Industries & Students Perception of Faculty of Manufacturing Engineering Program Educational Objectives and Program Outcomes

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Abstract

The Engineering Accreditation Council (EAC) of Malaysia has mandated that Outcome-Based Education (OBE) learning approach is to be adopted in engineering programs in Malaysia [1]. One of the main components involved in the process towards OBE is to develop Program Educational Objectives (PEO) and Program Outcomes (PO). The Faculty of Manufacturing Engineering at University Teknikal Malaysia Melaka has identified five PEO's and eleven PO's [2]. Survey from 36 industries and 35 final year students was conducted to obtain their feedback on the appropriateness of the PEO's and PO's based on the Manufacturing Design curriculum. It was found that the PEO and PO were well accepted by these stakeholders and at a good level.

Keywords: industry perception; program educational objectives; program outcome

1. Introduction

There is a debate that the current engineering graduates do not provide enough emphasis on communication, leadership, teamwork and the ability to synthesize between interdisciplinary engineering knowledge [3].The objectives of this survey is to investigate the industries' and the students perception on faculty Program Educational Objectives (PEO) and Program Outcomes (PO). Program Educational Objectives (PEO) "describe the expected accomplishments of graduates during the first several years following graduation from the program" [1]. The determination of the PEO is based on the Motto, Vision, Mission and Objectives of the university as an institution, as well as the Vision and Mission of the Faculty. Based on the above, and the expected needs of the various stakeholders, the Faculty drafted five PEO and acceptable by all faculty members.

Faculty PEO is to produce manufacturing engineers who:

1. Have strong understanding of fundamental and interdisciplinary engineering knowledge.
2. Are skilled and competent to analyze, solve problem and conduct research in the manufacturing engineering field.
3. Are able to communicate and work in teams effectively.
4. Possess leadership and managerial skills with ethical standard.
5. Creative and innovative in fulfilling the needs of industry and society.

Program Outcomes (PO) are "statements that describe what students are expected to know or be able to do by the time of graduation"[1]. To prepare the students for the achievement of PEO's, almost all the POs as listed in the EAC Manual were adopted. Program outcomes are also derived from program educational objectives. It is expected that the graduates of Manufacturing Design Engineering program will exhibit the following outcomes at the time of graduation:

1. The ability to apply basic knowledge of sciences, engineering and technology in their profession.
2. The ability to design develops, implement and maintain manufacturing systems.
3. The ability to analyze problems and synthesis solutions in manufacturing engineering
4. The ability to communicate effectively with both the engineers and also the society.
5. An understanding of the engineering ethics & social responsibilities.
6. Ability to utilize a systems approach to design and evaluate operational performance.
7. Having in-depth technical competence in a specific engineering discipline.
8. Ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member.
9. The ability to design and conduct experiments as well as to analyze and interpret data.
10. The ability to function and multi-disciplinary teams.
11. Knowledge on contemporary issues and lifelong learning.

2. Methodology

This analysis is done based on the response obtained from 36 distributed questionnaires to the industries and 35 distributed questionnaires to the final year students on April 2007 since they are the program's stakeholders. It has been designed to evaluate the effectiveness of the Program Educational Objectives and the Program Outcomes. Base on the curriculum structure of Manufacturing Design Program shown in Table 5, the feedback was obtained. Likert's scale (l: Very Poor; 2: Poor; 3: Moderate; 4: Good; 5: Excellent) was used in the survey. The analysis involves the calculation of percentage, frequency, and mean in terms of tables, figures and chart with the aid of Microsoft Office 2003 and SPSS for Windows (version 14.0).

There are 5 questions asked concerning Program Educational Objectives as listed below:

A. Program Educational Objective (PEO): Long term goals describing expected achievements of graduates in their career and professional life after 5 years of graduation.

