

# Institutional Strategies Implementing Outcome-Based Education for Engineering - First Experiences from Universiti Teknologi Malaysia

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## Abstract

Being a developing nation, Malaysia strives to compete within the global frontiers in science and technology. Compared with developed nations, educating and training of engineers is viewed as social needs and obligations. Over the last fifty years of independence, there has been a mushrooming of industries, resulting in a high demand for engineers. The expectation to produce quality engineers is high, and this role is not an easy task. Universiti Teknologi Malaysia (UTM) has been responsible for producing the majority of engineers for the country for more than 30 years. With the impact of the Engineering Criteria 2000 (EC2000), crafted by ABET, the university has been continuously stepping up efforts to improve its programmes to meet the above aspirations. Therefore, as Malaysia's premier university for engineering, UTM first embarked on the development and implementation of a model of Outcome-Based Education (OBE) from as early as 2002 to programmes offered in the university. During that year, an awareness program regarding OBE was introduced to academic staff of the Faculty of Science. OBE was deemed essential to meet the requirement for Malaysia to become a full signatory member of The Washington Accord. The objectives of OBE are to incorporate professional skills into the programme curriculum, as well as knowledge and technical competencies of students. UTM's Outcome-Based Education has involved three stages of development: (i) the planning stage (ii) the implementation stage, and (iii) the assessment stage. Discussion in this paper focuses on the process of implementation, and the challenges faced by university administrators to make OBE successful.

## Introduction

Being a developing nation, Malaysia strives to compete within the global frontiers in science and technology. Compared with developed nations, educating and training of engineers is seen as social needs and obligations. Prior to independence of the nation, hardships resulting from conflict, war and colonialism further aggravated the situation of producing adequate numbers of qualified engineers. After independence, factors such as the stability of the country, and the realization of the importance of education, have contributed to the change of scenario where more locals are training as engineers, although still in relatively small numbers, though. Over the last fifty years of independence, there has been a mushrooming of industries, resulting in a high demand for engineers. The expectation to produce quality engineers is high, and this role is not an easy task. Universiti Teknologi Malaysia (UTM) has been responsible for producing the majority of the engineers for the country for more than 30 years. With the impact of the Engineering Criteria 2000 (EC2000), crafted by ABET, the university has been continuously stepping up efforts to improve its programmes to meet the above aspirations through changes to its engineering programs. Therefore, as Malaysia's premier university in engineering, UTM first embarked on developing and implementing a model of Outcome-Based Education from as early as 2002 to programmes offered in the university. During that year, an awareness program regarding OBE was introduced to

academic staff of the Faculty of Science. Roadshows to other Faculties followed suit, involving activities such as:

- conducting talks, workshops and seminars on awareness and implementation to Faculty members
- establishing Programme Objectives (PEOs), Programme Outcomes (POs) and Course Outcomes (COs)
- gaining feedback and views from employees, Faculty members, and students on the PEOs, Pos and COs, and their attainment
- reviewing existing curricula and courses to take into consideration feedback from the various stakeholders on the incorporation of the PEOs, POs and COs
- discussing suitable assessment and evaluation tools to measure the achievement of the above
- monitoring the implementation of the whole approach through Academic Auditing.

This paper reports on the authors experiences of implementing OBE for engineering undergraduate programmes only. OBE is deemed essential to meet the requirement for Malaysia to become a full signatory member of The Washington Accord. A lot of time and effort has been involved in the redevelopment of education, its structure, curriculum and documentation in relation to this. The university has needed to transform its engineering curriculum in accordance with requirements from the Engineering Accreditation Council of the Board of Engineers, Malaysia (a provisional member of The Washington Accord), along with the Malaysia Quality Framework introduced by the Ministry of Higher Education in 2004. The Malaysian Qualification Agency (MQA) has responsibility to ensure that an adequate Malaysian Qualification Framework is in place.

#### **Literature Review of Outcome-Based Education**

OBE has emerged as a major direction for educational reform. It grows out of concern that the education system cannot adequately prepare students for life and work in the twenty first century. This phenomena prompted the engineering academics to explore new ways of designing education for the training of engineers. William Spady (1993) who is a leading exponent of OBE in USA describes OBE as means of focusing and organizing a school's entire programme and instructional efforts around the clearly defined outcomes we want all students to demonstrate when they leave school. Educational literature evolving OBE has emerged in different forms over the last few decades (Brady, 1995), but the definitions of outcome based education provided by Towers (1994, 1992), Glatthorn (1993), Hansen (1989) and Abrams (1985) suggest that it is characterised by: the development of clearly defined outcomes, the design of learning activities to assure the demonstrated performance, the monitoring of individual performance through the use of criterion referenced assessment and the provision of remediation and enrichment.

