A dynamic approach to outcomes based education in engineering curriculum

Chockalingam Aravind VAITHILINGAM
UCSI University
Kuala Lumpur, Malaysia
aravind_147@yahoo.com

Rajparthiban RAJKUMAR
Taylors University
Selangor, Malaysia
rajparthibankumar.rajkumar2@taylors.edu.my

ABSTRACT

Changes in the curriculum of Engineering programs have been an on-going need to be addressed and practiced by the university to consistently generate well groomed learners suitable for industry. The high demand of industry on their potential employees with good technical competence and professional skills continuously drive the need for change. The conventional role of the university as a learning centre has been transformed to fill the increasing pressure from employers to generate competent graduates. Outcome Based Education (OBE) is a method of teaching that focuses on what attributes the learners are able to show as they graduate. All curriculum and teaching decisions are made based on the goal of accomplishing the desired outcomes. This leads to a reverse in the traditional process of educational planning. The desired outcomes are selected first and the curriculum is designed then to support the intended outcome. The awareness of OBE by members of institutions of higher learning has tremendously improved over the years, and the academics are increasingly becoming accustomed to it. However, assessment of OBE in the curriculum is always a challenging task as institutions of higher learning lack proper assessment model. This paper attempts to articulate the merits and implications of OBE with a continous quality assessment cycle and propose two straegic tools that would help to achieve the key attributes.

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Keywords: *Outcomes Based Education, Engineering Curriculum, Employability, Assessment strategy*

INTRODUCTION

The Washington Accord is an international accreditation agreement signed in 1989 for professional engineering degree programs. This grants recognition of graduates from accredited programs. In Malaysia, the OBE implementation in engineering programs is mandatory for obtaining accreditation from the Engineering Accreditation Council (EAC) (EAC Manual, 2000). The need for OBE arose due to the fact that the locally trained graduates have strong technical skills but lacked in professional skills. The Malaysia Engineering Education Model (MEEM) (Megat Et.al, 2004) (Aziz Et.al, 2005) was introduced to improve on graduates' skill sets, and incorporates a much more dynamic approach as seen in other educational model globally. This led to the introduction of graduate attributes by the EAC as a move towards implementing OBE and become compulsory requirement for all engineering programs to move Malaysia towards permanent membership in the Washington Accord (EAC Manual, 2000). The awareness of OBE by members of the institutions of higher learning has gained momentum over the years, and increasingly many new academicians are now accustomed to it. Many universities have sinced embraced the OBE model and have taken steps to make change in their core areas like curriculum development, assessment startegies, and delivery methods (Megat Et. Al, 2004). However, the difficulty faced by these universities in adopting OBE lay not in the curriculum development and program assessment methods but rather in evaluation of the result for the changes required. Unlike previous models, which rely on quantitative results, most of the data gathered in OBE implementation are inherently qualitative, hence making assessment of OBE a task of utmost difficulty (Aravind Et.Al,2008). This paper presents a dynamic OBE model and articulates the merits by proposing dynamic strategy tool for assessment and evaluation.

FRAMEWORK OF OBE

OBE is an education system designed based on predetermined objectives and learning outcomes. This requires a dynamic teaching and learning system that implements closed loop Continual Quality Improvement (CQI) through an adaptive model (Petar, 2005). However the initial challenge is to classify the skills and to link the components of the OBE setup to formulate the various assessment strategies. Outcomes Based Education focuses on learning by:

(i) defining intended Learning Outcomes (LOs) to make explicit what the leaner is expected to be able to know, understand or perform
(ii) defining learning activities that assists the learner to achieve the LOs
(iii) assessing the extent of learner achievement of LOs through the use of explicit assessment criteria

Figure 1 shows the typical framework of the OBE model proposed in this paper.

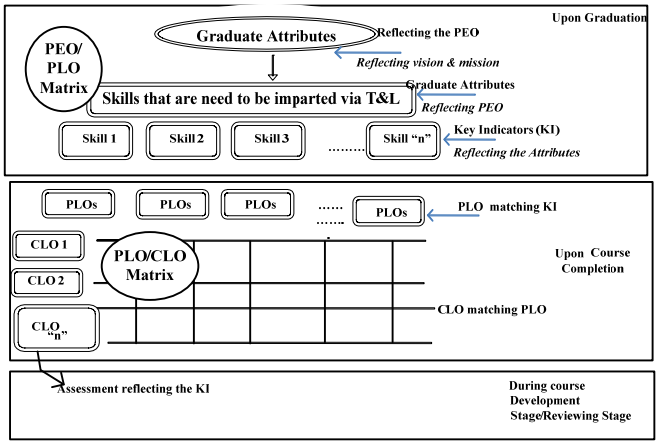

Figure 1: Stages/levels in OBE.

