

Design and execution of strategies for effective implementation of Outcomes Based Education (OBE) in Engineering

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Abstract: Outcomes based education is at the center of engineering education today. National board of accreditation (NBA) in accordance with Washington accord has laid down the requirements that must be satisfied by engineering graduates in order to make them compatible and acceptable by the world outside. It is learnt that, the effective implementation of Outcomes Based Education (OBE) framework definitely gives fruitful results in the form of attributes that are achieved by graduates passing out from the programme. At the same time, implementation of OBE is a tedious and time consuming exercise. This necessitates that the systematic plan is prepared and implemented to get the intended results after the implementation.

The present paper focuses on the systematic and stepwise plan designed and executed to understand and experience OBE framework. An awareness was

created amongst the students and faculty about OBE framework that includes design of Programme Educational Objectives, Program Outcomes, Course Learning Outcomes, their mapping and assessment procedure. A systematic methodology was developed to ensure system in place for design of formats and for exhaustive collection of required data for attainment of course outcomes, program outcomes and program educational objectives. Attainment of all the courses contributing to POs, attainment of all POs and attainment of PEOs was calculated with appropriate selection and use of direct and indirect assessment tools. Finally, results on level of attainment of CLOs, POs and PEOs are presented to be useful in removing lacunae if any, in curriculum design, delivery of instructions and assessment methods.

Keywords: Outcomes based education, Graduate attributes, Accreditation, Washington accord.

1. Introduction

National Board of Accreditation (NBA) [1] in line with guidelines by ABET expects the engineering graduates to possess eleven attributes to make them eligible to be accepted nationally as well as internationally. These include characteristics such as design of experiments, problem solving skills, working in teams, use of modern tools etc. In order to

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ensure that these attributes are possessed by the engineering graduates, it requires effective implementation of Outcomes Based Education (OBE) that includes establishing Program Outcomes, Program Educational Objectives, Course Learning Outcomes and efforts to achieve the attainment of each of these to the level of satisfaction. Successful implementation of OBE thus needs careful attention to be given to three important aspects of engineering education, namely; design of curriculum, delivery of instructions and assessment strategies. Earlier researches have shown that the process of OBE is evolving with time and there are differences of opinions with regard to its usefulness as reported by Liezel et al. [2] questioning the need of OBE in engineering education. The issues and challenges involved in effective implementation of OBE are also addressed and discussed by N. Rajae et al. [3]. Various models have been presented for implementation of OBE [4,5] and methodology for attainment of COs and POs is presented through work done earlier [6,7]. Rechara Felder et al. [8] has focused on equipping students to achieve the skills and attitudes necessary to achieve the outcomes expected in ABET criteria. Apart from this, skill sets necessary from engineering graduates, gap analysis from this view point and analysis of the same has been reported by Meenakshi et al. [9]. After all, it concludes that, OBE is still not fully understood and implemented and lots of experiments are going on, resulting in an increase in level of understanding as well as awareness about its usefulness. The present work reports efforts taken to systematically plan and execute the strategies to implement OBE in engineering education at Automobile Engineering Department of Rajarambapu Institute of Technology, Rajaramnagar. Originality of the work lies in design and execution of systematic plan to ensure effective implementation of OBE and hence methodology in place to ensure achievement of outcomes in the form of graduate attributes.

2. Design and execution of plan for effective implementation of OBE

Outcomes based education and its implementation is an evolving process and it needs thorough understanding of the concepts at all levels including faculty and students. The participation in an International Conference (ICTIEE-2014) at Hubli and in a two phase workshop on 'Identifying and training master trainers' at WCE, Sangli [10] helped the authors to better understand the concepts and

methodology of OBE. One and half years back, to begin with ground preparation, a plan (Table 1) was designed to ensure proper understanding of the terms in OBE, mapping of outcomes, assessment tools and alike. The successful execution of plan brought clarity about the methodology of OBE right from establishment of POs, PEOs and CLOs to the attainment of each of these as well as correlation between outcomes attained and curriculum design, delivery of instructions and assessment methods.

3. Outcomes and their mapping

Vision and Mission of the department are established so as to map with the Vision and Mission of the institute. Program Educational Objectives (PEOs) are the career and professional achievements of the graduates of the program 3 to 5 years after graduation. Program Outcomes (POs) are the technical and professional skills the program graduates are expected to demonstrate after completion of the program. The basis for establishment of PEOs is Mission of the department and feedback from various stakeholders and that for POs is the graduate attributes expected by NBA as well as its mapping with PEOs. The outcomes (POs, PEOs, CLOs) (Table 2) were established through discussions in the faculty meetings, 4.