Research regarding OBE are tremendous as pointed out by Brady ( 1995) - some of the reports showing the benefits of OBE (McGhan 1994, Haack 1994, Mitchell, Hoyle and Martin 1994, Jasa and Enger 1994, Fitzpatrick 1991, Abrams 1985). Benefits claimed include the elimination of permanent failure and compromised standards (McGhan 1994), the focus on learning achieved rather than time served (Haas 1992). But, there are also strong criticisms of OBE (Evans and King 1994, Pliska and McQuaide 1994, Schwartz and Cavener 1994, Towers 1994, Glatthorn 1993, McKernan 1993). In the middle east, evidence of OBE in the curriculum development is reported by Bouslama et al (2003).

Despite debates on the approach of OBE, all institutions of higher learning in Malaysia, since the inception of the Malaysian Qualification Agency (MQA, 2008) who is responsible for the Malaysian Qualification Framework (MQF), was put in place do not have the luxury of choosing because it is obligatory. The Malaysian Qualification Agency (MQA) has placed a requirement on outcome based approach to be implemented by all academic programmes. A programme must specifically indicate its learning outcomes based on requirements of the *Malaysian Qualifications Framework: Point of Reference and Joint Understanding of Higher Education Qualifications in Malaysia* (Ministry of Higher Education Malaysia, 2007) or other regulatory or professional body affiliated with the programme, deliver and make necessary assessment activities in ensuring the achievement of the required level. In addition, the

Washington Accord, which the Engineering Accreditation Council of the Board of Engineers Malaysia (EAC-BEM) is a provisional member, has sternly placed Outcome-Based approach in the accreditation exercise as mandatory for all engineering programmes. In order to be a full member of the accord, there is a need for a shift within the engineering education system from conventional to outcome-based approach. UTM as Malaysia's premier university in engineering and technology is continually stepping up efforts to improve its engineering programmes in meeting the aspirations of the EAC-BEM to produce quality graduates that focus on the outcome-based education approach. In December 2005 an accreditation exercise, with a requirement of outcome based approach, was conducted on twenty one engineering programmes offered by UTM. Proudly, all of them secured full accreditation of five years.

### **Conceptual Framework of UTM's Outcome-Based Education**

UTM has embarked on this approach with a conviction that the efforts will really benefit both the students and staff as it is our desire to always continually improve our engineering programmes. Indeed, attempts to improve the competencies of the students in many aspects are actually neither new nor rare. In doing so, many engineering academic staff have consciously or subconsciously applied several approaches in their teaching. UTM's serious efforts towards outcome based approach started as early as 2002 when an awareness program was given to the academic staff of the Faculty of Science. Other activities followed, for instance, conducting talks, workshops and seminars on awareness and implementation to faculty members; establishing Programme Objectives (PEOs), Programmes Outcomes (POs), and Course Outcomes (COs). Feedback and views was sought from employers, faculty members, and students on the Programme Objectives and Outcomes and their attainment. Existing curricula and courses were reviewed to take into consideration the feedback from the various stakeholders on the incorporation of Programme Objectives, Programme Outcomes and Course Outcomes; discussing suitable assessment and evaluation tools to measure the achievement of Programme Objectives, Programme Outcomes and Course Outcomes and monitoring the implementation of the whole approach through Academic Auditing.

Through the Outcome-Based Approach, UTM has employed a comprehensive methodology of combining technical competencies and generic or professional skills sought by employers, alongside numerous activities associated with it. These activities, some in bits and pieces, which all the while have been practiced by some of the academic staff, in isolation or groups, are put together to give the 'big' picture known as the UTM OBE framework. Figures 1 and 2 describe the overall view of UTM's Outcome-Based Education, explaining the relationship between activities, and giving the rationale to the necessity of such activities, along with the monitoring and execution of assessment. In summary, the illustrations include three stages: (i) the planning stage (ii) the implementation stage, and (iii) the assessment stage. The setting up of an Academic Quality Office in April 2005, headed by a Director, is responsible for monitoring quality assurance of academic programmes offered in UTM. These measures are taken to ensure related information and activities can be communicated and understood by all academics supporting staff, as well as students. Written policy and guidelines on the teaching and learning activities in relation to OBE are provided in both the Teaching and Learning Policy and the Code of Practice, which were available to academic staff from 2004.

### **Methodology of UTM's Outcome-Based Education**

Any change in an organization to achieve an aspiration towards a positive improvement needs the support of the senior management of the university. As such, the commitment of those entrusted to fulfil such tasks are to be applauded in moving forward with the implementation of OBE. The authors' experience confirms this was not an easy task; tremendous effort was required to educate and train academic staff of the university.

