

Outcome Based Assessment: A Case Study on Undergraduate Course on Control Systems

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Abstract: The Outcome Based Assessment (OBA) has been one of the major concerns of most engineering departments in India since the National Board of Accreditation (NBA) has made it compulsory towards programme accreditation. Implementation of the OBA may not be an easy task when considering the mapping of the course outcome (CO) to Programme Outcomes (PO). This paper describes the analysis process of the CO and PO attainment for an undergraduate course on control systems, a subject, which is offered to 3rd year students of Electrical & Electronics Engineering at Manipal University. Two methods are incorporated for the assessment of course outcomes and PO attainment (1) direct measurement, and (2) indirect measurement. As a whole, this paper gives complete procedure and a sample analysis for Outcome Based Assessment starting from course curriculum development to its outcome attainment based on defined criteria's.

Keywords: Outcome Based Education, Course Outcome, Programme Outcome, Engineering Education

1. Introduction

The implementation of Outcome Based Assessment (OBA) has been among the main focus of academic institutions in India, especially among engineering departments as India signed in as provisional member of the Washington Accord through the National Board of Accreditation Council (NBA) [1-2]. NBA has made OBA implementation as a compulsory practice in order for the programme to attain accreditation. The implementation of OBA is intended to ensure the curricula design fulfils the programme outcome and programme education objective, which shall reflect the achievement to the university's mission and vision. The concept of OBE is about developing the curricular structure based on what the learner are expected to achieve at the end of the education programme [3]. In order for OBE to be successfully implemented, there is a need to have the basic components which are: (i) University Mission & Vision (ii) Programme Educational Objectives (PEO); (iii) Programme Outcomes (PO) and (iv) Course Outcomes (CO) [4-5].

OBA implementation involves a regular and systematic data collection process in the departments. In addition, the execution of OBA is complex as the mapping of Course Outcome (CO) to PO may not necessarily be mapped to one item only. It reflects student centered learning focuses on measuring student performance since joining to throughout their career, with emphasis on 3-5 years of graduation.

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Electrical & Electronics engineering programme features core courses that cover fundamental electrical engineering science and design areas to help students gain in depth knowledge of engineering principles. Students also have the opportunity to select a variety of technical elective courses and open elective courses from other disciplines. Mini projects, seminar, major project, industrial training and technical club activities will help them to practice professional approach to learning. Students are encouraged to join, participate, and help organize conferences, student paper contest and industry - institute interactions. IE (E&E) student chapter, IEEE student branch and robotics club is active with E&E student participation.

Curriculum development process is shown in Fig.1; it is framed and approved by Board of studies and Senate. The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program. E&E curriculum is mainly designed based on lead societies IEEE. The generation of power, efficient use of electrical energy and control of electrical machines require an in depth study modeling and control of such systems. So the following courses are introduced.

- Linear Control Theory (Professional Core)
- Modern Control Theory (Professional Core)
- Advanced Control Systems (Program Elective)

Course coordinator of the course will provide a detailed plan for the semester including lecture plan, tutorials and evaluation plan. This will help to maintain uniformity of teaching learning process across the sections.

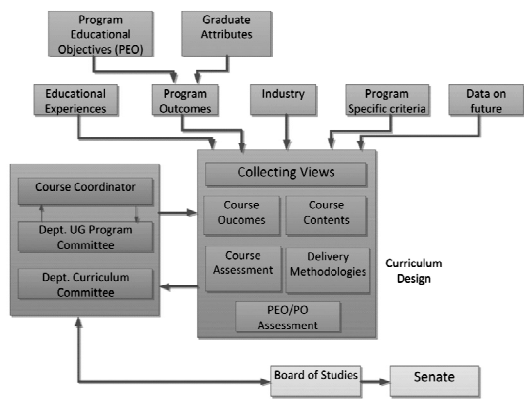


Fig.1: Curriculum development process

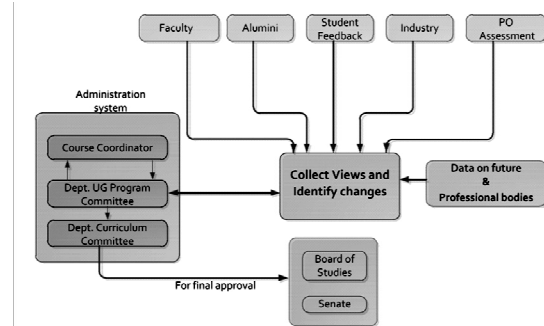


Fig.2: Process involved in improving the curriculum

Fig.2 shows the process involved in improving the curriculum which takes the feedback of industry and alumni also. Feedback from industries helps in future development of course structure to cater to their needs and also to introduce new and upcoming technologies. Interaction with alumni and current students helps the future graduates to decide on their long term goals