Table 1. Plan for effective implementation of OBE

Activities	Date of conduct
1. Sessions for awareness amongst faculty about;	
i) NBA Criterion	Jan. 29, 2014
ii) Bloom's Taxonomy	Jan. 30, 2014
iii) Establishment of PEOs, POs, CLOs and ULOs	Feb. 03, 2014
iv) Mapping of PEOs, POs, CLOs	Feb. 11, 2014
v) Assessment of PEOs and POs	Feb. 17, 2014
2. Interactions with students to create awareness amongst them about PEOs, POs, CLOs and ULOs	Throughout Semester II, 2013-14
3. Exercises	
i) Revisiting Vision, Mission and PEOs	March 03, 2014
ii) Faculty Presentations on CLOs and their Mapping with POs	04, 06 and 11 March 14
iii) Gap Analysis and Revisiting Vision, Mission, PEOs and CLOs again	17, 24 and 31 March 2014
iv) Faculty Presentations on CLOs and their Mapping with POs	09 April, 05 May and 30 July 2014
4. Session on Assessment tools	20 August, 2014
5. DAB meeting to seek inputs on CLOs, POs, PEOs established	22 August, 2014
6. Session on course end survey and presentations by faculty	02 and 16 September 2014
7. Collection of data and attainment calculations for POs, PEOs	06 and 23 Jan., 24 Feb., 02, 03, 10, 11, 16, 18 March 2015
8. Program Exit Survey	20 May, 2015
9. DAB meeting to seek inputs on attainment calculated	September 18, 2015

Table 3 CLOs and their mapping with POs for sample course 'Noise and Vibration'

Course Learning Outcomes (CLOs)	Program Outcomes (POs)											
	a	b	c	d	e	f	g	h	i	j	k	l
Explain basic concepts related to noise and vibrations	H							H		L		
Formulate mathematical model for multi DOF vibration system	H		H		H		L			L		
Select measurement system and appropriate sensor for measurement of vibration in the structures under consideration	H		L							L		H
Select measurement system and appropriate sensor for measurement of noise in the systems under consideration	H		L							L		H
Analyze different automotive and mechanical systems for noise and vibration in them	H		H		H		L			L		H

Table 4 Sample for Courses and their Mapping with POs

Courses	Program Outcomes (POs)											
	a	b	c	d	e	f	g	h	i	j	k	l
AE 407	H		H		H		L			L		H
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4. Assessment Strategies

As POs are to be measured immediately after graduation, assessment of the attainment of POs is contributed by theory and laboratory courses, seminars and projects and co-curricular and extracurricular activities that are part of four year curriculum of the program. Therefore, tools for assessment of attainment include direct tools such as In Semester Evaluation (ISE), Mid Semester Examination (MSE) and End Semester Examination (ESE) and indirect tools such as Course End Surveys (CES). On the other hand, since PEOs are to be measured 3 to 5 years after the graduation, assessment

of attainment of PEOs is to be made with the help of indirect tools in the form of Alumni and Employer surveys. Efforts to achieve good attainment of CLOs of all such courses will directly lead to attainment of POs. Assessment strategies are summarized in Table 5.

Table 5 Details of tools for assessment of attainment of CLOs, POs and PEOs

Type of Outcome	Assessment Tool	Weightage (%)	Freq. of assessment	Responsible person
Course Learning Outcomes (CLOs)	*ISE	16	Half Yearly	Course Teacher
	**MSE	24	Half Yearly	Course Teacher
	+ESE	40	Half Yearly	Course Teacher
Program Outcomes (POs)	++CES	20	Half Yearly	Course Teacher
	#PES	20	Yearly	NBA Coordinator
Program Educational Objectives (PEOs)	POs attainment based on contribution of courses	80	Half Yearly	NBA Coordinator
	Employer Survey	50	Yearly	Department Alumni In charge
* In Semester Evaluation	Alumni Survey	50	Yearly	Department Training and Placement officer

** Mid Semester Examination

+End Semester Examination ++ Course end survey

Program Exit Survey

4.1 Description of Assessment tools

4.1.1 Assessment for attainment of CLOs

i) Course end surveys

Course end surveys are conducted to seek response of the students on a scale of 1 to 5 on the statements designed in line with Course Outcomes of the corresponding course. Course teacher submits comments and action plan on either sustenance or improvement in attainment of CLOs. A sample copy of report on 'analysis and findings' is shown in Table 6 for the course 'Noise and Vibration' for final year B.Tech.

ii) ISE, MSE and ESE

Question papers during Mid Semester and End Semester examination are set considering mapping of each question

Table 6 Report on analysis and findings on course end survey results for Noise and Vibration

Course End Survey

Report on Analysis and Findings

Course and Course Code : Noise and Vibration (AE 407)

