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Education Reform Model at Faculty of Mechanical Engineering, Universiti Malaysia Pahang

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***Abstract* - This paper presents the implementation of education reform model namely outcome-based education (OBE) in terms of course delivery, assessment, evaluation and continuous quality improvement (CQI) at the Faculty of Mechanical Engineering, Universiti Malaysia Pahang (UMP). It was formalized based on the quality management system principle which is formulated its philosophy on OBE as well as on teaching and learning to facilitate the implementation. Board of External Examiner (BEE), Board of Industry Advisor (BIA) and Board of Stakeholders (BOS) are engaged for the third party review on the faculty vision, mission, curriculum, and assessment. The aspects of delivery, assessment and evaluation are discussed.**

***Index Terms*: Outcome based education, quality management system, teaching and learning**

I. INTRODUCTION

Teaching and learning is a process of delivery and receiving the knowledge. The traditional teaching and learning is base on one way flow from lecturer to student. It's resulted less communication and feedback by student to lecturer and by lecturer back to student. The proponents view outcome based education as a valuable replacement of the traditional model of relative ranking by ability and getting credit for merely sitting through class. Felder and Brent [1] finding that the main concern of OBE is about defining the proper outcomes based on the needs of the stakeholders and taking whatever actions necessary to achieve it. There are no hard and fast rules on what must be done. Although there are references on what should be done. Liberal politicians often support OBE because of its vision of high standards for all groups. The conservatives like the idea of measuring outputs rather than inputs (such as money spent or number of hours of lecture given) and insisting that student demonstrate learning rather than just showing up. According to Mohamed *et. al.* [2], active learning promotes students become actively involved in classroom, and collaborative learning enhancing on students working in pairs or groups, the cooperative learning emphasis on getting students to work together in a structured group activity to accomplish a common goal, under the condition that involve interdependence (all member must cooperate to complete the task) including individual and group accountability to complete the final outcome. Aziz *et. al.* [3] and Basri *et. al.* [4], state that outcome-based methods have been successfully adopted in significant ways in the United States, Australia, South Africa, Hong Kong, and other countries. The OBE implementation plan was first mooted when Malaysia signed in as a provisional member of the Washington Accord through the EAC in 2003.

Board of Engineers Malaysia (BEM) thru Engineering Accreditation Council (EAC) has directed that Outcome-Based Education (OBE) learning approach is to be adopted in engineering academic programs in Malaysia. According to Acharya [5], OBE is a method of curriculum design and teaching that focuses on what students can actually do after they are taught. Furthermore, OBE recognizes that a complex organization is more likely to produce what it measures, and to downplay anything it considers unimportant. The adoption of measurable standards is seen as a means of ensuring that the content and skills covered by the standards will be a high priority in the education of students. OBE is a system of CQI to meet the needs of the stakeholder and EAC requirements. Observation made by Nagaletchumi *et. al.* [6], showing that the survey results of Academic Year 2007/08, Semester 2 (Universiti Tenaga Nasional) show that, OBE has had a positive impact on the teaching and learning process.

The standards-based education movement rejects social promotion and the inevitability of inferior performance by disadvantaged groups. Finding by Ark [7], shows that while recognizing that some students will learn certain material faster than others, the standards movement rejects the idea that only a few can succeed. All students are capable of continuous improvement. The opportunities that were previously afforded to those at the top of a bell curve are opened up to the diversity of all students, in a democratic vision, sometimes connected to social justice. Aman and Roseleena [8] find that Outcome Based Education is an approach to education in which the curriculum development designs are driven by the outcomes of what the students should display by the end of the course. While Mohamad *et. al* [9], claim that the measurement of the outcomes is one of the most challenging aspects of OBE and Spady [10] find that OBE also urges schools to generate "exit outcomes" based on the challenges and opportunities that students will face after graduation, and then to "design down" from the outcomes for all other aspects of educational delivery. There have been rapid changes in the technologies and consequently the needs and expectations of the industrial sectors of graduates from engineering university. Leonard and Nault [11] and Doepker [12] find that assessment of the engineering programs by the various parties is an essential activity in the process of continuous program development. This is also in line with Al-Baski [13] which is claim that the assessment of the programs by senior students immediately prior to their graduation, by means of senior exit surveys, is one of the key tools for the development process. Same to the conclusion made by Sani *et. al.* [14] which claims that survey was found to be an essential tool which can be for CQI.

