Programme Learning Outcomes Assessment and Continuous Quality Improvement in Faculty of Mechanical and Manufacturing, UTHM

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Abstract. This paper describes the assessment and continuous quality improvement of Programme Learning Outcomes (PLOs) in the Faculty of Mechanical Engineering and Manufacturing. PLO is known as an elementary requirement in Outcome Based Education (OBE) system. All PLOs have been mapped with graduate attributes by EAC Manual 2012. Conceptual process for establishing and reviewing PLOs has been explained in the Plan-Check-Do-Act cycle. PLO assessment has been shown in different types which classified as direct and indirect methods. Continuous Quality Improvement has been extracted from a variety of assessment and has been discussed. Seven (7) CQIs are identified using different assessment methods of PLO during years 2013 to 2016 and subsequent improvement actions have been taken by the faculty within three years.

1. Introduction
The development of OBE system requires main parts of Programme Educational Outcomes (PEO), PLOs and Course Learning Outcomes (CLO). Thus, the importance of PLO is realised as the primary element and assessment report are needed to ensure OBE system has been implemented. The 13 PLOs of the programme were established according to the Engineering Programme Accreditation Manual 2012 and the Ministry of Higher Education requirements. For this academic programme, the senate and faculty has approved and decided on the thirteen (13) of PLO as shown in FKMP PLO column in Table 1. In order to promote the PLOs, some initiatives have been taken to publish them through the media such as
(i) Faculty website (http://fkmp.uthm.edu.my/)
(ii) Poster-placed at strategic locations including all laboratories, lecturer rooms, faculty classroom and main office
(iii) Font Cards – All PLOs are published and distributed to the Faculty staffs and student in form of font cards

Table 2 shows the corresponding PLOs mapped with EAC Manual 2012 with additional one attribute satisfying Ministry of Higher Education (MOHE) requirement.
Detailed descriptions of individual PLOs which are related to the EAC graduate attribute areas as given in the Engineering Programme Accreditation Manual 2012 are shown in Table 1.

| EAC Attributes             | FKMP PLO   | Indicators of PLO Achievement by the Students                                                                 |
|----------------------------|------------|-------------------------------------------------------------------------------------------------------------|
| Knowledge                  | PLO 1      | Ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialisation to the solution of complex engineering problems |
| Problem Analysis           | PLO 11     | Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences |
| Design/Development of Solution | PLO10     | Design solution for complex engineering problems and design systems, components or processes that meet specified need with appropriate consideration for public health and safety, cultural, societal, and environmental considerations |
| Investigation              | PLO 4      | Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitation |
| Modern Tool Usage          | PLO 2      | Conduct investigate into complex problems using research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusion |
| The Engineer and Society   | PLO 13     | Apply reasoning informed by contextual knowledge to assess society, health, safety, legal and cultural issues and the consequent, responsibilities relevant to professional engineering practice |
| Environment and Sustainability | PLO 12    | Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development |
| Ethics                     | PLO 8      | Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice |
| Communication              | PLO 3      | Communication effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions |
| EAC Attributes                      | FKMP | PLO | Indicators of PLO Achievement by the Students                                      |
|------------------------------------|------|-----|------------------------------------------------------------------------------------|
| Individual and Team Work           |      | PLO 5 | Function effectively as an individual, and as a number or leader in diverse teams and in multi-disciplinary setting |
| Life Long Learning                 |      | PLO 6 | Recognise the need for, and have preparation and ability to engage in independent and life-long learning in the broadest context of technological change |
| Project management and Finance     |      | PLO9 | Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to management projects and in multidisciplinary environments |
| Entrepreneurship                   |      | PLO7 | Recognise the importance of entrepreneurship in mechanical engineering and its’ related discipline. |
|                                    |      |      | - As required by Ministry of Higher Education (MOHE)                                |

Table 2. Relationship of Current PLOs with the EAC Accreditation Manual
2. PLOs Conceptual Process

The PLOs were first established in 2004. The conceptual process for establishing and reviewing PLOs is as shown in Figure 1. Plan-Do-Check-Act cycle have been used to describe this conceptual process which contribute to establishment of PLOs.

![Diagram](image)

**Figure 1.** The Conceptual Process for PLOs Establishment and Review

*Plan*

The Planning Stage is mainly steered by Malaysian education system governing bodies such as Ministry of Higher Education and Board of Engineers Malaysia (Engineering Accreditation Department). Domains are standard and set by the Washington Accord. In Malaysia, the body in charge of coordinating all accredited engineering program is Board of Engineers Malaysia (BEM) and supported by Accreditation Engineer Department (EAD). There are 12 suggested POs outlined in the manual and disclosure for guidelines. EAC has three major domains of Affective, Cognitive and Psychomotor. Nonetheless, it is also the establishment of PLOs is based on the needs of program’s constituencies/stakeholders’ expectations and interest. The PLOs are very specific to attain specified PEOs. This is translated through the PEOs to PLOs mapping which is further relates to Course Learning Outcomes (CLOs). In order to enable the measurement of the PLOs achievement, key performance index of the PLOs is determined by the attainment of score for related courses.
Do
The implementation of PLOs is divided into two types of assessments namely indirect and direct method. The indirect method comprises of exit survey, industrial training survey and stakeholders meeting. Stakeholders include the industries, external examiners, visiting professors, adjunct professors and students are involved in the assessment exercises to ensure their views are given due consideration when implementing improvements to the programs. The direct method mainly sourced from the achievement of the CLOs.

