

Implementing a sustainable methodology for assessment of course outcomes and program outcomes in an Indian Engineering Institute

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Abstract—In India, National Board of Accreditation (NBA) has been mandated with the quality assessments and accreditation of engineering programs. NBA has introduced the accreditation system based on Outcome Based Education (OBE) with paradigms like program educational objectives (PEOs), program outcomes (POs), course outcomes (COs), assessments, continuous improvements etc. A sustainable assessment methodology based on students' feedbacks on course outcomes has been adopted and implemented in an engineering institute. Based on the assessments of COs and COs vs POs mapping, attainments of POs were arrived. Further, the COs attainments are validated against the University Results. Assessments are repeated every semester, leading towards periodic assessments of COs and POs. The process was found to be sustainable and achieved continuous quality improvements across all programs, when implemented.

Keywords – *Quality; Course outcomes; Program Outcomes; Program Educational Objectives; Assessments; Continuous Quality Improvements; Engineering Institutions; India.*

I. INTRODUCTION

India has been a provisional member of Washington Accord (WA) since 2007, which enables mutual recognition of under-graduate engineering programs among the signatory countries. NBA has been mandated with the task of becoming permanent member and has revised its accreditation processes since 2009, enabling adoption of universal graduate attributes as proposed by WA. Its current accreditation system has the following nine criteria [1]: 1 Vision, Mission and Programme Educational Objectives (75); 2 Programme Outcomes (150); 3 Programme Curriculum (125); 4 Students' performance (100); 5 Faculty contributions (175); 6 Facilities and technical support (125); 7 Academic Support Units and Teaching-Learning Process (75); 8 Governance, Institutional Support and Financial Resources (75) and 9 Continuous Improvement (100). Institutions are evaluated under these nine criteria and those obtaining 750 marks and above, with minimum 60% in each criteria will get accredited for five years. Institutions getting 600 and above marks will get provisional accreditation for two years [1,2].

The new accreditation system necessitates a major shift in Indian engineering education system, which so far rallied as a input-output based system. The new 'Outcome Based

Education' system has introduced newer paradigms like Program Educational Objectives (PEOs), Program Outcomes (POs), Course Outcomes (COs), Assessments, Continuous Quality Improvements (CQIs) etc., which are aliens to Indian faculty and stake-holders like students, parents, alumni, employers etc. The new accreditation process necessitates a change of mind-set of the traditional engineering faculty members, asking them to spell out the course objectives, course outcomes, program outcomes mapping, gaps in the syllabus, topics beyond syllabus, additional value addition activities and various methodologies to assess COs, POs and PEOs.

II. OUTCOME BASED EDUCATION

Program educational objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve [3]. Program outcomes (POs) are narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge and behaviors that students acquire in their matriculation through the program [3]. A program consists of number of theory, practical and project courses. Each Course shall have a set of course objectives and course outcomes, which describe what a teacher wants to teach and what students will be able to do as a result of teaching and learning. Course Outcomes (COs) are comprehensive sets of statements of exactly what the students will be able to achieve after successful study. Course Objectives are to be framed by the teacher, at the beginning of the course along with the Course Outcomes.

Based on the Institute's and the Department's Mission Statements, the Program Assessment Committee (PAC) and the Department Advisory Committee (DAC) have formulated the following PEOs for the undergraduate engineering program.

- I. Domain Knowledge: Graduates shall have the knowledge of mathematics, science, computing and engineering fundamentals, breadth and in-depth studies in Mechanical Engineering, laboratory and project based experiences in addition to proficiency in computer-based engineering and use of modern computational tools.

- II. **Employment & Higher Studies:** Graduates shall succeed in entry-level engineering positions with manufacturing firms in regional, national, or international industries and with government organizations. In addition, they will succeed in the pursuit of advanced degrees in engineering or in other fields and will have skills for, continued independent, life-long learning.
- III. **Professional Skills:** Graduates shall have the ability to organize and present information, to write and speak effective English, to work effectively on team-based engineering projects and will practice ethics and have a sense of social responsibility.

Further, the PAC and the DAC have decided to adopt the following program outcomes that are similar to that of ABET recommended program outcomes ('a'-'k'), in addition to a program specific program outcome ('l').