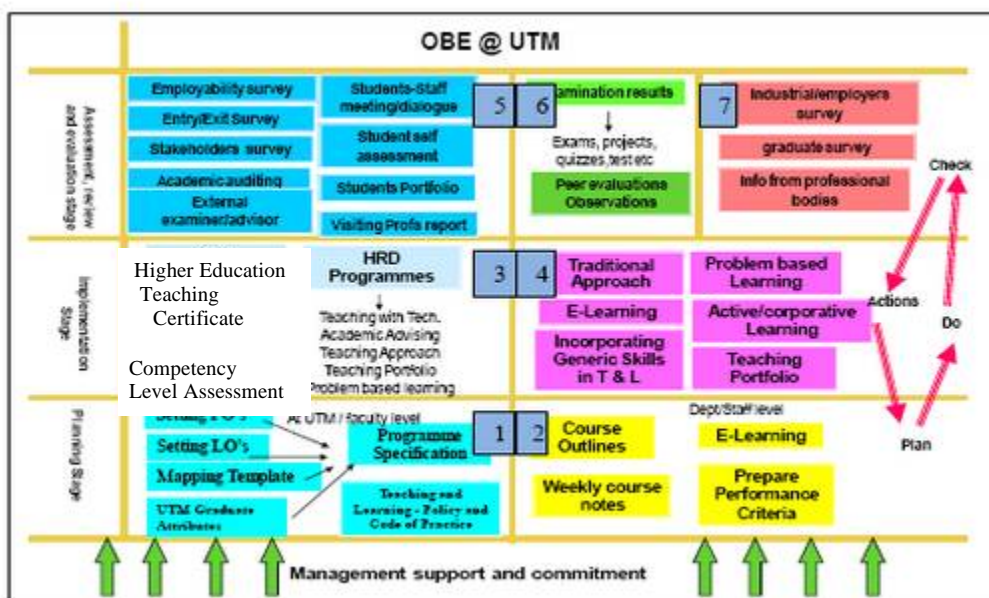


Figure 1 : Conceptual Framework of University Teknologi Malaysia's Outcome-Based Education

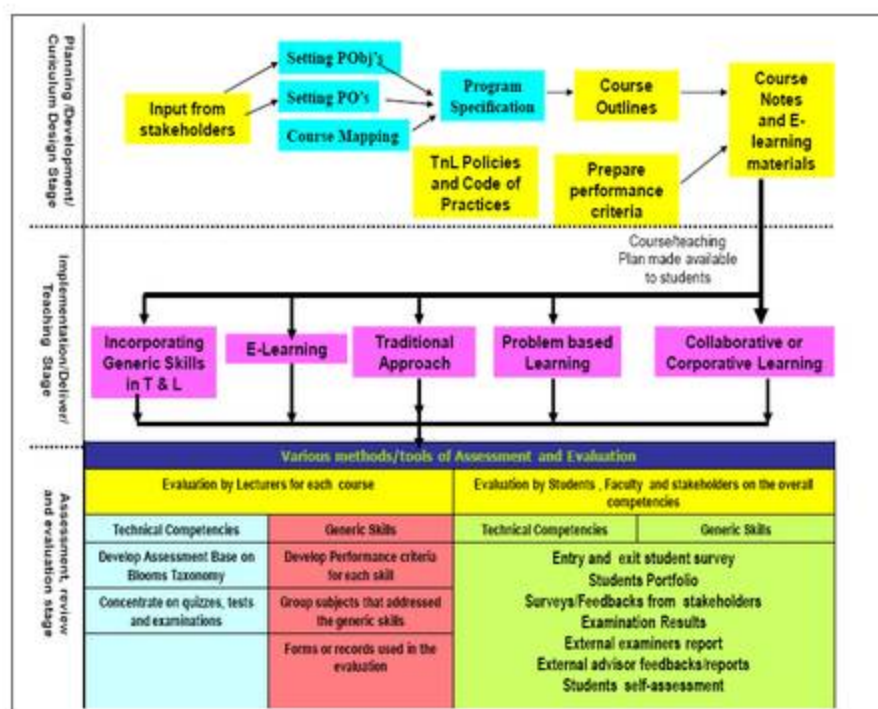


Figure 2 : The UTM OBE 3-Stage Framework

**The Planning Stage of OBE**

The Planning Stage comprises Part 1 and Part 2 (as shown in Figure 1). Part 1 consists of activities steered by the Deputy Vice Chancellor (Academic and International), this through the Centre for Teaching and Learning (CTL) and the Academic Quality Office (AQO) at UTM. The CTL provides training and tools to improve teaching and learning activities. Led by the Dean, it has been restructured with a task to meet educational change and challenges. A proactive and important role of CTL is to equip the academic staff with adequate training and

tools to improve teaching and learning activities. AQO is responsible for quality assurance of academic programmes offered by UTM was set up in April 2005 headed by a director.

With the existence of CTL and AQO, the university feels the desire to inform and activities to be communicated and understood by academics, support staff and students. So in 2004, a draft of the Teaching and Learning Policy and Code of Practice which spells out the teaching and learning activities in relationship to OBE was published and made available to academic staff. Prior to this, in December 2003, the university set up a taskforce to address issues on students' employability and professional skills, which then led to the launch of UTM's Graduate Attributes in April 2004 such as communication skills, team working, problem solving, adaptability, lifelong learning, self-esteem and ethics. The taskforce comprised academic staff of various Faculties, whose function was to seek feedback from stakeholders and employers of UTM graduates identifying skills requirements which form the basis in the development of the Programme Objectives and Program Outcomes of a particular programme. Seven graduate attributes or generic skills in the blueprint outline the expectations of students upon graduation. However in the year 2006, the Ministry of Higher Education Malaysia and the cooperation of public universities including UTM derive and recognize seven generic skills for higher institutions nationwide such as communication skills and information management; team working; problem solving and critical thinking; lifelong learning; entrepreneurship; ethics and integrity; leadership skills (UTM's Teaching and Learning Policy 2006). Several reports shows evidence of such effort, such as: "Towards Successful Inculcation of Generic Skills: Issues and Strategies" (Hassan A et al, 2007), and "A Survey on Academic Ethics among the University Students" (Ahmad UNU, 2007). The attributes, as well as the required technical skills, form part of the Programme Specification, which comprises the programme objectives, programme outcomes, programme content, course menu and course matrix. Also included are the method of delivery and assessment utilized in the programme. The programme specification (Figure 3) has been distributed to the new intake of students along with their offer letters since the start of academic year 2005/2006.