Class and Branch : B.Tech. (Auto.) Semester : VII

Day and Date of Survey : Thursday, October 16, 2014

Total strength : 35 No. of students participated : 29

Expected Outcomes	Total score (145)	% attainment	Course teacher's comment	Plan of action
Explain basic concepts related to noise and vibrations	137	94.48	Attainment is excellent and is due to emphasis on experiential learning.	The efforts would be continued to achieve same level of attainment.
Formulate mathematical model for multi degree of freedom vibration system	122	84.13	Attainment is very good and is the effect of innovative assignment given, including mathematical modeling of real life vibrating systems.	Actual automotive problems would be introduced to model them mathematically to take the attainment to excellent level.
Select measurement system and appropriate sensor for measurement of vibration in the structures under consideration	111	76.55	Attainment is satisfactory and is the result of experiential learning with hands on experience on measurement system.	Lacunae, though very few, would be identified and practice of experiential learning would be continued.
Select measurement system and appropriate sensor for measurement of noise in the systems under consideration	106	73.10	Attainment is satisfactory and is the result of experiential learning that is made possible with hands on experience on noise measurement system.	Number of exercises covering actual noise measurement were limited. So, more such exercises will be given to ensure ease in selecting systems.
Analyze different automotive and mechanical systems for noise and vibration in them	112	77.24	Attainment is satisfactory and attributed to innovative assignment involving use of research papers.	Lacunae, though very few, would be identified and practice of experiential learning would be continued.

Course Teacher

Chairman, B.O.S.

with CLOs (Table 7) of the corresponding course and average of marks secured by all the students for each question is used to calculate percentage attainment of CLOs based on performance of the students during ISE, MSE and ESE. The procedure is then repeated for all the courses to calculate attainment of CLOs through examination results.

4.1.2 Assessment for attainment of POs

i) Program Exit Survey

Survey of graduates at the end of their program in final year was conducted to seek their responses on a scale of 1 to 5 on the statements designed in line with the Program Outcomes. The average of points scored for each of the twelve POs is indication of percentage attainment of each of the POs.

ii) Attainment of POs based on contribution of courses

Mapping of every CLO of every course to POs and attainment of each of these CLOs once known will help to know attainment of the course itself. As shown in Table 4, status of mapping of each course to POs is also known to help in calculating attainment of POs based on type of correlation; strong or weak.

4.1.3 Assessment for attainment of PEOs

Since the attainment is possible to be measured only after three to five years after graduation, assessment of Program Educational Objectives is done using indirect assessment tools. Therefore, surveys are designed and conducted to seek responses of the alumni, and employers with whom alumni of the concerned graduated batch are working.

i) Alumni Survey

Alumni is expected to apply the knowledge gained in the field of automotive engineering to successfully complete the assignments, being either an entrepreneur or an engineer serving the society or an industry. The responses, if sought on how this knowledge helped him to be successful in his assignments, make the picture clear about the attainment of concerned PEOs.

Table 7 Sample showing mapping of questions with CLOs

Question No.		Level(Bloom's Taxonomy)	Max. Marks	CLO's Mapped
1	a	3	10	2
	b	3	10	2
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ii) Employer Survey

Employers have their own expectations about performance of the graduates that they are recruiting, for the completion of the tasks assigned to them. The responses are obtained from these employers on their expectations and actual performance of the graduates working with them. This provides useful information on where our students are and hence level of attainment of the related PEOs.

5. Attainment Results

Results for level of attainment of CLOs for every course contributing towards attainment of POs are obtained after collection of exhaustive data and by applying systematic methodology mentioned earlier. Though the institute is 30 years old, it was under university pattern and only started practicing OBE in recent years when entered into autonomous status in 2011. Therefore, targets set for attainment of POs and PEOs are 65 % and 60 % respectively. Results for level of attainment of POs are obtained after considering contribution of each of the courses in terms of attainment and analysis of the surveys conducted. Figures 1, 2 and 3 shows CLO attainment for sample course 'Noise and Vibration', POs attainment and PEOs attainment respectively

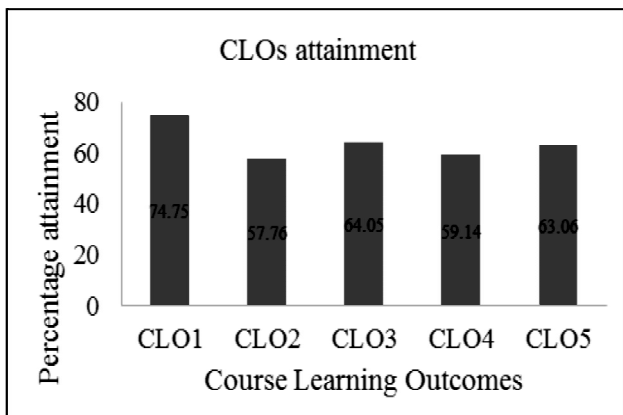


Fig. 1 Attainment of CLOs for 'Noise and Vibration'

