

Outcome Based Education - Design Delivery and Assessment of Product Design and Development Course at undergraduate Engineering Program

Dr. Martnad T. Telsang
Dean Academic
Rajarambapu Institute of Technology
Rajaramnagar, India.415414
martand.telsang@ritindia.edu

Abstract— The implementation of Outcome Based Education (OBE) has been the focus of attention of technical institutions in India, often regarded as compliance driven instead of performance driven because of the mandatory requirement of NBA accreditation. Though the implementation seems very structured on paper, it involves daunting data collection process which results in lack of commitment among faculty members in ensuring success of OBE to reap the full benefits. This study reports the implementation of outcome based course design based on intended course learning outcomes (CLOs), planning the instruction delivery to get the intended outcomes to match learning preferences of students and assessment of course outcomes and measuring the attainment of outcomes as against the target for the continuous quality improvement. The New Product design & Development course offered as an open elective at seventh semester of undergraduate programme is chosen. A heterogeneous batch of 5 engineering programs has opted for this course, which is first time offered as open elective. The challenge lies in designing the curriculum to meet specific POs of five programs, designing the instructional delivery to address the students learning styles of different background and assessment tools and the attainment. The moderate target of 60-65 percent COs attainment target was kept and could be able to achieve about 55 percent attainment and this gap has given a lot of inputs for CQI of course design, delivery & assessment. The learning out of this course feedback has helped to improve the all aspects of course and look to a strong mapping with identified program outcomes.

Keywords- Outcome Based Education, Program Outcomes, Course Learning Outcomes, assessment methods, Graduate attitudes., Problem Based Learning ,Project Based Learning

I. INTRODUCTION

Outcome based education (OBE) is a process that 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 [1]. 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. Outcomes are clear learning results that learners have to demonstrate at the end of significant learning experiences: what learners can actually do with what they

know and have learned. Outcomes are actions/performances that embody and reflect learner competence in using content, information, ideas and tools successfully. OBE is based on three assumptions: all learners can learn and succeed; success breeds success and teaching institutions control the conditions of success [1]. Basically two types of outcomes are defined [2]. The first includes performance indicators often measured in terms of tests, completion rates, post course employment etc. It also emphasizes learner mastery of traditional subject related academic outcomes. The second is less tangible and usually expressed in terms of what learners know, are able to do or perform. It stresses long term, cross curricular outcomes which relate to future life roles of the learner such as being a productive worker, a responsible citizen. OBE implementation has been among the main focus of technical institutions in India often regarded as compliance driven instead of performance driven because of NBA accreditation mandatory requirement.

This paper attempts to report the implementation of outcome based course design based on the intended course learning outcomes. course delivery and instructions to get the intended CLOs based on learning styles of students and assessment tools to achievement of students in meeting CLOs and Continuous improvement based on gap between the target and attainment of CLOs.

II. COURSE DESIGN

Developing a clear program mission, program educational objectives (PEOs) and Program Outcomes (POs) based on program graduate attributes require faculty to have perfect understanding of what the program is and what they want it to be. The outcome of this exercise constitutes a unifying frame work for course and curricular development. If faculty members then structure their course syllabi, learning outcomes and teaching and learning methods to address the program outcomes, the result of which is a coherent curriculum in which all the courses have well – defined and interconnected roles in achieving the mission of the program. The course learning outcomes (CLOs) are explicit statements of what the students at the end of the course should be able to demonstrate their mastery of course material creating a course to achieve specified outcomes requires efforts in three

domains (Fig. 1). Course planning (identifying course content and defining measurable learning outcomes for it), Instruction (selecting and implementing the methods that will be used to deliver the specified content and facilitate student achievement of outcomes), and assessment and evaluation (selecting and implementing the methods that will be used to determine whether and how well the outcomes have been achieved and interpreting the results). The (Fig. 1) shows that all three stages are not purely sequential the information collected in each of them feeds back to each of the others in a cycle that leads to continuous improvement. If the assessment reveals that outcomes have not been satisfactorily achieved, the analysis and nature of the failure may suggest the reframing outcomes or modifying the instruction used to address it.

With the improved quality of instructions, new outcomes may be formulated to encompass higher levels of achievement and the course instructions and assessment modified accordingly.

A. Assessment of CLOs

Course learning outcomes are statements that describe significant essential learning that is achieved, and can reliably demonstrate at the end of the course [4]. CLOs should be measurable and observable via cognitive, psychomotor and affective learning outcomes CLOs should reflect essential knowledge skills and attitudes and finally, should represent the minimum performance that must be achieved to success fully complete a course. The CLO assessment is continuous starting from the first week of the course until the end of the course examination [5]. The CLO attainment that uses direct and indirect measurement tools are collected from the assessment system and analyzed by the faculty to take appropriate actions for CQI. Course learning outcomes (CLOs) assessment methods are represented in Figure 2.