Part 2 focuses on work at departmental level, such as reviewing course outlines, so they are aligning with the programme outcomes matrix, based on the Programme Specification. The course outcomes must be aligned to the programme outcomes; which, in turn, must be mapped to the programme objectives, derived from the involvement and requirements of stakeholders, as shown in Figure 4. The programme and course outcomes have been revised for students, and regularly reviewed to ensure correctness and ease of understanding. Students need to know their supporting role, based on the written course outcomes as defined by the matrix shown in Table 1. The course outlines and notes have been uploaded to the UTM e-learning portal, accessible by staff and students. Information on the programme and course performance criteria acts as an assessment tool, to provide common understanding between students and staff. Table 2 is an example of a rubric of performance criteria for assessing communication skills.

### **The Implementation Stage of OBE**

Part 3 and Part 4 describe the Implementation Stage, translating into action once the programme and course documentation are ready. Part 3 specifies the activities carried out by supporting units, such as the Human Resource and Development Division, to prepare academic staff in undertaking their task efficiently, by conducting seminars, briefings, workshops and short courses. Mainly the courses relate to aspects of teaching with technology, problem-based learning, active learning, e-learning, as well as incorporating professional skills in teaching and learning. The unit also manages the Competency Level Evaluation course, as well as the Higher Education Teaching Certificate course respectively. The speakers and facilitators for such courses are mainly from various Faculties the university refers to as the "Champions". Reports of such activities are evidence from conference presentations, such as "Effective Strategies for Integrating E-learning in Problem-based Learning for Engineering and Technical Education" (Tasir Z, 2005).

Part 4 specifies teaching and learning approaches to be carried out to achieve the objectives and outcomes, as stated in the programme specification. Problem-based learning, active learning, cooperative learning, project based learning, laboratory work, field work, industrial

training, e-learning and research based training are all examples that are being implemented by academic staff. New methods of teaching are evidenced in reports on: "Problem-Based Learning (PBL) in an Engineering Course from Students' Perspective" (Aleem SM and Jamaludin MZ, 2007); "Comparison between Project-Oriented Learning and Problem-Based Learning (PBL) in Design Subject" (Awang D, 2007); "A Problem-Based Learning (PBL) Model for Engineering & Technical Courses" (Yusof KM, 2007); "Enhancing Thinking through Active Learning in Engineering Mathematics" (Rahman RA et al, 2007).

### **The Assessment Stage of OBE**

The final stage in OBE process comprises of Parts 5, 6 and 7 which explain the assessment stage. The entire curriculum is driven by assessment focussing on well-defined learning outcomes, and a variety of teaching and learning approaches to achieve the outcomes. The types of assessment to be implemented should be manageable, but reliable and valid. With OBE, the university proposed two ways of assessing student performance: (i) assessment based on the course outcomes, (ii) assessments by the students themselves, with Faculty and stakeholders reviewing the overall performance of students. Some of the assessment tools to assess the student learning and to evaluate the programme as indicated in Part 5,6,7 are the entry and exit survey, students portfolio, examination results, external examiners, external advisors, survey form industries and graduate survey. Evidence of such efforts are elaborated by academic staff, who report on modes of assessment such as: "An Examination of Electrical Engineering Course Learning Outcomes using Rasch Measurement Model: A Performance Evaluation" (Rashid RA et al, 2007); and "Proposed Rubrics for Evaluation of Class Project" (Ahmad R et al, 2007).

Closing the loop refers to the whole process of OBE are analysed to identify any weakness that need to be addressed to improve the teaching and learning process such as delivery, teaching techniques, resources that need upgrading, management support, staff incompetency and other deficiencies can be work out. Once the weaknesses have been rectified or corrected, OBE is considered done thus realizing the continuing improvement.