Check
The monitoring and review stage include analysis of indirect assessment, direct assessment and consolidation of indirect and direct assessment. Consolidation of indirect and direct assessment involves correlation of exit survey, industrial training survey and course assessment analysis. Input from various parties are analysed by the relevant committees in the Faculty to assess the achievement of the PLOs. Outputs from each assessment are utilised by the Faculty in identifying any issue that needs rectifications or improvement.

Action
The Faculty will then outline the necessary plan of actions and table them to the Faculty academic committee meeting for their endorsement. The endorseplan and actions to be implemented may be issued to the Senate meeting for the approval.

3. Evaluation of Programme Learning Outcomes
There are two methods of evaluating the PLOs, namely (i) indirect assessment and (ii) direct assessment. The tools used in these assessments are summarised as in the following Table.

| Types of Assessment | Platform                  | Method/Tools | Output              |
|---------------------|---------------------------|--------------|---------------------|
| Indirect            | Industrial Advisory Committee (IAC) | Annual Meeting | Reports             |
|                     | Adjunct Professor         | Annual Meeting | Reports             |
|                     | External Examiner         | Annual Meeting | Reports             |
|                     | Exit Survey               | Survey       | Reports             |
|                     | Industrial Training Survey | Survey       | Reports             |
| Direct              | Summative Evaluation of Students | CEPAT        | Students’ achievement |
|                     | Formative Evaluation of Students | CEPAT / SAS / OBESYS | Students’ achievement |
3.1. **Indirect Assessment**

The PLOs attainment is assessed continuously by the Faculty through indirect assessment. The types of indirect evaluations and their mechanisms are explained as follows:

(i) **Industry Survey**

The industry survey is a tool to identify the needs and gaps of skill in industry based on the employer’s perception in terms of students’ abilities to attain the PLOs. The industry survey was conducted yearly during the Semester 3 of the third year academic session. The respondents are the employers of whom the FKMP students are undergoing the industrial training, including the managers, senior engineers and practicing engineers.

(ii) **Exit Survey**

The Exit Survey refers to an indirect measurement method of students’ self-evaluation or individual perception for the assessment of qualities as prescribed in PLOs, which was conducted upon graduation.

(iii) **Assessment by External Examiners/Adjunct Professor/Visiting Professors/IAC**

The review from the External Examiners, Adjunct Professor, Visiting Professors and IAC regarding the appropriateness of the Faculty PLOs are taken during periodic review through annual stakeholder meetings.

3.2. **Direct Assessment**

PLOs in FKMP were analysed by using online and offline systems. The established of management system (online and offline) used are divided into three systems as stated below:

(i) **Offline system - Course Evaluation and Performance Analysis Tool (CEPAT)**

(ii) **Online system - Students Assessment System (SAS)**

(iii) **Online System – Outcome Based Education System (OBEsys)**

The CEPAT assessment template, which is an offline excel-based programming developed by the Faculty member, is capable in analysing the relations of the assessments for each courses to the course learning outcomes (CLOs) and further to PLOs. The SAS and OBEsys are online database system developed by the University (Information Technology Centre), which offer similar function with CEPAT with extra features. The different functions and features of the systems are as summarised in Table **Error! No text of specified style in document.**

| System | Basic Function (Marks compilation) | Features |
|--------|-----------------------------------|----------|
| 1. CEPAT | Continuous assessment | • Offline System  
| | Final examination | • Analysis of CLO achievement  
| | | • Mapping of CLO achievement to PLOs  
| | | • Analysis of CLO and PLO KPI achievement  |
| 2. SAS | Continuous assessment | • Online System linked to TCIS  
| | Final examination | • Systemised compilation of courses CQI  |
| 3. OBEsys | | |

**Table** Error! No text of specified style in document.: Summary of Functions and Features of Different Systems of Assessments
CEPAT and SAS were used to store continuous assessment and final examination marks of all students by the respective lecturer. CEPAT is managed by the Faculty’s OBE Committee meanwhile SAS is managed by the University. SAS is linked to the Total Campus Integrated System (TCIS). TCIS is an online system which integrates necessary information of personal, teaching and learning activities of each individual staff, regardless of academic or supporting staffs.