- a) an ability to apply knowledge of mathematics, science, and engineering
- b) an ability to design and conduct experiments, as well as to analyze and interpret data
- c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- d) an ability to function on multi-disciplinary team
- e) an ability to identify, formulate, and solve engineering problems
- f) an understanding of professional and ethical responsibility
- g) an ability to communicate effectively
- h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- i) a recognition of the need for, and an ability to engage in life-long learning
- j) a knowledge of contemporary issues
- k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
- l) an ability to work professionally in both thermal and mechanical system areas including the design and realization of such systems.

Faculty members have been given intensive training on outcome based education, PEOs, POs, framing of Course Outcomes, mapping onto POs, assessment methodologies, continuous improvements etc., to adopt the new paradigms.

III. METHODOLOGY

The authors have implemented the following processes in their institutions to assess the COs, POs and PEOs and the same are as follows:

- 1) Crystalizing PEOs that are consistent with Institution's and Program's Mission.
- 2) Adopting Program Outcomes aligned with ABET program outcomes along with additional, program specific program outcomes.
- 3) Finalization of Course Objectives, Course Outcomes for all courses, Mapping of course outcomes to the program

outcomes for all the prescribed courses, by the faculty members and preparation of course-wise students' feedback forms on outcomes towards attainments of COs.

- 4) The COs, POs mapping and COs feedback are validated by the program assessment committee (PAC) of the program.
- 5) Each faculty member obtains the students' feedbacks on COs and then computes the level of attainment (%) of COs for each course.
- 6) By substituting the level of attainment of COs in the Courses Vs Program Outcomes mapping table, the PAC computes average percentage of POs attainments.
- 7) COs attainments are validated against University results and corrective actions are initiated in case of wide disparities.
- 8) PAC presents COs attainments, POs attainments, University Results, Students' feedback on faculty, performance of students in assignments, seminars etc in the Department Advisory Committee(DAC) meeting for further refinements.
- 9) Point Numbers 3 to 8 are repeated every semester, leading towards continuous assessments of COs, POs, reviews and Continuous Quality Improvements.

IV. IMPLEMENTATION

After finalization of the course outcomes and mapping of the course outcomes to program outcomes, a correlation was drawn between the course outcomes and program outcomes. The course outcomes for a sample course is as follows. Table -1 depicts the course outcome and mapping to program outcome for the sample course.

TABLE 1. COURSE OUTCOMES FOR A SAMPLE COURSE

Course Title	Course Outcomes(COs)	Mapping to Program Outcomes(POs)
ME 2352 Design of Transmission Systems	1. Ability to identify different types, advantages and disadvantages of power transmission systems such as mechanical, hydraulic, electrical etc. [a,h] 2. Ability to use relationships between power, torque, rotational speed, speed ratio and efficiency to solve problems on power transmission systems. [a, b, e] 3. Knowledge on gear types, gear terminology and gear manufacturing methods. [e] 4. Ability to explain fundamental law of gearing, failures and gear forces. [e] 5. Ability to identify, evaluate and compare the functions of different types of couplings, brakes and clutches. [e] 6. Ability to analyze, design and select belt, chain, rope drive systems. [b,c,e,i]	a,b,c,e,h,j

Students' feedbacks on attainment of course outcomes are assessed at the end of each semester, for all courses and the levels of attainments are computed for all courses in the semester. A sample

course outcomes assessment sheet is given in table 2 for the sample course.

TABLE 2. COURSE OUTCOMES ASSESSMENT SHEET

CAY: 2012-13	SEMESTER : EVEN	Date :
SUBJECT	DESIGN OF TRANSMISSION SYSTEMS	Year : III SEM : VI
FACULTY	P.MADHUMITHA	

CAY: CURRENT ACADEMIC YEAR

DESIGN OF TRANSMISSION SYSTEMS-COURSE OUTCOMES

- 1) Ability to identify different types, advantages and disadvantages of power transmission systems such as mechanical, hydraulic, electrical, etc [a,h]
- 2) Ability to use relationships between power, torque, rotational speed, speed ratio and efficiency to solve problems on power transmission systems [a, b, e]
- 3) Knowledge on gear types, gear terminology and gear manufacturing methods [e]
- 4) Ability to explain fundamental law of gearing, failures and gear forces [e]
- 5) Ability to identify, evaluate and compare the functions of different types of couplings, brakes and clutches [e]
- 6) Ability to analyze, design and select belt, chain, rope drive systems [b,c,e]