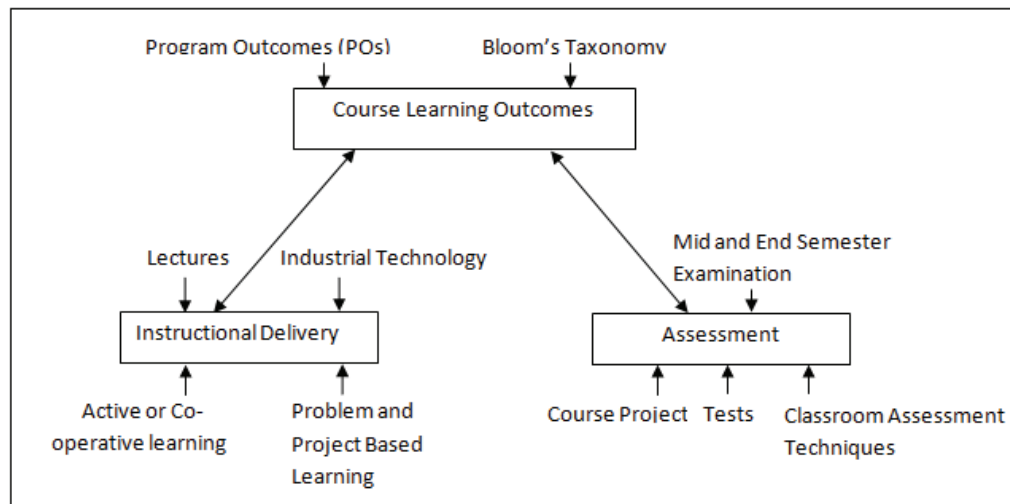


Fig. 1. Framework of Course Design

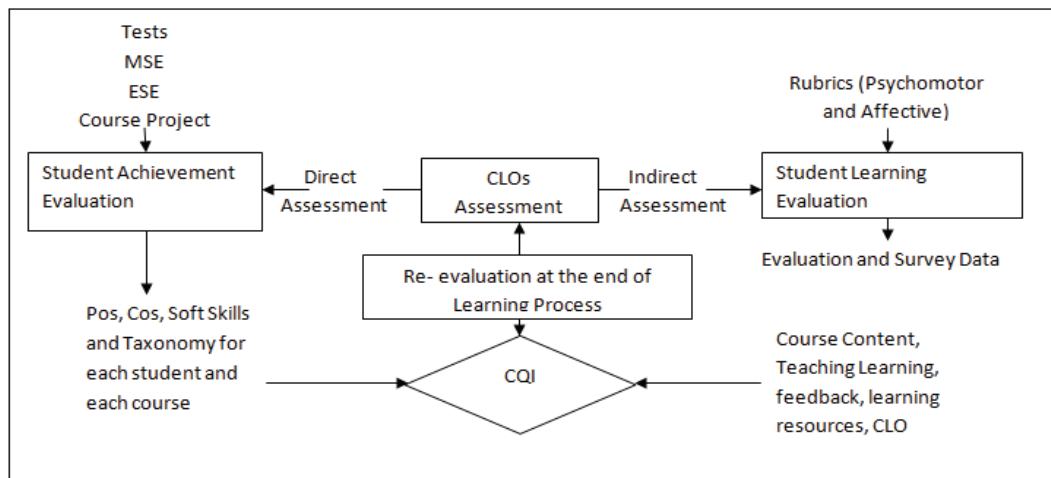


Fig. 2. Cos assessment methods

B. Planning Instructional Delivery

The equations are an exception to the prescribed A good curriculum design in itself will not in itself complete without the two other components; instructional planning and delivery and assessment. The successful course delivery is one which takes in to consideration the learning preferences (learning styles) of students to devise the instructional strategies. Because the course under consideration is of interdisciplinary nature of students with diversified background like mechanical, automobile, electronics and telecommunication, electrical and information of technically, it is more challenging for the course instructor to match the delivery to achieve the intended course learning outcomes. Based on the Felder's learning styles questionnaire, the learning styles of students opted are found out which guides the teaching style. As a new experiment, the course teacher instead of major thrust on lecturing one way, a participative learning is adopted with teacher as a facilitator[7]. For example, the course outcomes are broken down in to unit outcomes and further for each lecture the outcomes expected various instructional activities planned. Instructional resources like product models, power point presentations, video clips, creative exercises etc are planned meticulously. This requires a transformation in the true sense from a teacher to a learning facilitator [6]. A continuous feedback on how things are moving with students learning, whether they accepted the new methodology a constant interaction with it is important. This requires a full commitment on the part of course instructor to communicate the intended learning outcomes from the beginning of the course and make clear the expectations from the students to minimize the surprise content.