The course coordinators were given the authority to set up the mark weightage for continuous assessment and a final examination in SAS which is linked to the TCIS system. The continuous assessment includes quizzes, assignments, projects and tests. The total mark of continuous assessment is 50% and remaining 50% are allocated for final examination marks for the courses. Respective lecturers can fill up the marks after the weightage has been set up in TCIS by course coordinator.

In SAS, overall marks were analysed to represent the CLOs achievement percentages. The analysis results would show the overall report which consists of the continuous assessment, overall marks, analyses of CLO and PLO achievement. This system allows the student to check their grades on-line. The lecturers and the Faculty management team are able to monitor and evaluate the result of the examination for student accordingly.

Currently, FKMP with CAD (Centre for Academic Development and Training) and Information Technology Centre have developed a system which manages the PLOs assessment known as ‘OBEsys’. OBEsys is managed by the Faculty’s OBE committee and the Information Technology Centre. This system is capable to manage and measure the PLOs assessment.

4. Continuous Quality Improvement
Continuous CQI is essential, in improving the quality of the programme. Error! Reference source not found. summarises the action taken and further planned CQI to review the programme PLOs based on the direct and indirect assessment, respectively. Seven of aspect has been revised include both in direct and indirect assessments.

(i) Revision of PLO
The potential improvement are due to EAC outlined a new set of PLOs as in EAC Manual 2012. The Faculty structured a new set of PLOs, which are in accordance with the PLOs in the EAC manual 2012. The number of PLOs increases to 13, taking into consideration the requirement of EAC and MOHE. The PLOs were approved by the Senate and implemented from Semester 1, Session 2013/2014.

(ii) Addition of critical problem solving and complex engineering activities in PLOs
This potential improvement need implementation of CPS and CEA in PLOs. The Faculty has self-initiated addressing the implementation of complex problem solving in the curriculum. The courses mapped to PLO 1, PLO 4, PLO 10 and PLO 11 are identified for the embedment of complex engineering problems, while the courses with PLO 2 and PLO 3 are identified for the embedment of complex engineering activities. The full implementation of the complex problem solving is targeted to start from Semester 1, 2016/2017.

(iii) Review on PLOs assessment tool - exit survey of student
The potential improvement are identified as verification of exit survey by subject matter experts. As the action taken, the designed questionnaire could be reviewed by subject matter experts during the pilot test before the distributions gauge the graduates’ satisfaction on their PLOs achievement upon graduation.

(iv) Review on PLOs assessment tool – industry survey
Potential improvement are highlighted as mechanism to increase the number of respondents. Currently the industry survey is conducted annually during the Semester 3. The respondents are the employers of whom the FKMP students are undergoing the industrial training. For CQI, the Faculty has initiated a facebook group in an effort to encourage information dissemination to the active students and graduates. In long run, it helps the faculty to reach out to the industry during the reviewing of the PLOs.

(v) Review on PLOs assessment tool - external examiner review
This aspect of reviewed has been raised by External Examiner: The PLOs should be in accordance to the EAC 2012 manual, issues related to the complex problem solving should be addressed and PLOs need to be arranged into technical section and generic skill section. Some actions have been taken by continuous consultation with the external examiners was maintained. Faculty has taken measures to the raised issues:
- The revision of the PLOs has been made in accordance to the manual EAC 2012 and MOHE requirement
- The integration of complex problem solving has been initiated since year 2013
- The PLOs are categorised into cognitive domain, psychomotor domain and affective domain.
- The PLOs related to the cognitive domain are PLO 1, PLO 4, PLO 10 and PLO 11, the PLOs related to the psychomotor domain are PLO 2 and PLO 3, while the PLOs related to the affective domain are PLO 5, PLO 6, PLO 7, PLO 8, PLO 9, PLO 12 and PLO 13.

(vi) PLOs assessment
This potential improvement focused on measurement of overall PLOs assessment. As an action taken, CEPAT software was introduced to the Faculty member which measure real achievement as required. Furthermore CEPAT has also come out with detailed course performance analysis that satisfies the OBE requirement.

(vii) Course improvement
This involved with improvement in CLOs assessment. As an action taken, improvement of CLO assessment in current and previous semester can be accessed through TCIS System by Course Coordinator. Meanwhile, a SAS system shows an example of CQI report proving CLO assessment for two subsequent semesters. These CQI report will be attached to the SAS report submitted to Departmental Examination Committee level. Other Improvement is on individual attainment of PLOs. The action has been taken on using OBEsys to show the attainment of 13 PLOs related to CLOs for each courses reflected for individual student.

5. Conclusion
PLOs evaluation method in direct and indirect assessments have contribute to continuous quality improvement for the faculty in several aspect includes CPS and CEA, indirect assessment tool, external examiner review, measurement of overall PLOs assessment, CLOs assessment and PLOs attainments

6. Reference
1. Engineering Programme Accreditation Manual 2012, Engineering Accreditation Council, Board of Engineers Malaysia.