1. Have strong knowledge understanding of fundamental and interdisciplinary engineering know ledge.
2. Have skill and competent to analyze, and solve problem, conduct research in the manufacturing engineering field.
3. Be able to communicate, and work in teams effectively.
4. Possess leadership and managerial skills with high ethical standard.
5. Be creative and innovative in fulfilling the needs of industry and society.

There are 11questions asked concerning Program Outcome as listed below:

B. Program Outcomes (PO): Statements that describe what students are expected to know or be able to do by the time of graduation.

1. Apply basic knowledge of science, engineering and technology in their profession.
2. Have the ability to design, develop, implement and maintaining manufacturing systems.
3. Have the ability to use necessary techniques, skills and modern engineering tools for engineering needs.
4. Communicate effectively with both the engineers and also the society.
5. Have understanding of the professional engineering ethics & social responsibilities.
6. Utilize systematic approach to design and evaluate operational performance.
7. Have in-depth technical competence in a manufacturing engineering.
8. Function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member.
9. Design and conduct experiments, as well as to analyze and interpret data.
10. Have the ability to function multidisciplinary teams
11. Have knowledge on contemporary issues and lifelong learning.

3. Results of industries responses

For the purpose of analysis, the responses obtained are divided into two tables as follows:

i) Table 1: Industries Responses to Program Educational Objectives
ii) Table 2: Industries Responses to Program Outcomes

Table 1 shows the average mean value is 4.05 which reflect a good level as referred to the Likert's scale. Question 1 result in mean value of 4.17 which reflects a good level in terms of industries awareness of the programme curriculum that need to provide strong knowledge understanding of fundamental and interdisciplinary engineering knowledge to students. Generally, 60% of the industries agree that the PEO's is at a good level. The response also reflects that with the various courses offered by the faculty and the department such as the Compulsory Courses, Programme Core Courses and Department Core Courses, students is expected to have the skill and competent to analyze and solve problem, conduct research in the Manufacturing Engineering field. The response also reflects that the curriculum can be expected to improve student's ability to communicate and work in teams effectively as describe by question 3.

Table 2 shows the mean average value of program outcomes is 4.04. Generally, 43% of the Industries agree that the PO's is also at a good level. The industries response has also shown particular emphasis for question 1 that they agrees the curriculum would be able to provide basic knowledge of science, engineering and technology to the students.

4. Results of students responses

For the purpose of analysis, the responses obtained are divided into two tables as follows:

i) Table 3: Students Responses to Program Educational Objectives
ii) Table 4: Students Responses to Program Outcomes

Table 1. Industries response to Program Educational Objectives

No	Items	Frequency (Score)					N	Mean	sd
		Very Poor	Poor	Moderate	Good	Excellent			
1	Have strong knowledge understanding of fundamental and interdisciplinary engineering knowledge		1	4	19	12	36	4.17	0.737
2	Have skill and competent to analyze and solve problem, conduct research in the manufacturing engineering field.			4	26	6	36	4.06	0.532
3	Be able to communicate and work in teams effectively.			7	17	12	36	4.14	0.723
4	Possess leadership and managerial skills with high ethical standard.		1	13	16	6	36	3.75	0.77
5	Be creative and innovative in fulfilling the needs of industry and society.			7	18	11	36	4.11	0.078
Total			2	35	96	29			
Percentage (%)			1.2	21.6	59.3	17.9			

Average Mean: 4.05

Table 2. Industries response to Program Outcomes

No	Items	Frequency (Score)					N	Mean	sd
		Very Poor	Poor	Moderate	Good	Excellent			
1	Apply basic knowledge of science, engineering and technology in their profession.			4	15	16	35	4.34	0.684
2	Have the ability to design, develop, implement and maintaining manufacturing design.			7	18	10	35	4.09	0.702
3	Have the ability to use necessary techniques, skills and modern engineering tools for engineering needs.			6	20	9	35	4.09	0.658
4	Communicate effectively with both engineers and also society.			5	19	10	35	4.15	0.657
5	Have understanding of the professional engineering ethics & social responsibilities.			8	19	8	35	4.00	0.686
6	Utilize systematic approach to design and evaluate operational performance.			8	20	7	35	3.97	0.664
7	Have in-depth technical competence in a manufacturing engineering.			8	21	6	35	3.94	0.639
8	Function effectively as an individual an in a group with the capacity to be a leader or manager as well as an effective team member.		1	11	14	9	35	3.89	0.832

Table 2. Industries response to Program Outcomes…(cont.)