EAC Self Assessment Report Submission to BEM by Faculty of Mechanical Engineering, Universiti Malaysia Pahang [15] stated that in 2002, UMP established its vision and mission. The university revised

its vision and mission statement to account for the surge of activities and development, both academic and with regard to research experiencing and world environment. The reflection was necessary as UMP is still at its initial stage of forming its own identity. The vision of the university is to be one of the world-class competency-based technical universities for its achievements and the mission is to provide the highest quality technical education exceeding the expectations of their stakeholders by offering excellent academic programs through the conducive environment that encourages creativity and innovativeness. The philosophy of the university is knowledge which is trust given by Allah to man, as vicegerent on earth, to be utilized. The emphasis is on applied knowledge and its applications, founded on exemplary morals, and are able to create a person who will contribute to universal harmony and prosperity. The Faculty of Mechanical Engineering vision is to become a world class competency-based mechanical engineering faculty and the mission is dedicated to produce global mechanical engineers with high level of knowledge, lifelong learning capability, competency and integrity. Moreover, the faculty are committed to enhance research and development towards introducing commercially viable products and services in manufacturing and automotive sectors. To produce good engineer, the effort of the student and lecturer must be good. According to K.Kadirgama *et. al.* [16] In order to have good graduate engineer the foundation must be very strong, if the students want to perform better in final year subjects. Freedmen [17] write that pre-requisite means course required as preparation for entry into a more advanced academic course or program.

Adam [18] claim that at its most basic level, OBE is where the school and community first determine what skills and knowledge students should possess upon graduation, then work backwards from there to develop curriculum, strategies and materials to help students achieve those goals, or "exit outcomes". Generally, in OBE learning, all educational programs and instructional efforts are designed to have produced specific, lasting results in students by the time they leave school. Schools that have successfully implemented OBE program which described auspicious results. According to Briggs [19], Alhambra High School in Phoenix, Arizona, reported significant improvements in attitude and performance by both students and teachers within the first year and Brown [20] claim that after four years of OBE, the Sparta School District in Illinois achieved radical gains in grades and test scores in spite of its previous financial and labour problems. On the other hand, Neir [21] wrote that the "student-centered" educational approach is focused on course "outcomes" consisting of a list of skills and knowledge in which the students are coached to master and able to demonstrate upon completion of the course. While Malan [22] claim that these learning outcomes are designed to inculcate a platform for life-long learning and they are finally assessed in terms of set learning objectives. Based on the EAC requirement for the implementation of Outcome Based Education (OBE) in all engineering programs, the Faculty of Mechanical Engineering, UMP had taken initiatives to revise its curriculums. The revised curriculum for student intake of July 2006/2007, the students who registered for semester July 2006/2007 onward were taught and assessed according to OBE principles. EAC 2007 Manual Book [23] stated that this is applying to newly registered and current student which is in year 2, 3 and 4. While Kamsiah et. al [24] proposed that curriculum should have a powerful impact on student learning as the design sequence beginning from the first year will have an impact on the cumulative building process of engineering and design skills.

II. BASIC IN THE IMPLEMENTATION OF OBE

Implementation of OBE started with vision and mission of the university which later translate to vision and mission of the faculty or academic department. From the vision and mission of the faculty, Program Educational Objectives (PEO) and Program Outcomes (PO) were developed and map to teaching plan thru Course Outcome (CO). The first challenge in the outcome-based education at the faculty of mechanical engineering is to PEO and PO, which is meet the requirement and have the ability to be accessed and evaluated in every course (subject) thru CO. EAC Self Assessment Report Submission to BEM by Faculty of Mechanical Engineering, Universiti Malaysia Pahang [15] listed the Program Educational Objectives and Program Outcomes as shown below:

1. Programme Objective 01 (PEO1): Global Engineers, Become competent mechanical engineers that view engineering as a profession with extensive global interactions.
2. Programme Objective 02 (PEO2): High Level of Knowledge, Able to apply engineering principles with an ability to adapt the changes in latest tools in the design, analysis and synthesis of engineering system.
3. Programme Objective 03 (PEO3): Integrity, Aware and practice professionalism and responsible in conducting their careers.
4. Programme Objective 04 (PEO4): Competency and Learning Capability, Competence in communication skill and able to work in team with the ability to continue and expand learning necessary.