III. COURSE DESCRIPTION

The course New (NPDD) course is designed as an open elective at seventh semester of engineering degree program and open to students of all the seven programs of the institute. Maximizing the success of new products and services can drive growth and shareholder value, lead to significant competitive advantage and leapfrog a company ahead of its competitors. However, innovation is risky and most new products fail in the marketplace. Often, failure is due to an ineffective process. Thus, expertise in the design and marketing of new products is a critical skill for all managers, inside and outside of the marketing department. In this course, we first focus on the tools and techniques associated with analyzing market opportunities and then focus on designing, testing, and introducing new products and services. This course will introduce the new product development process and cover the three main areas of focus:

- Discovery - opportunity identification
- Design - concept and product design, development and evaluation
- Delivery - innovative approaches to product launch and introduction.

A. Course Delivery Methodology

A good blend of traditional lecturing along with project based learning (PBL), problem based learning and flipped

classroom approach was adopted to give a better learning experience which takes care of heterogeneous mix of students with varying learning preferences. A traditional lecture mode helps to orient the students to familiarize with basic concepts, philosophies, principles and procedure for product design. Problem-based learning (PBL) is approaches that challenge students to learn through engagement in a real problem. It is a format that simultaneously develops both problem solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem-solvers confronted with an ill-structured situation that simulates the kind of problems they are likely to face as future managers in complex organizations. The process is aimed at using the power of authentic problem solving to engage students and enhance their learning and motivation. PBL is unique in that it fosters collaboration among students, stresses the development of problem solving skills within the context of professional practice, promotes effective reasoning and self-directed learning, and is aimed at increasing motivation for life-long learning. Engineering design through PBL provides Intellectual Maturity by allowing students to become Independent Learners, not only acquiring knowledge about what they know but also making them aware what they do not know hence keeping their expectations real and protecting them from what they do not know.,

The opportunity to obtain "design" experience, this means that the student goes through the complete design process, from drawing up their own program to arranging formal engagements (deliverables). To learn how to avoid common pitfalls early in the design process the students assume responsibility for defining core interaction, people, and resources related to the design process. A small illustration demonstrates the power of this technique and how the collective experience is sought and used in design process. The problem of pump selection for specific application is under consideration (Table I). An approach to design that's focused on student experience with a goal to simplify the total, think reflectively and reflect the importance of this experience.

It will include readings from a prescribed text, relevant articles, illustrative actual examples, guest speakers from industry, and case studies. The course is delivered using a combination of lectures, cases, group/team project, and class discussion. Classes will be interactive and collaborative.

B. Who can opt for this course?

Course is open to all Students. The course demands application of creativity, sensitivity towards solving problems and liking for doing something new and creative.

C. Course curriculum

Curriculum is designed in to six units from product idea to commercialization and launching of products. The curriculum is summarized in to six units: (1) Discovery - Opportunity identification for new products (2) Identifying Customer Needs (3) Product Concept Generation, Selection and Testing (4) 4 Product Design Process and Tools and Techniques (5) Design Considerations (6) Product Launch and Market Entry.

V. COURSE OUTCOMES

TABLE I. PROBLEM OF PUMP SELECTION

1	What is your prior knowledge about pump selection? What do we need to find out about; flow rate, total head, friction, fluid viscosity, temperature, PH, temperature, RPM, pump performance, energy balance, Bernoulli's equation, suction size, discharge size, failures causes (vibration)?
2	How will we go about sizing a pump? Manufacturer's catalogue, pump curves, rules of thumb, industry standards.
3	How will we go about finding out? Manufacturer's catalogue, pump curves, rules of thumb, industry standards.
4	What do we expect to learn? Pump selection, (centrifugal, positive displacement, Reciprocating, diaphragm), pipe sizing, Best efficiency point (BEP),
5	How will we apply what we have learned to our next projects? Individual responses What new questions do we have following our inquiry? Individual responses

IV. PROGRAM OUTCOMES (POS) APPLICABLE TO NPDD COURSE

Institution works with a vision of Transformation of young minds into competent engineers to face global challenges and a vision to offer the state of art technical education programmes to shape promising engineers with requisite skills, knowledge, research aptitude, values and ethics ensuring rewarding careers. The program outcomes are developed in line with the graduate attributes (GAs) specified for each program and the PEOs of respective programs. The POs addressed by the program and also POs addressed by the NPDD course are represented in the Table II.