Refer to Figure 1 the graduate attributes are predefined with identification of the skills that need to be nurtured at the university. The skills can be categorised as general (reflecting reliability, integrity & teamwork) and specific (enterprenuership, communication & ability to use modern tools and techniques).

STRUCTURAL DESIGN

OBE is implemented using a backward approach with the graduate attributes defined as the Program Education Objectives (PEO). Program Learning Outcomes (PLO) is then defined in line with the PEO. Finally the Course Learning Outcomes (CLO) of each module is formulated to cover the PLO. The objectives are then assessed at various point of the leaner's progress.

(a) Program Education Objectives (PEO)

Program Education Objectives (PEO) is used to classify the skills that need to be imparted into the leaner. Each of the skills has a number of criteria that is used to evaluate the model as Program Learning Outcome (PLO). Table 1 shows a model PEO matrix designed defining the key indicators. Table 2 shows the matrix the PEO- PLO matrix mapping representation that are rated as A (strongly), B (moderately) and C (slightly related) in a way for correlations**.**

Table 1: PLO-PEO Model.

Program Learning Outcomes (PLO)	Program Educational Objectives (PEO)			
	PEO 1	PEO 2	PEO 3	PEO 4
Key Indicators (Graduate Attributes)	Skill 1 & Skill 4	Skill 2 & Skill 3	Skill 3 & Skill 4	Skill 1 & Skill 2

Table 2: Model PEO-PLO Matrix Mapping.

Program Educational Objectives (PEO)	Program Learning Outcomes (PLO)										
	Skill Set 1			Skill Set 2			Skill Set 3		Skill Set 4		
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11
PEO 1	A	B	A	A	B	A		A	B		
PEO 2	A		A	A	A	B	C	A	B	C	B
PEO 3						A	B				C
PEO 4	B	B	C	C	B	B		C	B	C	

Keys: A: Strongly related B: Moderately related C: Slightly related

The assessment feedback from the lectures, group tutorials, laboratory works, seminars and e-forums, directed and self learning and industrial visits are some of the tools that can be used for evaluating the system.

(b) Program Learning Outcomes (PLO)

Table 3 shows a generalized model for the PLO table. For each PLO defined, the relative teaching and learning, as well as assessment methods are to be clearly defined.

Table 3: Model Key Attributes-PLO Mapping Model.

Key Indicator	PLO	Teaching & Learning	Assessment Methods
Skill 1	PLO1, PLO2 & PLO3	Acquisition of knowledge through lectures and associated problem solving/practical sessions to reinforce the lecture contents. There is some directed learning through project work at varying degrees of complexity as the leaner progresses	Through examinations, assignments & laboratory reports
Skill 2	---	---	---
Skill 3	---	----	---
Skill 4	---	----	---

To further ensure a clear correlation between the PEO and the CLO, relationships between the PLO criteria and the CLO of each module are defined.

(c) Course Learning Outcomes (CLO)

Table 4 shows a model CLO-PLO matrix mapping the correlation of each module with the CLOs. The CLO of each module must comprehensively cover all areas of PEO.

Table 4: CLO-PLO Matrix Mapping.

Course Module	Course Learning Outcome (CLO)	Program Learning Outcomes (PLO)											
		Skill Set 1			Skill Set 2			Skill Set 3		Skill Set 4			
		PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	
XX "1"	**CLO 1**	A	B	A	A	B	A		A	B			
	CLO 2	A		A	A	A	B	C	A	B	C	B	
	CLO 3						A	B				C	
	CLO 4	B	A	A	A	B	B		C	B	C		
XX "2"	**CLO 1**	A	B	B	C	C	B	B	A	A	A	B	
	CLO 2	A		A	A	A	B	C	A	B	C	B	
	CLO 3						A	B				C	
	CLO 4	B	B	C	C	B	B		C	B	C		
XX "n"	**CLO 1**	A	B	A	A	A	B		A	B			
	CLO 2	A		A	A	A	B	C	A	A	A	B	
	CLO 3	A	A	A	B		A	B				C	
	CLO 4	B	B	C	C	B	B		C	B	C		

Keys: A: Strongly related B: Moderately related C: Slightly related

ASSESSMENT STRATEGY

Defining the PEO, PLO and CLO are the more straightforward tasks in OBE implementation. The intricate task of OBE implementation is the linking of the PEO, PLO, CLO and the continuous review of the programs.