Program outcomes are specific statements of graduates' knowledge, skills and attitudes that are evidences in the programme objective achievements. According to the EAC thru Engineering Programme Accreditation Manual 2006 by BEM [25], there are 10 outcomes that the students should display by the end of their engineering study. EAC Self Assessment Report Submission to BEM by Faculty of Mechanical Engineering, Universiti Malaysia Pahang [15] stated that consistent with world-class mechanical engineering programme, the faculty had adopted 12 generic program outcomes for all its Bachelor of Mechanical Engineering programmes addresses the minimum requirements by EAC and Ministry of Higher Education, Malaysia. All the graduates of the Faculty of Mechanical Engineering, UMP are expected of all graduates receiving the bachelor degree in mechanical engineering. The program outcomes are listed in the Table 1 below.

The program outcomes are developed through a comprehensive curriculum design and application of appropriate teaching methodologies and strategies. Mohammed *et. al.* [26] wrote that the implementation of OBE requires practicing successful strategies in teaching

through cooperative learning which covers homework assignments, laboratory experiments and design projects. Felder and Brent [27] finding claim that we also have set-up a guideline for teaching philosophy and any students can be taught almost anything. PEO and PO must have direct relations and the relationships between these program outcomes and the Program Educational Objectives are given in Table 1. The faculty articulated a set of strategies for achieving these program outcomes. Table 2 are listed the strategies for achieving the program outcomes. Once the program educational objectives and program outcomes are finalized, faculty members are developed the course contents with related course outcomes. The course outcomes that were formulated for each course, address part or all of the stated program outcomes. All of these outcomes are categorized into three main domains including the Cognitive, Psychomotor and Affective domains.

Domain of taxonomy that needs to be assessed may vary from courses to courses. Each course within a program addresses each of the domains with appropriate taxonomy level which referred to as different level of attainment for each domain. This should have been earlier identified and decided during the coordination and harmonization at the program level. Table 3 shows the levels of taxonomy in each domain, which has been categorized into level 1 - Basic; 2 - Intermediate; and 3 - Advanced with related PO's addressing each domain.

Table 1: Mapping between Programme Educational Objectives (PEO) and Programme Outcomes (PO)

	Programme Outcomes	PEO			
		1	2	3	4
a	An ability to apply fundamental knowledge of mathematics, science, and mechanical engineering		√		
b	An ability to design and conduct experiments for thermal, fluid and mechanical systems, as well as to analyze and interpret results		√		
c	An ability to design a system, component, or process to meet desired needs include costing, manufacturability, environmental, societal, ethical, sustainability and other constraints.		√		
d	An ability to functions as a successful team member on multi-tasking and multi-disciplinary issues.	√			√
e	An ability to identify, formulate, and solve well-defined and open-ended mechanical engineering problems		√		
f	An ability to understand and practice professional and ethical responsibilities.	√		√	√
g	An ability to communicate effectively.	√			√
h	An ability to recognize and apply knowledge to solve mechanical engineering issues in a global, economic, environmental, and societal context	√	√		
i	An ability to recognize the needs and motivation to engage in life-long learning				√
j	An ability to apply knowledge of current and contemporary issues.	√		√	√
k	An ability to use the techniques, skills and modern engineering tools necessary for mechanical engineering practice.		√		√
l	An ability to acquire entrepreneurship knowledge.	√	√		