2. Programme Educational Objective (PEO)

The plan for outcome based education starts with defining vision and mission of the department in line with the institute vision and mission by taking input from various stake holders such as faculty, top management, professional bodies, alumni, industries and graduating students. The defined mission and vision is approved by the Department Curriculum Committee (DCC) ensuring consistency with the vision and mission of the Institute. Programme Educational Objectives (PEO) is based on NBA Graduate attributes and the present context of Engineering [4-6]. Each program is designed to prepare students for continued learning and successful careers in industry, academia and research. The curriculum is one of the main tools to prepare students in achieving PEOs. Therefore, the relevance of the courses in the program specific curriculum to PEO needs to be quantified in order to establish their level of support to PEO. Various administrative systems help in ensuring the Achievement of the PEOs of the department. Program Educational Objectives (PEOs) relate to the career and professional accomplishments of students after they graduate from the program. Consequently, assessment and evaluation of the objectives requires assessment tools that can be applied after graduation. However, keeping the significance of contribution of the curriculum and the assessment opportunities such as placement data and higher education entrance performance, these assessments are taken as supplementary evidence. Consistency of the PEOs with the mission of the department is an important concern.

3. Course on Control Systems

This section presents the description of the course on Control System considered for the discussion. Linear Control Theory is a first level course that emphasize on classical control theory. It is based on firm mathematical foundations and has rigorous design tools which improves the problem solving and design skills. The course deals with fundamental concepts, control system terminology, principles of system modeling, analysis and control design. The course focuses on linear time invariant continuous time systems. The course explains the concept of stability and various graphical methods for stability analysis and describes the design performance criteria in detail. Proportional, PI, PD and PID controller design and analysis are discussed comprehensively. Students are also familiarized to use MATLAB for controller design and analysis. Finally an introduction to state space modeling is contained in the course, the more analysis and design using state space modeling approach is discussed in the next level course. At the end of the course the students will be able to model electrical, mechanical and electro- mechanical systems, design controllers for various interdisciplinary applications and use MATLAB as a tool for verifying theoretical concepts.

4. Programme outcomes

PO1: Apply the knowledge of mathematics, science and engineering to solve the electrical & electronics engineering problems.

PO2: Identify, formulate and solve power & energy system problems.

PO3: Design and conduct experiments on analog and digital electronic systems to analyze and interpret data.

PO4: Apply the principles of electrical circuits and machines for testing and analysis.

PO5: Design power electronic systems and control systems as per needs and specifications

PO6: Model and simulate signals and systems, control systems and energy systems using modern engineering tools.

PO7: Practice professional ethics and engage in life-long learning.

PO8: Communicate effectively and work in a team using common tools to achieve project objectives.

PO9: Recognize professional and personal responsibility towards the community.

Table 1: Mapping of Course Outcome with PO

ELE 301: Linear Control Theory		
C01	Derive the Transfer function & State space modeling of linear time invariant systems.	PO1,PO4, PO6
C02	Use signal -flow graphs and block diagrams to derive systems input -output relations.	PO1,PO4, PO6
C03	Describe quantitatively the transient response and frequency response of linear time invariant systems.	PO1,PO4, PO6
C04	Determine absolute and relative stability of linear systems.	PO1,PO5, PO6
C05	Design controllers to meet steady state error performance and transient response specifications.	PO1,PO4, PO6

Table 1 shows mapping of control system course with PO where the strength of the correlation is indicated as - strong, moderate, low.

5. Attainment of the POs

Different course delivery methods/modes such as power point presentations, tutorial, lecture combined with simulation and discussion etc. are used to deliver the course and measure the effectiveness of these methods for the attainment of the POs. This may be further justified using the indirect assessment methods such as course-end surveys. Mapping of course outcome with question paper helps to assess the knowledge level, design and analysis content. Table 2 gives the mapping of course outcome with internal examinations, assignment and end semester examinations. Table 3 shows the delivery modes used for linear control theory course.

Table 2: Course Outcome - Direct Assessment Mapping

CO	T1	T2	A1	A2	A3	A4	A5	End Sem. (Regular)
C01	X		X					X
C02	X		X	X				X
C03		X		X	X			X
C04		X			X	X		X
C05						X	X	X

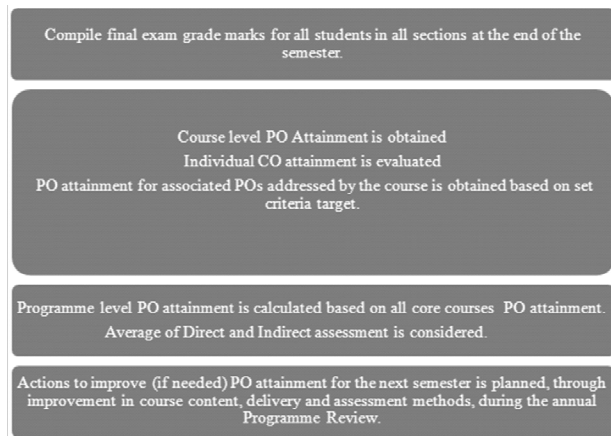
Table 3: Course -Content Delivery Mapping