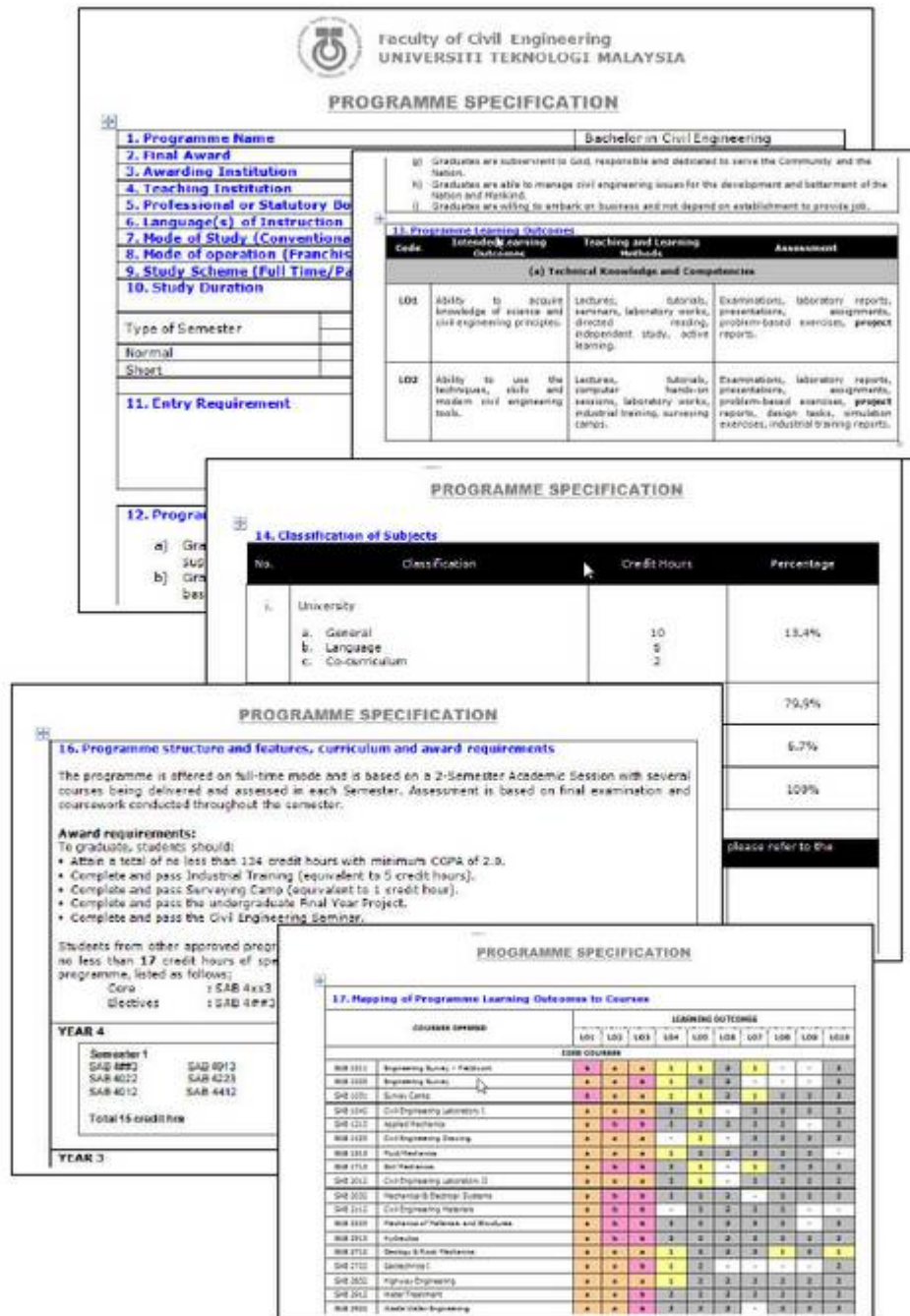


Figure 3 : A Typical UTM Programme Specification

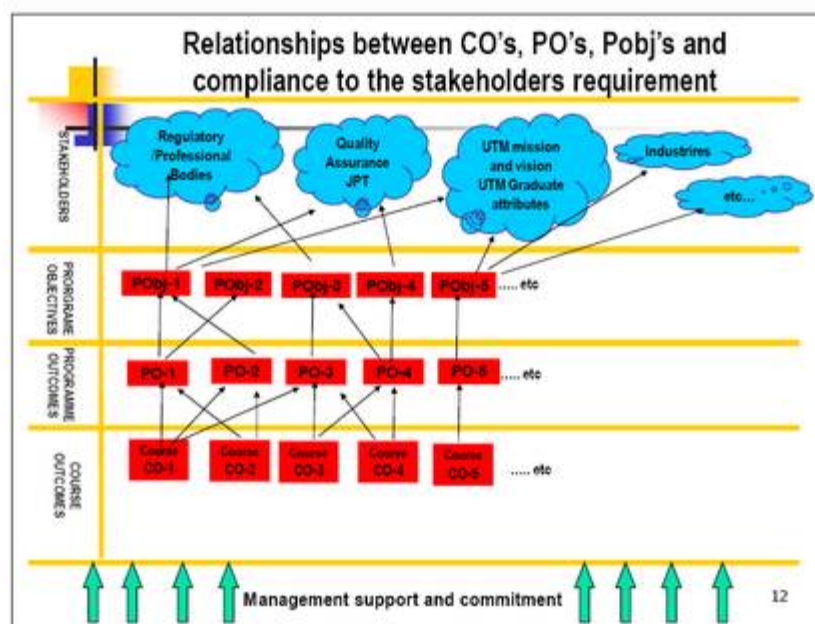


Figure 4 : The Relationship between course outcomes, programme outcomes, programme objectives and compliance to the stakeholders requirement