Evaluation Scale:

Excellent(E)	Very Good(VG)	Good(G)	Average(A)	Poor(P)
5	4	3	2	1

SNo	Questionnaire	E	VG	G	A	P
Course Outcomes(COs)						
1)	Are you able to identify different types and understand advantages and disadvantages of power transmission systems such as mechanical, hydraulic, electrical etc.					
2)	Are you able to use the relationships between power, torque, rotational speed, speed ratio and efficiency to solve problems on power transmission systems					
3)	Have you acquired knowledge on gear types, gear terminology and gear manufacturing methods					
4)	Have you understood the fundamental law of gearing, failures and gear forces					
5)	Will you able to identify, evaluate and compare the functions of different types of couplings, brakes and clutches					
6)	Will you able to select, design and analyze belt, chain, rope drive systems etc					

Based on the sample size (number of students), attainment of course outcomes on the scale of five is computed based on the weighted average method, for the course. In addition, each faculty member gets feedbacks on each course outcome at the micro level,

which helps them in improving their course content, delivery, quality of assignments etc. The attainment of Course Outcomes (COs) for all courses in a semester is given below in the table 3.

TABLE 3. COURSE OUTCOMES ATTAINMENTS FOR ALL COURSES IN A SEMESTER

Course Code	Course Name	Mapping to Program Outcomes	Assessment of Course Outcomes (On a scale of 5)
ME2351	Principles of Management	a,c,f,h,	4.1
ME2352	Finite Element Analysis	a,b,e,h	4.1
ME2353	Gas Dynamics & Jet Propulsion	a,b,c,e,j	4.2
ME2354	Design of Transmission System	a,b,c,e,h,j	4.3
ME2355	Automobile Engineering	a,c,e,h,j	4.4
ME2356	Thermal Engineering Lab	a,b,c,e,	4.5
ME2357	Design & Fabrication Project	a,b,c,d,e,f,g	4.0
ME2358	Communication Skills Lab	g,d	3.9

Tabulating the attainments of course outcomes against the mapped program outcomes resulted in the following table 4, enabling assessment of program outcomes(POs) for the semester.

Table 4 Attainments of course outcomes against the mapped program outcomes

Course Details		MAPPING ONTO PROGRAM OUTCOMES											
N O	Course Names	a	b	c	d	e	f	g	h	i	j	k	l
1	Principles of Management	4.1		4.1			4.1		4.1				
2	Finite Element Analysis	4.1	4.1			4.1			4.1				
3	Gas Dynamics & Jet Propulsion	4.2	4.2	4.2		4.2					4.2		
4	Design of Transmission System	4.3	4.3	4.3		4.3			4.3		4.3		
5	Automobile Engineering	4.4		4.4		4.4			4.4		4.4		
6	Thermal Engineering Lab	4.5	4.5	4.5		4.5							
7	Design & Fabrication Project	4.0	4.0	4.0	4.0	4.0	4.0	4.0					
8	Communication Skills Lab				3.9			3.9					
POs Attainment (Scale of 5)		4.20	4.22	4.25	3.95	4.25	4.05	3.95	4.23		4.23		
POs Attainment (Percentage)		84%	85%	85%	79%	85%	80%	79%	85%		86%		

V. RESULTS AND CONCLUSION

The results of the implementation of the different processes are presented here. The program assessment committee of the department has tabulated the attainments of COs and the University Results for the both odd and even semesters. The COs attainments were in the range of 75-85% correlating with the University Results. The POs attainments were computed from the COs attainments and were in the range of 75-85%. The DAC has suggested quality content, contents beyond the syllabus, additional value addition programs, innovative and modern pedagogy delivery, e-

learning etc., to continuously improve the attainments of COs and POs and to achieve the PEOs. The processes were found to be consistent and sustainable and have achieved continuous quality improvement.

VI. REFERENCES

- [1] National Board of Accreditation (NBA), India, www.nbaind.org
- [2] Manual of Accreditation, National Board of Accreditation(NBA), All India Council for Technical Education, New Delhi, India, 2004-2013.
- [3] Accreditation Board for Engineering & Technology (ABET), www.abet.org