Board and Chalk	Power Point Presentation	QIEEE/ Video Lectures	Seminars / Mini Project / team based assignments	Tutorial / Problem Sheet	Debate/ Group Discussion Quiz/	simulation / Demonstration	PO's attained
X	X			X	X	X	PO1, PO4, PO5, PO6,

Table 4: Direct and Indirect Assessment Methodology

Direct Assessment	- PO assessment through Course results. - Mapping of course outcome with question paper.
Indirect Assessment	- Course feedback at the end of each course - Graduate survey at the end of the program - Project work (Area of work)

The program outcomes are assessed with the help of course outcomes of the relevant courses by result analysis. Direct measures are provided through direct examinations i.e. through end semester examination grades of the respective courses. End semester grade reflects continuous evaluation including 2 internal tests, assignments and the end semester examination results. Indirect assessment strategies are implemented by embedding them in the course feedback and Graduate survey. Finally, program outcomes are assessed with above mentioned data with respect to the specified target.

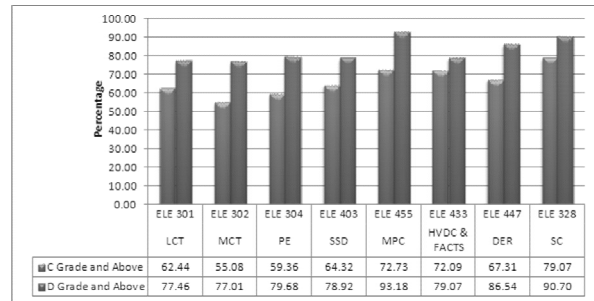
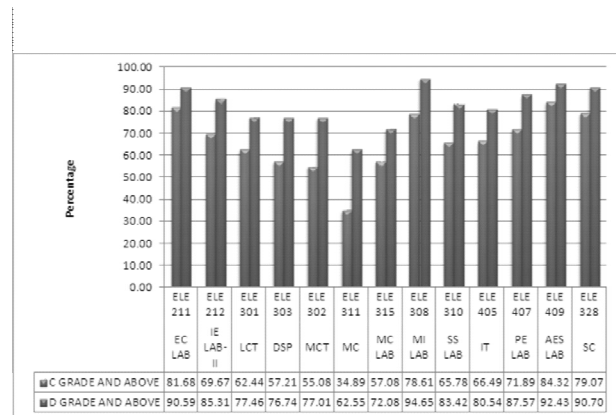
**Fig.3 Process flow chart for PO attainment analysis**

6. Performance Criteria Target

For direct assessment, 65% of students achieve a minimum of grade C in the respective courses. If the percentage of PO attainment is 75% or more taking the average of direct and indirect assessment, the PO is considered as achieved.

Sample Analysis is shown in Fig.4 & Fig.5 to indicate results of Evaluation of PO5 and PO6.

$$\text{Attainment of PO (\%)} \text{ at programme level} = \frac{\text{No of YES (i.e PO is attained by the subject)}}{\text{No of subjects addressing to this PO}} \times 100$$

**Fig.4 Sample Evaluation of PO5****Fig.5 Sample Evaluation of PO6**

7. Indirect Assessment (Graduates Survey)

Table 5: Analysis of Graduate / Exit survey of 2014 passed out students.

Criteria: Above Good is considered as 'YES'.		
75% of samples YES PO is attained.		
1	Solve engineering problems.	PO1, PO2
2	Design a component or process as per needs and specifications.	PO3, PO5
3	Use modern tools to analyze engineering problems.	PO6, PO4
4	Work in a team, carry out multi disciplinary projects.	PO7, PO8, PO9
5	Participate and succeed in competitive exams and higher studies.	PO7

According to the analysis carried out using 88 samples all the POs are attained.