Table 2: Strategies for achieving the program outcomes

No.	Strategies for improving PO
1	To teach effectively courses whose objectives support the PO
2	To offer seminars, lectures and specific events which broaden students' perspective and enhance their professional development
3	To provide an infrastructure that effectively supports and enhance academic and research programs
4	To seek input from others on issue related to curriculum content
5	To advise and council students effectively on academic and to some extent, career options
6	To encourage student participation in organizations, particularly student chapters of national and international professional societies
7	To encourage student participation academic and technical competitions
8	To encourage student participation in undergraduate research activity

Table 3: Levels of taxonomy in each domain

Level/Domain	**Cognitive/Knowledge (K)**	**Psychomotor/Skills (S)**	**Affective/Attitude (A)**
1 – Basic	1 - Knowledge 2 - Comprehension	1 - Perception 2 - Set	1 - Receiving 2 - Responding
2 – Intermediate	3 - Application 4 - Analysis	3 - Guided Response 4 - Mechanism	3 - Valuing 4 - Organisation
3 – Advanced	5 - Synthesis 6 - Evaluation	5 - Complex Response 6 - Adaptation 7 - Origination	5 - Characterisation
Program Outcomes	PO-a , PO-c , PO-e , PO-f , PO-h & PO-j	PO-b and PO-k	PO-d , PO-g and PO-i

The flowchart illustrated in Figure 1 summarizes the procedure that explains in general of the OBE-CQI process in teaching and learning. Starting with coordinate

PO for the semester for each cohort then prepare and approve the teaching plan, issue the teaching assignment by academic committee to all the lecturers and finally course assessment and PO evaluations. This cycle is part of CQI in the teaching and learning.

The role of a lecturer and instructor in OBE Implementation is very important. All the faculty members have the role to play in the implementation. The most important role plays by the lecturers or instructors to implement the outcome base education in the teaching and assessing the student. The procedure would be more meaningful if it could be described in a simulated manner by taking the role of the process owner. Having been given the teaching assignment by the academic committee and approve by the dean, a lecturer will have to prepare and develop their Teaching Plan taking into account all the POs to be addressed.

After identifying the POs of the course, the lecturer needs to determine the appropriate modes of delivery based on the required program outcomes. Then the lecturer needs to determine the appropriate assessment methods and tools to be used in assessing student achievements. All these parameters are already included

in the Teaching Plan. Based on the required outcomes the lecturer may have proposed the followings as his/her modes of delivery and his/her assessment methods as shown in Table 5.

III. ASSESSMENT TOOLS

Assessment is compulsory to measure the performance of student achievement and lecturer ability to convey the knowledge. The tools that we have in place to assess effectiveness of our program and making changes when needed fall into direct and indirect evidence categories. Among the indirect evidence category is selected to conduct and analyze several surveys including course learning outcomes surveys, exit surveys, annual student satisfactory surveys, alumni surveys etc. Course learning outcomes surveys in all courses at the end of each semester conducted to determine self assessment of students on how well the course outcomes are met. Exit surveys on program outcomes conducted at the time of graduation to obtain self assessment of the graduates on how well the program outcomes are met. Annual student satisfactory survey conducted annually to determine the student satisfaction with the program Alumni survey for measuring the impact of program outcomes in the performance of graduates. The direct evidence tools consist of:

1. Final examination (FE) results
2. Employer survey for measuring effectiveness of the program outcomes in the work force
3. Board of External Examiner (BEE) review
4. Board of Industrial Advisor (BIA) that provides input on performance and expected qualities of graduates
5. Board of Stakeholder (BOS) that review vision, mission, PEO and PO of the program.
6. Feedback forms for course outcomes survey results completed and submitted at the end of each semester by the faculty teaching the courses
7. Panel evaluations in key courses that involve final project reports or presentations in front of an audience of faculty and fellow students
8. Instructor's assessment of student performance in course outcomes via evaluation of key exams, projects and homework against the course outcomes.

It is to be noted that the course outcomes surveys are independent of the course and instructor evaluations. While the course outcome survey results are shared with all faculties, course and instructor evaluation survey results are confidential and shared only with the individual faculty as a means of feedback to improve his or her teaching. The assessment methods used to assure that the program outcomes are achieved. The methods for assessment of achievement of program outcomes are given in Table 6.