9	Design and conduct experiments, as well as to analyze and interpret data.			5	23	7	35	4.06	0.591
10	Have the ability to function multidisciplinary teams.		1	6	19	9	35	4.03	0.747
11	Have knowledge on contemporary issues.			9	20	6	35	3.91	0.658
Total			2	77	208	97			
Percentage (%)			0.42	16	43	20.2			

Average Mean: 4.04

Table 3 shows the average mean value is 3.90 which reflect a good level as referred to the Likert's scale. Question 3 result in mean value of 4.09 which reflects a good level in terms of student's awareness of the program curriculum that is expected to enable them to communicate and work in teams effectively. Generally, 58% of the industries agree that the PEO's is at a good level.

Table 4 shows the mean average value of program outcomes is 3.88. Generally, 55% of the students agree that the PO's is also at a good level. The students response has also shown particular emphasis for question 1 that they agrees the curriculum would be able to provide basic knowledge of science, engineering and technology to the them that would beneficial for their profession later.

Table 3. Students response to Program Educational Objectives

No	Items	Frequency (Score)					N	Mean	sd
		Very Poor	Poor	Moderate	Good	Excellent			
1	Have strong knowledge understanding of fundamental and interdisciplinary engineering knowledge			9	21	5	35	3.89	0.631
2	Have skill and competent to analyze and solve problem, conduct research in the manufacturing engineering field.		1	14	14	6	35	3.71	0.789
3	Be able to communicate and work in teams effectively.			5	22	8	35	4.09	0.612
4	Possess leadership and managerial skills with high ethical standard.			8	23	4	35	3.89	0.583
5	Be creative and innovative in fulfilling the needs of industry and society.			11	16	8	35	3.91	0.742
Total			1	38	96	31			
Percentage (%)			0.60	22.9	58	18.7			

Average Mean: 3.90

5. Conclusion

As a result from this analysis, it is discovered that the Program Educational Objective and Program Outcomes is appropriate and at a good level. However, the faculty has decided that the Program Educational Objective and Program Outcomes will be reviewed every 3 years to enable continuous improvement. This analysis enables the Faculty of Manufacturing Engineering, particularly the Department of Manufacturing Design to conduct systematic evaluation on the satisfaction level of industries and students towards the learning output in order to enable continuous improvement on arising weaknesses. Thus, it is also for the purpose of improving the quality of teaching and learning system of the faculty, in line with the university's missions and visions.

Table 4. Students response to Program Outcomes

No	Items	Frequency (Score)					N	Mean	sd
		Very Poor	Poor	Moderate	Good	Excellent			
1	Apply basic knowledge of science, engineering and technology in their profession.			6	19	10	35	4.11	0.676
2	Have the ability to design, develop, implement and maintaining manufacturing design.			10	17	8	35	3.94	0.725
3	Have the ability to use necessary techniques, skills and modern engineering tools for engineering needs.			5	24	6	35	4.03	0.725
4	Communicate effectively with both engineers and also society.			8	23	4	35	3.89	0.583
5	Have understanding of the professional engineering ethics & social responsibilities.		2	9	18	6	35	3.80	0.797
6	Utilize systematic approach to design and evaluate operational performance.		1	14	15	5	35	3.69	0.758
7	Have in-depth technical competence in a manufacturing engineering.		1	11	19	4	35	3.74	0.701
8	Function effectively as an individual an in a group with the capacity to be a leader or manager as well as an effective team member.			8	21	6	35	3.94	0.639
9	Design and conduct experiments, as well as to analyze and interpret data.			9	19	7	35	3.94	0.684
10	Have the ability to function multidisciplinary teams.		3	6	23	3	35	3.74	0.748
11	Have knowledge on contemporary issues.			11	16	8	35	3.91	0.720
Total			7	98	214	67			
Percentage (%)			1.81	25.38	55.44	17.36			