In general, Continuous Quality Improvement (CQI) is an ongoing effort to improve products, services or processes. UTM's CQI model is based on the four-step quality model - the plan-do-check-act cycle (PDCA Cycle). Originally, the PDCA Cycle was conceived by Walter Shewhart in 1930's and later adopted by W. Edwards Deming who provide the framework such as: *Plan*: Identify an opportunity and plan for change. *Do*: Implement the change on a small scale. *Check*: Use data to analyze the results of the change and determine whether it made a difference. *Act*: If the change was successful, implement it on a wider scale and continuously assess your results. If the change did not work, begin the cycle again. The PDCA Cycle provides framework for the improvement of a process or system and is designed to be used as a dynamic model. The completion of one turn of the cycle flows into the beginning of the next so much so that it can be reanalyzed and a new test of change can begin. Figure 5 illustrates the expectation of Engineering Accreditation Criteria and Board of Engineers Malaysia (EAC-BEM) to test for CQI for assessment strategies; CQI for curriculum design, resources, criteria and teaching activities; CQI for P-Obj and PO and CQI for out-of-class activities. This allows feedbacks for stakeholders regarding their needs with respect to institutional mission. The university appoints "champions" comprising academic staff from different faculties as taskforce committee overseeing, identifying and setting the common criteria which are to be implemented at faculty level. Figure 6 shows CQI model for Programme Objectives and Programme Outcomes and Figure 7 illustrates CQI model for Course Outcomes Level.