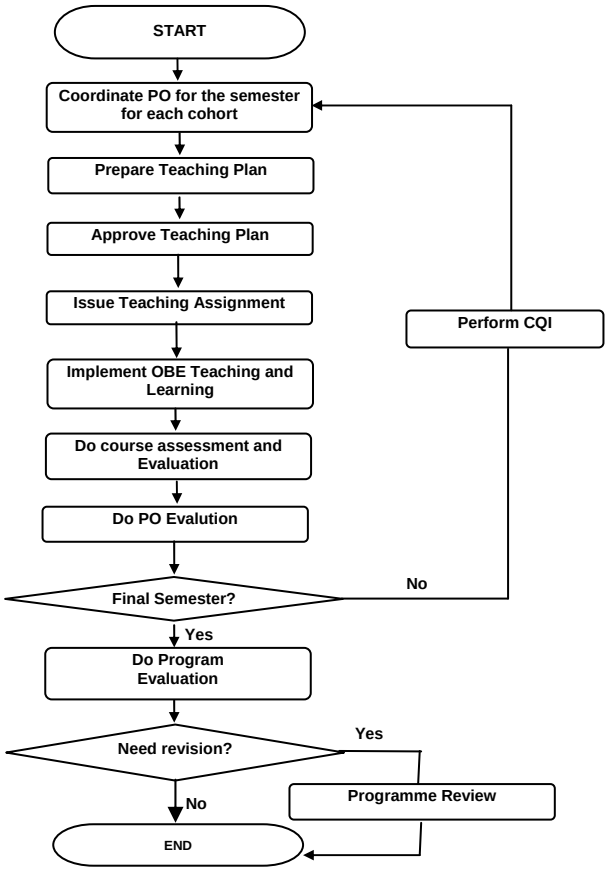

Figure 1: OBE-CQI in Teaching & Learning

In order to systematically analyze the survey results, the faculty members are asked to provide feedback on the survey results explaining the reasons for the lowest three outcomes, reflect upon the adequacy of the outcomes; indicate any changes made in the course or any suggestions for changes. The suggestions are implemented if approved by the faculty academic committee (FAC). The benefits of these forms are:

1. To give faculty opportunity to analyze the results and provide feedback
2. To document any changes or suggestions made
3. To guide those who might be teaching the same course in subsequent semesters

Table 5: Assessment and delivery methods for program outcomes

POs	Criteria	Delivery	Assessment method
a	PO-a(3)	1. Lecture 2. SCL	1. Test 2. Quizzes
b	PO-b(2)	Laboratory Work	Use related rubrics
e	PO-e(1), PO-e(2) PO-e(3)	1. Lecture 2. SCL	1. Test 2. Quizzes
g	PO-g(1), PO-g(2)	Presentation Project Work	Use related rubrics
k	PO-k(3)	Project Report	Project Assessment

Table 6: Methods for assessment of achievement of program outcomes

No.	Methods use to assess program outcomes
1	Conduct exit survey with graduate seniors
2	Conduct alumni surveys
3	Conduct employer surveys
4	Conduct student satisfactory survey in every semester
5	Conduct course evaluation survey
6	Conduct reviews by academic area committees
7	Conduct the survey based on cognitive domain for every course
8	Maintain records on student performance on Final exam
9	Maintain records of students' progress through the curriculum
10	Maintain records of students' pursuing graduate or professional school

These completed feedback forms are included in the course portfolios prepared by the faculty for each course and kept as a faculty record on the faculty's assessment database. The program coordinator plays an important role for evaluating the achievement of cohorts for each semester. The coordinator will collect the Course Assessment Summary (CAS) for all courses in particular semester and cohort. The evaluation of CAS is to identify and achieving the program outcomes. If the students did not manage to achieve the minimum requirements, hence the coordinator ensures that the same PO be addressed again in one or more of the courses for the following semester. This is to be part of CQI process. This was done every semester. Once the PO's are harmonized for the particular cohort, the coordinator updates the POs to be addressed for each course include the information on the updated PO's for each course.