(a) CLO Achievement Strategy

Similar to previous educational models, which rely on quantitative outcomes to measure leaner level of achievement the OBE model here quantifies the achievement of CLO through its assessments. To ensure that intended CLO are met, after the delivery of each course, the course lecturer performs the preliminary assessment of the learners' level of achievement based on the assessment strategies and by the course work evaluation. A model CLO assessment matrix is shown in Table 5.

Table 5: CLO Assessment Model.

Assessment/CLO		CLO1	CLO2	CLO3	CLO4
Assessment 1	Q1				
	Q2				
Assessment 2	Q1				
	Q2				
	Q3				
Assessment 3	Exp 1				
	Exp 2				

Keys: Q: Questions (from tests &exams) Exp: Experiments (from laboratory)

Each assessment is broken down to its question level and mapped to the CLOs. The score of the assessment is obtained from individual leaner marks weighted over that particular assessment component. This indicates the percentage of the CLO achievement. Table 6 shows the achievement of CLO over a range of learners in a particular course.

Table 6: Course Evaluation Report.

Course Evaluation (Learner Details)	Assessment 1		Assessment 2			Assessment 3	
	20%		10%			10%	
	Q1	Q2	Q1	Q2	Q3	Exp1	Exp2
XXXXXXX							
XXXXXXX							
XXXXXXX							
Average %							

The course evaluation report will serve as quantitative indicators for the achievement of the CLO, which are then linked to the overall PLO achievement.

(b) PLO Achievement Strategy

Table 7 shows the overall quantitative achievement of PLO through the CLO achievement from Table 5 and Table 6. This indicates the percentage achievement throughout the whole four year program and reflects the strength of the particular component. Together with the qualitative indicators, it furthers strengthens the OBE model. The ultimate goal that steers the efforts of the continuous review is to produce graduates with key attributes in them. To achieve consistent results in the OBE review process, it is essential to have a dynamic assessment tool. This would ensure that graduates have skills relevant to the requirements of the work force.

Table 7: PLO-CLO Correlation Achievement Model.

CLO/ PLO		PLO										
		Skill Set 1			Skill Set 2			Skill Set 3		Skill Set 4		
		PLO1	PLO2	PLO3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11
Module 1	CLO1											
	CLO2											
	CLO3											
	CLO4											
Module 2	CLO1											
	CLO2											
	CLO3											
	CLO4											
Module "n"	CLO1											
	CLO2											
	CLO3											
	CLO4											

Figure 2 shows the likely assessment methodology and process involved in the PLO review. Revision to the PLO can be performed by analyzing commonly available data such as course evaluation and feedback from learners, staff, external examiners, and the EAC.

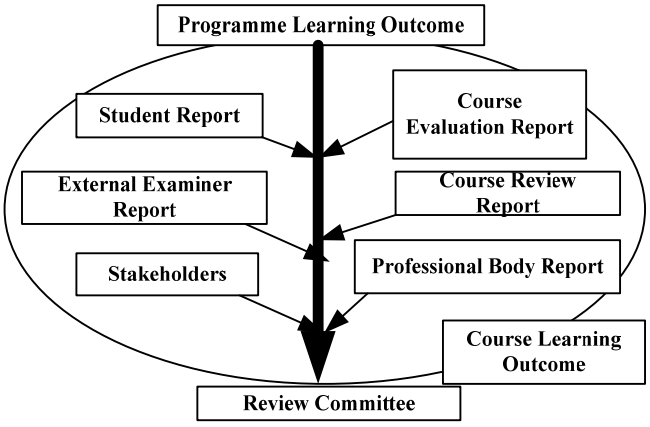

Figure 2: PLO assessment strategy.

(c) PEO Achievement Strategy

Figure 3 summarizes the PEO assessment process implemented using the OBE strategy. Graduate attributes are assessed by way of feedback from employers, industry boards, external examiners. The compiled data are utilized in the review of PEO and CLO for a more dynamic approach to OBE.