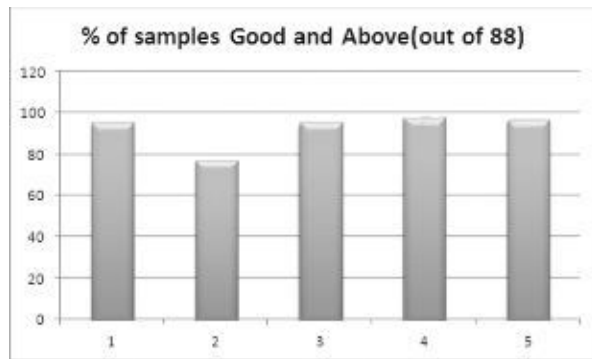


Fig.6: Results of Indirect Assessment

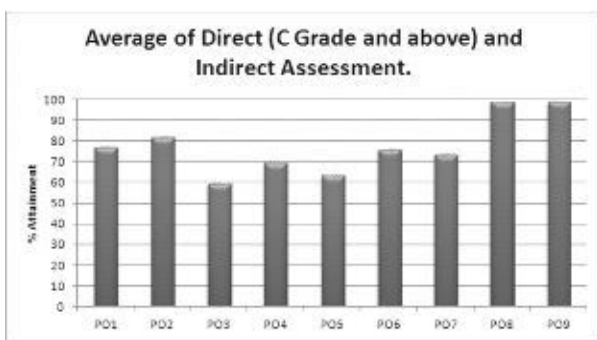


Fig. 7: Average of Direct and Indirect Assessment

8. Course Outcome Assessment:

Table 6: Course End Survey (Indirect Assessment) Analysis

Excellent(E)	Good(G)	Average(A)	Poor(P)	No Comment(NC)
5	4	3	2	1

Question	CO	Survey data		Assessment					CO Assessment Point ≥ 3 , satisfied
		No. of responses	Satisfaction no. ≥ 3 , satisfied	5 E	4 G	3 A	2 P	1 NC	
Q1 How good are you in deriving Transfer function models & State space models of linear time invariant systems.	CO1	175	167	36	77	54	7	1	3.80
Q2 How comfortable are you in using signal-flow graphs and block diagrams to derive systems input-output relations.	CO2	174	170	43	86	41	4	0	3.97

Q3 How well have you understood the concept and significance of the transient response and frequency response of linear time invariant systems?	CO3	175	150	20	54	76	23	2	3.38
Q4 How good are you in determining the absolute and relative stability of linear systems using various graphical methods.	CO4	175	146	27	55	64	24	5	3.43
Q5 How comfortable are you in Designing controllers to meet steady state error performance and transient response specifications.	CO5	174	125	19	30	76	44	5	3.08

Table 7: Result (Direct Assessment) Analysis (November 2014 Exam)

Result Analysis (End Semester Examination November 2014)						
	Qn .1	Qn .2	Qn .3	Qn .4	Qn .5	Qn .6
Question-CO Mapping	CO 1, CO 2	CO 2, CO 3	CO 3, CO 4	CO 4, CO 5	CO 3, CO 4	CO 1, CO 5
Average	5.56	3.74	4.98	3.74	6.17	4.46
Minimum	0	0	0	0	0	0
Maximum	10	6.5	10	10	10	10
No. of students with Excellent Performance (>8) E	30	0	24	17	67	19
No. of students with Good Performance (>6 & <8) G	73	10	38	17	33	15
No. of students with Average Performance (>4 & <6) A	44	85	60	35	29	26
No. of students with Below average Performance (>2 & <4) B	18	52	38	45	24	41
No. of students with Poor Performance (>0 & <2) P	11	20	13	40	18	11
Course outcome Assessment Point = $(5x E + 4x G + 3x A + 2x B + 1x P) / N$ ≥ 3 Satisfied	3.51	2.51	3.13	2.52	3.63	2.91
No. of students attempted the question, N	177	167	173	154	171	112
% Students attempted	99 %	93 %	97 %	86 %	96 %	63 %
No. of students with marks more than or equal to avg.	103	95	93	69	94	44
% students with marks more than or equal to avg.	58 %	53 %	52 %	39 %	53 %	25 %

Table 5 & 6 shows the level of CO attainment. Wherever the course outcome is not attained the faculty coordinator along with fellow teachers should decide upon the action plans to improve the system. In this particular study course end survey as well as course outcome question paper mapping is showing satisfactory attainment of CO's. In order to obtain continuous improvement, set target must be increased and analyze the assessment. The feedback from alumni and industry experts arise the need for the curriculum design with more industry institute interaction and simulation assisted study.

9. Acknowledgement

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10. Conclusion

OBE promotes a continuous quality improvement on the programme based on regular evaluation of the attainment of COs & POs. POs are assessed in general with the result end surveys and COs are assessed through a rigorous process of question to CO attainment. This requires an active role of subject coordinator in deciding sensible question paper pattern to achieve the outcome. Subject coordinator holds a big responsibility of designing the subject curricula to setting up of question paper that can ease the attainment analysis process. All assessments to be implemented in the course (e.g., Assignment, Test, Project, and Final Exam) should be prepared before the beginning of the semester. This is achievable if the subject coordinator has sufficient experience to plan for. Continuous improvement may be implemented by focusing on the issues at hand. However, managing extensive data is time consuming and deters the

commitment of academic members towards effective OBE implementation. An Academic Management System should develop a system that provides standardized CO-PO attainment analysis. Finally, the effectiveness of OBE implementation goes back to the practice of the concerned subject coordinator and institutional facility available

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