The PO Summative Assessment of the program would follow including the external summative assessment like, entry survey, exit survey and final CPA. The internal summative assessment like final year project and industrial training along with formative assessment of all courses is taken by the cohort throughout the study period. All these assessment would be evaluated to gauge against the attainment of Program Educational Objectives in the years to come, usually 5 years after graduation. These data can be obtained through employer survey, alumni survey and among others. The results of the summative assessment would later be used in revised the curriculum and part of the CQI. The flowchart of the CQI for mechanical engineering program is shown in Figure 2.

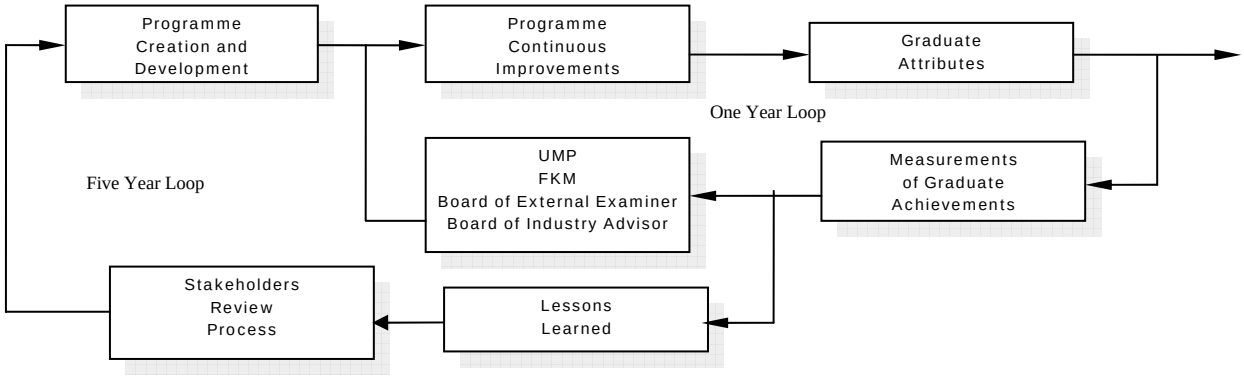

Figure 2: Flowchart of CQI for mechanical engineering program

BOARD OF EXTERNAL EXAMINER (BEE)

Professors and experts from local and overseas universities in the faculty's focus area are appointed as BEE. The main task of BEE is to evaluate the curriculum structure and assessment of the program. Detail curriculum will be discussed in order to meet the requirement of the BEM. The ratio of the engineering fundamental course and general course are determined and evaluate. Minimum requirement is 67% of the course content must be engineering fundamental course and 33% or less is general course which is advance mathematics; English relates course and university basic courses. BEE will discuss with faculty member and report the findings to university management and suggest some improvement whenever necessary.

BOARD OF INDUSTRY ADVISOR (BIA)

Board of industry advisors task is to review the curriculum and feedback to faculty for the industry's requirement and their needs. BIA's are appointed from mix area in the mechanical, manufacturing and automotive engineering field. Experts from the industry are selected which are from:

1. Manufacturing and assembly industry
2. Automotive industry
3. Oil and gas industry
4. Mechanical engineering consultation's company
5. Mechanical engineering sales and trading company

BOARD OF STAKEHOLDER (BOS)

Stakeholders are all parties which have the importance and interest to the program and faculty. Stakeholder also call in Malays "Pemegang Taruh" is very important part of faculty and university organisations. Main task of the stakeholders is to review

and advice on vision, mission and graduate attribute for the faculty. Review process will be done every 4 or 5 years on big loop of the CQI flow as shown in figure 2. Stakeholder members appointed as below:

1) University's top management
2) Faculty's top management
3) Representative from faculty academic and non academic staff
4) Representative from other universities
5) Representative from industries
6) Representative from ministry of higher education
7) Representative from ministry of finance
8) Representative from state government
9) Representative from student's parent
10) Representative from alumni

CONCLUSION

Education reform model and CQI are very important. Input from BEE, BIA and BOS are very important to ensure the faculty always on track and feedback to improve current conditions. The program outcomes assessment tools are discussed. The course coordinator or/and lecturers plays the major role to the implementing the OBE in the mechanical engineering program in UMP. The student performance can be measured and continuously improvement.

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