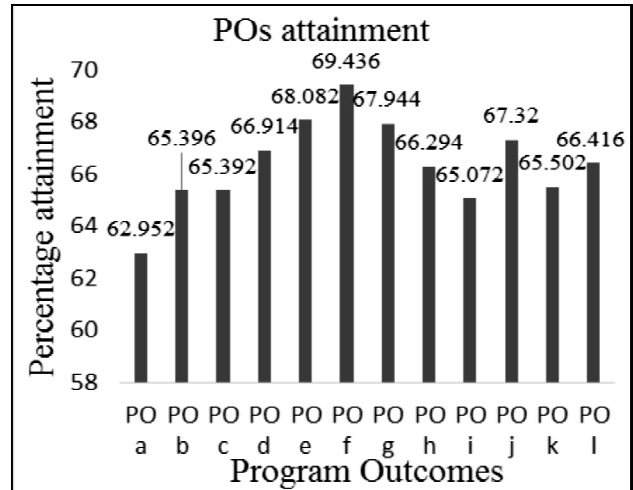


Fig. 2 Attainment of Program Outcomes (POs)

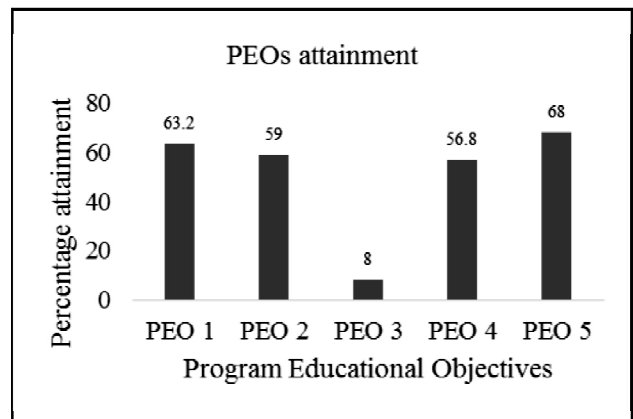


Fig. 3 Attainment of Program Educational Objectives (PEOs)

The results for PEOs are obtained after analysis of the Alumni and Employer surveys conducted. The results of attainment of CLOs, POs and PEOs suggests the steps to be taken at curriculum design, delivery of instruction and assessment stages as appropriate. As courses are directly contributing towards attainment of POs, course owners are asked to prepare action plan (Table 6) in order to improve attainment status if not up to the mark. Improvement in curriculum during annual curriculum revision process is based on attainment inputs from attainment results for POs and PEOs along with inputs from various stakeholders. Results shows scope for improvement with regard to some of the POs and PEOs, emphasizes necessity to revisit the strategies and highlights the need for refinement of few PEOs.

6. Issues and Challenges

Though awareness and clarity about OBE is improving with time, still, there are several challenges in design and implementation of OBE. These are;

1. Education and awareness amongst faculty members about OBE is not that great.
2. Volume of data necessary to conclude on outcomes is too much including mapping of everything to outcomes and all achievements of students including performance in curricular and extra-curricular activities.
3. Though outcomes are really fruitful, amount of time and efforts are proportionally more.
4. The concept of OBE does not provide any specific procedure on how to achieve the outcomes.
5. The assessment of professional POs is not as straightforward as technical ones and involves subjectivity.
6. Indirect assessment, which is not avoidable in some of the cases, generally results in higher points for attainment of outcomes.
7. Alumni and Employer surveys which are indirect tools for assessment of PEOs, are a challenge to conduct due to slow response of the respondents due to their busy schedule.

6. Conclusions

An exhaustive study was carried out to understand, plan and implement Outcomes Based Education framework in engineering education. A mechanism was developed to design and install a system in place to collect all the data and facts necessary to know level of attainment of course and program outcomes as well as program educational objectives. OBE is an evolving process and therefore a developed system in place will make the cumbersome task of OBE comparatively easier for future operations. Authors reached to a conclusion that practicing outcomes based education in engineering is extremely useful as it gives a logical base for improvements in curriculum design, delivery of instructions and assessment strategies. OBE helps to systematically focus on achieving attributes that graduates should possess in order to make them competent in technical as well as professional skills. At the same time, it was concluded that unless it is well planned and executed and system in place, it is really a cumbersome task to implement OBE and get fruitful results. To bring ease in the task at least to certain extent, instead of exhaustive data collection, by adhering to principles of statistics, sample data should be used for attainment calculations to save volume of data, time and efforts towards implementation of OBE. Further, results of attainment of POs and PEOs have given direction to

revisit the strategies for curriculum design, delivery and assessment. Appropriate actions based on analysis of the results of attainment of CLOs, POs and PEOs are taken to improve acceptance of the graduates in terms of attributes that they possess.

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