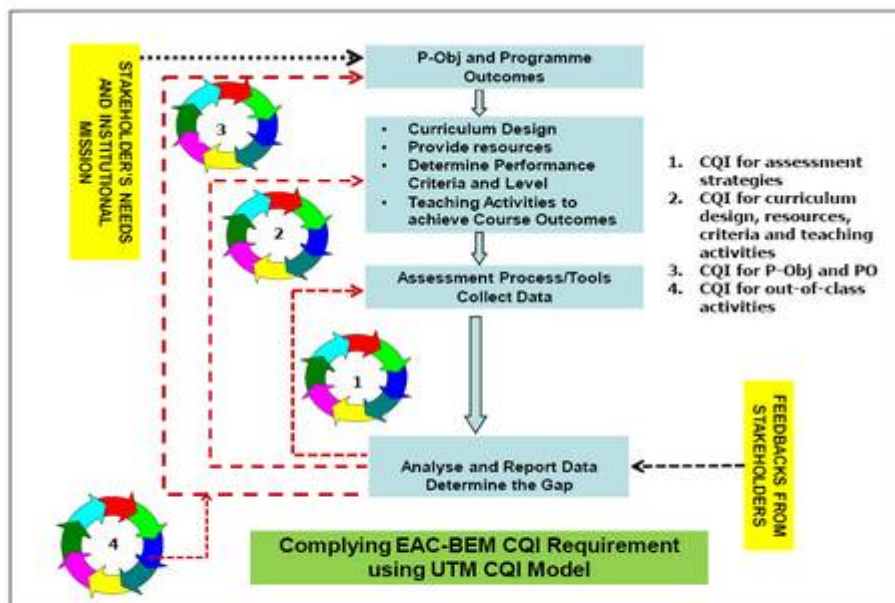


Figure 5 : Complying to EAC-BEM requirement using UTM-CQI model

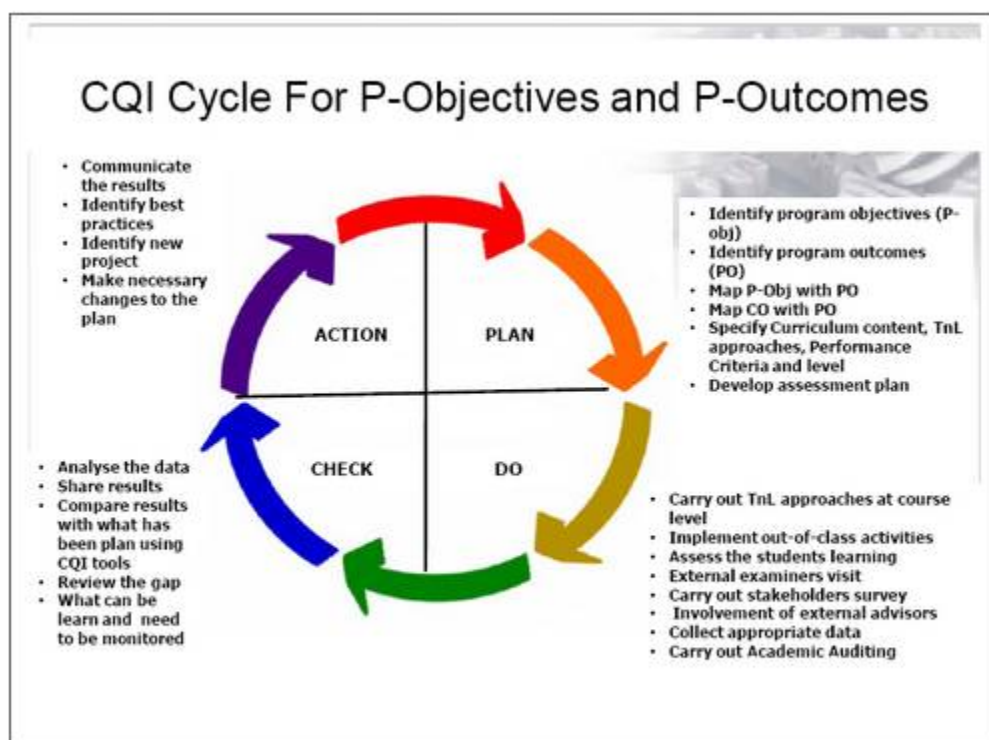


Figure 6 : Programme Objectives and Outcomes CQI model

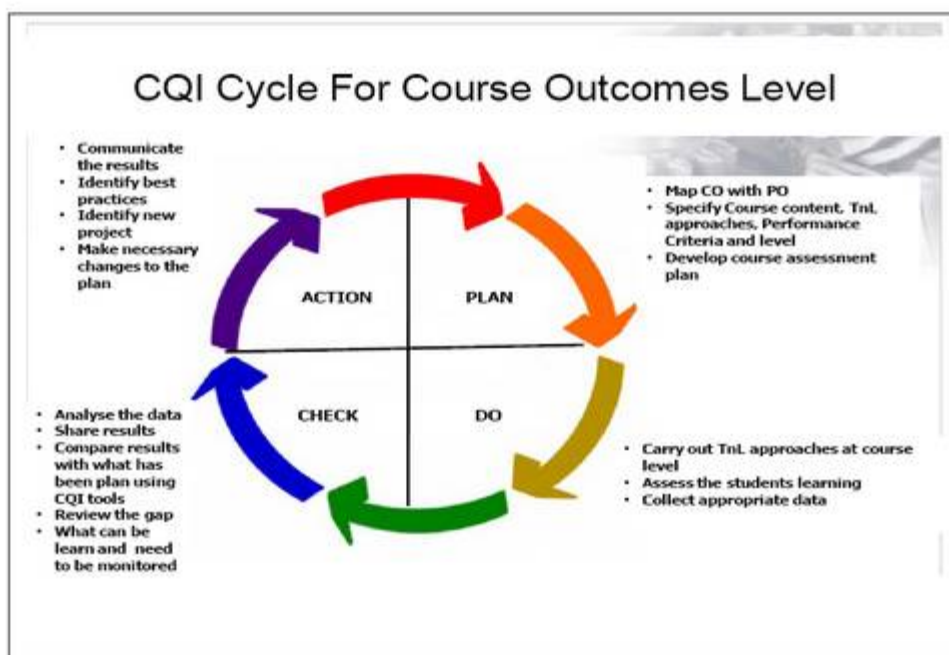


Figure 7 : Programme Objectives and Outcomes CQI model

### Challenges of UTM's Outcome-Based Education

Lattuca LR et al (2006) indicate engineering programme changes following the implementation of EC2000. UTM experienced similar considerable change, especially at the initial stage of implementing OBE, and the university had to take time to put together procedures and instructional documents as reference for academic staff. There is therefore a need to ensure existing documents realign in compliance with OBE, and that new documentation is put together in an organised manner. In the process of implementing OBE, the university faced other challenges, such as dealing with staff that lacked interest, had low motivation or a heavy workload, as well as institutional issues of a poor reward system, unfair assessment, or poor teaching and learning practice. Efforts to promote a change of culture from the traditional approach to that of OBE need to be continuously carried out for academic staff, so that they are aware of the engineering education system that is happening globally. There is a need to review the programme specification, programme objectives and outcomes, and other supporting resources catering for the requirement of OBE in the curriculum. The issue of assessment to measure Educational Objectives and Learning Outcomes objectively need to be addressed. The assessment plan needs to be well structured, to address issues of validity, reliability, varieties in methodology, and the frequency of assessment. However, the biggest challenge for the university concerned the processes of monitoring, tracking, documenting, evaluating and reviewing all activities, bearing in mind that university administrators of a public university such as UTM adopt a two to three years rotational system in their careers.

