formal assessment techniques.

**What is involved in the assessment process?**

1. Establishing *expected learning outcomes* for the course;
2. Systematically gathering, analyzing, and interpreting evidence *(through formal assessment activities such as exams or papers and informal assessment activities such as in-class discussions or “muddiest point” exercises)* to determine how well the students’ learning matches:

* Faculty expectations for what students will learn AND
* The stated expected learning outcomes for the course

1. Faculty members should use this evidence/assessment of student learning to:

* Provide feedback to students about their learning (or lack thereof) AND
* Adjust their teaching methods and/or students’ learning behaviours to ensure greater student learning.

Create an assessment plan that outlines the specific methods that will be used to assess the expected student learning outcomes for the course;

**Direct Assessment Methods**

* Course-related assessment
  + Assignments / Projects
  + Case Studies
  + Classroom Assessment including Tutorials
  + Quizzes
  + Probing during and after lecture
  + Course-embedded Questions and Assignments
  + Essays
  + Theses, research and publications
* Presentations/Seminars, if any
* Standardized assessments (Internal Tests, End Exams)
* Other
  + Transcript analysis
  + Placement record of graduates

**Indirect Assessment Methods**

* Institutional and Program Surveys
  + Alumni Surveys
  + Employer Surveys
  + Graduating Seniors and Graduates Surveys
  + Student Satisfaction Surveys
* Other
  + Focus groups
  + Interviews (faculty members, graduating students, alumni)

**Learning Outcome(s) Assessment Method**

In the column on the left, please briefly list each Expected Learning Outcome for the course. In the column to the right, list the different Assessment Methods you plan to use to assess this expected learning outcome (e.g. classroom discussion, “muddiest point” exercises, etc.).

**Expected Learning Outcome(s) Assessment Method**

|  |  |  |
| --- | --- | --- |
| **S No (LOs)** | **Expected Learning Outcome(s)** | **Assessment Method** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **LOs** | **How will this expected learning outcome be assessed? What methods will you use to measure students’ mastery of this outcome?** | **When will this expected learning outcome be assessed? *(Please list the prospective dates for each of the assessment techniques listed in the first column)*** | **If these assessments show deficiencies in students’ mastery of this expected learning outcome, what are your plans for improving student learning related to this outcome?** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Describe how grades will be determined in a process that is separate and distinct from assessing the expected learning outcomes;

*Suggested topics to include in the “criteria for grade determination” section include:*

* A list/description of all assignments/projects/activities that will be assigned a grade and included in the calculation of the students’ final grade in the course
* The point values and/or percent of the final grade in the course related to each of these assignments/projects/activities
* A description of how point values/grades will be earned/determined for each assignment/project/activity as well as for the course as a whole
* Identify the common components of a course outline;

To guarantee the outcome of the course, the teaching of each topic in the course contents are to be designed to meet aforementioned criteria (a-l), (m-p) and evaluated by a set of assessment tools. Notice the keywords as follows:

“define, repeat, remember, describe, explain, discuss, illustrate, interpret, analysis, design, derive, apply, compare, solve, calculate, perform, produce, justify, and evaluate.”

These keywords determine the time and effort that the instructor has to spend on each topic. It also indicates the level of complexity for the learning process. The student’s learning outcome is evaluated according to the keywords using the assessment tools. These outcome based course assessment and evaluation tools are a combination of the following:

1. Tutorials
2. Homework assignments
3. Quizzes
4. Exams (Internal Assessment tests, University End semester exams)
5. Class attendance and participation in class
6. Laboratory experimentation and laboratory written reports
7. Design Project, its written Report and oral presentation
8. Computer simulation using C, C++, MATLAB, LABVIEW, ANSYS, etc
9. Prototype development, if any
10. Major project and teamwork
11. Course assessment/end survey (by students)
12. Instructor’s teaching performance evaluation (by students).

To guarantee the outcome of the course, the teaching of each topic in the course contents is to be designed to meet the aforementioned criteria (a-l) of the program outcomes (POs), (m-p) of the program specific outcomes (PSOs) and evaluated by a set of assessment tools selected from the above (12) tools. Table below shows the mapping of the sample course titled "Switching Theory and Logic Design" with course topics and outcomes to criteria (a-l), (m-p) and its corresponding assessment tools.

**Parameters for assessment of Project Work**

Students' design project performance should be evaluated based on written reports and oral presentations. The key elements that the student had to demonstrate in their design project include, but not limited to the following:

1. Were the objectives and purpose clearly stated?
2. Was the problem well defined?
3. Was the project properly justified (Why?) (Scientific, economic, value addition?)
4. Was the design, analysis and modelling understood?
5. Was the approach taken reached as part of a selection process?
6. Are the results technically and economically feasible?
7. Effective conclusions / recommendations?
8. Quality of the work or design.
   1. Was the content well organized?
   2. Were there appropriate use of graphs, charts, board, audio-video, etc.
   3. Was the message clearly delivered?
   4. Was Teamwork evident in the design, implementation and presentation?

After having completed the exercise of assessment and evaluation of various outcomes, we need to map the following to check whether we have achieved our objective of providing outcome based education and to what extent.

* COs to POs and PSOs
* POs and PSOs to PEOs

Over and above the mapping of the above, we also need to obtain feedback from all stake holders on a periodical basis so that we can verify the attainment of the various outcomes.

Towards the end, OBE programs must ensure

* Teaching is purposeful and systematic, rather than haphazard, while still allowing students to discover, to follow their interests, to take responsibility for their own learning, and to nurture and develop them both academically, personally and professionally.
* Teachers must provide students with *appropriate* and *purposeful* learning experiences and opportunities so that they can develop originality, self-motivation and independence at the same time as they acquire useful knowledge and skills which can be used for technological advancements and societal development.