TABLE II. PROGRAM OUTCOMES AND POS ADDRESSED BY NPDD COURSE

PO No	Program Outcomes(At the end of course student should be able to)	POs Addressed by NPDD course
PO1	Apply knowledge of mathematics, science and engineering	
PO2	Design and conduct experiments to analyze and interpret data.	
PO3	Design a system, component, or process to meet desired needs within realistic constraints.	✓
PO4	Function in multi-disciplinary teams.	✓
PO5	Identify, formulate and solve engineering problems.	✓
PO6	Responsiveness towards professionalism and ethics.	✓
PO7	Communicate effectively.	✓
PO8	understand the impact engineering solution in a global and societal context	
PO9	Recognize the need for, and an ability to engross in lifelong learning.	
PO10	Demonstrate Knowledge of contemporary issues affecting technical fields.	
PO11	an ability to use the techniques, skills, and modern engineering tools such as computers	✓
PO12	Demonstrate a knowledge and understanding project and finance.	✓

NPDD course is designed to familiarize students with the principles and practices in the development, design, Development and introduction of new products and services. After successful completion of the course, student will be able to:

- Identify the new product opportunities and sources of new product ideas (CO1).
- Understand the product life cycle and product design process and principles (CO2).
- Integrate the customer and end-consumer needs into design process (CO3).
- Apply the concepts and tools like DFMA, VE and QFD in design process, Life cycle cost (CO4).
- Assimilate the various product characteristics to design a novel product (CO5)
- participate in group work sessions and teams to become acquainted with the importance of teamwork and collaboration that is critical to new product success (CO6).
- Communicate effectively the product benefits and Project Feasibility.(CO7)

A. Course Assessment

Assessment is a powerful means to make sure that whether students are expected to learn and it drives the students learning. The assessment scheme for the course under consideration is represented in the table III. The course project is designed in order to give the students the hands on experience on what they study in curriculum to translate on to a product. It is a group assignment consisting of students from different discipline with diversified skills and competency working together towards a common goal. Many of the learning outcomes are addressed through course project. The course outcomes related to many of skills, knowledge and behaviors can be measured and gives the realistic feedback with respect to learning which helps for continuous quality improvement.

TABLE III. NPDD ADESSMENT SCHEME

In semester evaluation	Mid Semester Evaluation	End Semester Examination
Group Course Project (Continuous Assessment)	Written Examination (Week 8)	Comprehensive Written Examination (16 th Week)
20%	30%	50%

VI. COURSE OUTCOMES (COS) ATTAINMENT

The faculty has predetermined the POs that are addressed by course outcomes as represented in Table IV. The course outcomes are structured with respect to appropriate assessment methods. A assessment for the course includes tests, group course project and comprehensive end semester examination. Both direct measurement and indirect measurements are used for attainment of Cos and Pos.

TABLE IV. PROGRAM OUTCOMES AND POS ADDRESSED BY NPDD COURSE

Course Outcomes	PO3	PO4	PO5	PO6	PO7	PO8	PO11	PO12
CO1			✓		✓			
CO2	✓							
esCO3						✓		
CO4							✓	
CO5	✓							
CO6		✓						
CO7				✓				✓

TABLE V. COURSE LEVEL ATTAINMENTS

Course Outcomes	Course Outcomes	% attainment
CO1	Identify the new product opportunities and sources of new product ideas	68
CO2	Understand the product life cycle and product design process and principles	67
CO3	Integrate the customer and end-consumer needs into design process	55
CO4	Apply the concepts and tools like DFMA, VE and QFD in design process, Life cycle cost.	42
CO5	Assimilate the various product characteristics to design a novel product	60
CO6	Participate in group work sessions and teams	65
CO7	Communicate effectively the product benefits and Project Feasibility	61

The direct method uses the students' performance in tests and End semester examination. Each question is mapped to respective COs. The data collected from the assessment is used to get the average attainment of COs for both MSE and ESE. The indirect method uses the course project assessment data for mapping. The target for the attainment level is set moderately high at 70 percent as the course is taught and evaluated as per OBE for the first time. The overall COs attainment is in the range of 55 to 65 percentage, which on analysis gives feedback on the CQI. The learning out of the feedback has given way for improvement in all the aspects of the course, design, delivery and assessment. The COs attainment is represented in the table V.

VII. CONCLUSIONS

The framework for outcome based design, delivery and assessment of new product design and development course in engineering offered as open elective is discussed. The challenge in implementation lies in defining appropriate COs that map with Program POs and planning instructions that helps the students to demonstrate learning. Measuring attainment is much more complex and tedious as it demand more time of faculty. The challenge lies in making things simpler and effective. This approach along with course end survey gives a feedback regarding lower attainment. Steps are

initiated to redesign the course based on this feedback as a continuous quality improvement process.

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