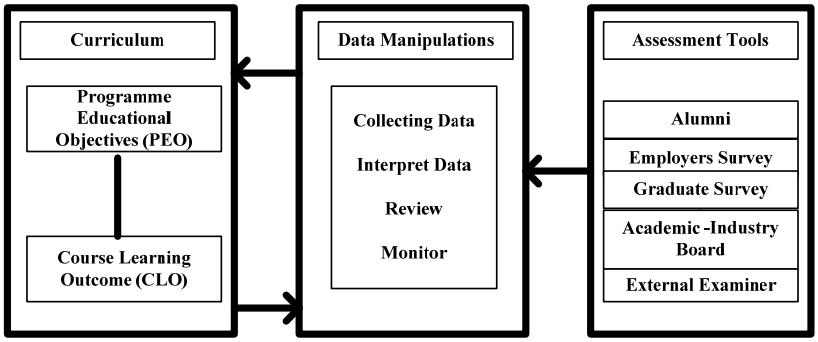

Figure 3: PEO assessment strategy.

KEY ASPECTS FOR A DYNAMIC OBE MODEL

OBE is profound to be of dynamic in nature with a continuous monitoring and assessment. The main objective of OBE is to produce measurable results that can be continuously improved. As presented in the earlier section, the CLO achievement for each module, can then be tabulated and for each PLO to obtain an overall achievement score. This score indicates percentage achievement of PLO. If the PLO achievement does not meet the intended target, the root cause can be traced easily and using the other PLO assessment methods like leaner's feedback, and external examiner etc, a corrective action be proposed for making the model more dynamic. Figure 4 shows the OBE measurement model.

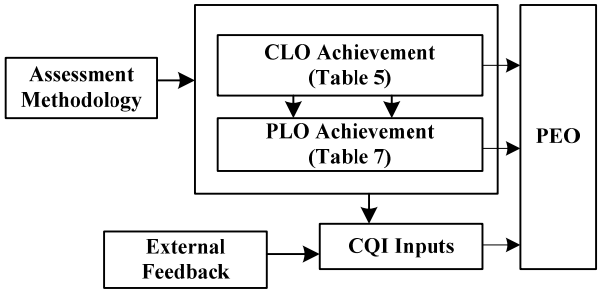

Figure 4: OBE Measurement Model.

(1) Industrial Attachments

In a typical engineering program learners are required to complete industrial attachment program for a particular duration during the course of their study at the university. This allows an adequate length for training in the engineering field for learners to experience the link between the classroom theories with industrial practice. This would help the graduates to develop transferable skills demonstrating effective communication skills, and apply their research skills in understanding the needs and objectives of the employer. Learners' exposure to industry brings the awareness of the Codes of Practice (COP) and ethics in work place, in relation to the roles and responsibilities of an engineer towards the social and environmental contexts. Professional skills such as interpersonal skills and time management are also nurtured during such attachments. This helps the leaner to become professional engineers who can think critically and independently for solving real world problems (Aravind Et.Al 2008).

(2) Academic-Industry Board (AIB)

An Academic Industry Board (AIB) comprising of members of industry, faculty mentors, learners and potential employers is another way to draw in the continuous quality improvement in the OBE setup. An AIB facilitates the interaction between the university, industry and the community at large. Collaborative programs such as outreach programs, leaner internships and employment, staff involvement with professional societies for joint ventures in research and sponsored projects. In a typical teaching-learning system model the AIB plays a significant role in contributing to the development and improvement of the overall curriculum of the various engineering programs promoting the development of graduates who progress to be highly employable graduates (Aravind Et.Al 2008).

CONCLUSIONS

A typical OBE framework, the structural components, the assessment methodology along with two major key aspects for enhancing the graduate's employability is presented. The continuous assessment through feedbacks from industrial attachments and the academic industry board role would give a good platform for curriculum continuous improvement towards employability of graduates. Members of the academic industry board diverse the expertise in technical field that would allow for consistent enhancement of the curriculum towards achieving the set graduate attributes. However it is arguable that the assessment tools proposed is not quantifiable, the result is indeed qualitative in nature as expected of an OBE system (Aravind Et.al 2008). It would nevertheless give a rough indication of performance improvement towards achieving the target set by the key indicator, the employability of the learners.

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