Table 1 : Course – Programme Outcomes Matrix showing the relationship between course outcomes, Programme Outcomes, Delivery, Assessment and Key Performance Indicators

No	Course Outcomes (CO)	Programme Learning Outcomes (PLO)								Delivery	Assessment	Key Performance Indicators/Index	
		Apply high ethical standards in professional practice and social interactions	Identify and create business opportunity and evaluate on entrepreneuriality	Seek and acquire contemporary knowledge	Function as an individual and/or (as a leader or follower) in a team	Respond and adapt to changing situations and outcomes	Communicate effectively with audiences	Think critically, identify, formulate and solve real engineering related problems	Analyse Develop concept, conduct eqpt design, systems or simulation, skills and tools				Acquire knowledge, science and engineering practices
1.	Able to describe the concept and philosophy of steel and timber design based on the relevant code of practice	a	a	a							Lectures, CL, design practices, tutorials	Tests, Final Exam	Students able to analyse, design and evaluate the member capacity of the structural element based on the standard codes of practice
2.	Able to estimate the design loadings and to analyse structural elements correctly	a	a	a	2	2	2		2		Lectures, CL, design practices, tutorials	Tests, Final Exam, Project Submission	80% achieving grade C and above
3.	Able to use the code of practice to design structural steel and timber elements.	a	a	a	2	2	2		2		Lectures, CL, design practices, tutorials	Tests, Final Exam, Project Submission	
4.	Able to prepare structural design report, drawing plan and structural element detailing before week 15	a	a	a	2	2		2	2	2	Project work, CL	Project Submission	Reports are clear, correct and well presented. Drawings according to standards specifications. 100% passes
5.	Able to work effectively in a team producing a design report within a stipulated timeframe					2		1	2		CL	Peer Assessment, Observation	No complains from team members 80% students achieved 80%

Key: Technical Skills : a = major contribution to outcome; b = moderate contribution to outcome; c = minor contribution to outcome  
 Generic Skills : 1 = Substantial (with assessment) 2 = not substantial (introduction/observation)

Table 2 : Performance Criteria and Rubrics for Team working skills

NO.	CRITERIA	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
1.	<b>Overall team-work skills</b>	Did not attempt to contribute to the success of the group. Was not a valuable asset to the group.	Only valued work and effort of other group members to a small extent. Was not a true team player who worked for the good of the group as a whole members.	Had success when working individually but struggled slightly when it came to collaborating with the group. Could have done more to value the effort and work of all group members.	Completed individual task and contributed to the groups success as a valuable team player. Had a positive attitude and showed respect to all group members.	Always completed individual task and contributed to the groups success as a valuable team player. Had a positive attitude and showed respect to all group members.
2.	<b>Contribution</b>	Rarely provides useful ideas when participating in the group and in classroom discussion. May refuse to participate.	Sometimes provides useful ideas when participating in the group and in classroom discussion. A satisfactory group member who does what is required.	Usually provides useful ideas when participating in the group and in classroom discussion. A strong group member who tries hard.	Routinely provides useful ideas when participating in the group and in classroom discussion. A definite leader who contributes a lot of effort.	Always routinely provides useful ideas when participating in the group and in classroom discussion. A definite leader who contributes a lot of effort.
3.	<b>Interactive and group skills</b>	Has problems working with others/avoids work with others. Does not contribute or contributes inappropriately in groups.	Makes efforts to develop interactive skills. Uses basic interactive skills appropriately.	Meets obligations to others (tutors and/or peers); can offer and/or support initiatives; can recognize and assess alternative options.	Can interact effectively within a learning group, giving and receiving information and ideas and modifying responses where appropriate.	Can interact effectively within a learning or professional group. Can recognize or support or be proactive in leadership. Can negotiate and handle conflict.
4.	<b>Attitude</b>	Often is publicly critical of the project or the work of other members of the group. Often has a positive attitude about the task(s).	Occasionally is publicly critical of the project or the work of other members of the group. Usually has a positive attitude about the task(s).	Sometimes is publicly critical of the project or the work of other members of the group. Usually has a positive attitude about the task(s).	Rarely is publicly critical of the project or the work of others. Often has a positive attitude about the tasks.	Never is publicly critical of the project or the work of others. Always has a positive attitude about the task(s).

## Recommendations and Conclusion

The concern of UTM Outcome-Based Education is its impact of engineering graduates upon employment based on the effectiveness of the approach so as to give significant impact on the graduates. In order to ensure success, the education provider should offer unconditional support at all levels of planning, implementation and assessment. Best practice of implementing OBE should continuously be encouraged, and funds should be provided for resources and facilities. Information needs to be relayed at all levels to ensure clear communication. The contribution of academic staff who commit to the success of OBE within the university will be strengthened if they are given incentives regarding training. They can then provide technological tools to help in the various stages of course delivery; in assessing, collecting and analysing the outcomes. Academic staff should be encouraged to maintain teaching portfolios, to enable them to document the quality of their teaching, which in turn contributes to an increase in professional accountability. Students play an important role too. The availability of student portfolios is highly recommended for a university to ascertain contribution towards the success of OBE. The portfolios provide feedback on students' performance. Evidence from this paper indicates that there should also be unconditional support at all levels of OBE planning, implementation and assessment. To conclude, successful implementation of OBE at UTM has called for team working, as it has required full cooperation, participation and partnership between students, learning providers and various industries. In addition, Continuous Quality Improvement is essential, focusing on customers, process improvement, clarification of vision and mission; this offers the opportunity to look into processes systematically and to address changing demand in education, society and stakeholders.

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