Average Mean: 3.88

References

1. Board of Engineers Malaysia (BEM), Engineering Programme Accreditation Manual, 2006.
2. The Faculty of Manufacturing Engineering Academic Guidebook 2005/2006.
3. Stouffer, W.B, Russell, J.S. and Oliva, M.G (2004) Making the strange familiar: Creativity and the future of engineering education. Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, American Society for Engineering Education.

Table 5. Curriculum structure of Manufacturing Design Engineering

	Year 1		Year 2		Year 3		Year 4		
Sem	**Sem 1**	**Sem 2**	**Sem 3**	**Sem 4**	**Sem 5**	**Sem 6**	**Sem 7**	**Sem 8**	
Compulsory Courses	Philosophy of Science& Technology BACW 1332	Co-Curriculum I BACW 1321		Co-Curriculum II BACW 2321	Comm. & Project Presentation BMFG 3912	Industrial Training BMFG 3926	Bachelor Project I BMFG 4913	Bachelor Project II BMFG 4923	**32 cdt hrs**
	Technical Communicatio n BACW1412	Titas I BACW 1312		Titas II BACW 2312		Industrial Report BMFG 3946	Engineering In Society BMFG 4812		
Program Core Courses	Engineering Mathematics BACS 1213	Sosio-Economic Development of Malaysia BACW 1322	Thermo-Fluid BMFG 2813	Technical Communication II BACW 2412	**Machine Tools Technology** BMFG 3363		CAD/CAM BMFR 4113	Business Entrepreneurship BMFG 4912	**75 cdt hrs**
	Physics BACS 1242	Differential Equation BACS 1223	Engineering Materials BMFB 2212	Machine Design BMFR 2123				Industrial Mgmt. & Costing BMFP 4512	
	Chemistry BACS 1232	Electric & Electronic Principle BENG 1113	Instrumentatio n & Control BMFA 2423	Fluid Power BMFA 2443				Industrial Law & O.S.H.A. BMFP 4573	
	Engineering Graphic & CADD BMFR 1313	Computer Programming BITG 1113	Applied Mechanic BMFG 2823	Numerical Methods BACS 2222					
	Applied Manufacturing BMFS 1313	Statistic & Probabilities BACS 2213	Manufacturing Process I BMFS 2513	Manufacturing Process II BMFS 2523					
			Industrial Engineering BMFP 2513	Quality & Reliability BMFP 2522					
Department Core Courses					**Plastic Materials & Metals** BMFB 3242		Design for Manufacturing BMFR 4143	Advanced Manufacturing Process BMFS 4353	**18 cdt hrs**
					Engineering Metrology BMFP 3543		Cutting Tool Technology BMFR 4353	Computer Aided Engineering Analysis BMFR 4163	
					Product Design BMFR 3133		CNC Technology BMFS 3373		
					Production Tools Design BMFR 3143				
Total Credit / Sem	**17**	**17**	**17**	**18**	**17**	**12**	**17**	**16**	
Total Credit	**131**								

Towards Achieving Excellence in Teaching and Learning for Electrical Engineering Bachelor Degree Program through the ISO 9001:2000 Quality Management System

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Abstract

To ensure quality in teaching and learning at the bachelor degree programs, the Faculty of Electrical Engineering, UTM has pursued on a quality management system (QMS) based on the ISO 2001:2000 standard. Besides the core teaching and learning process, the QMS covers supporting activities such as facilities, purchasing and human resources. Besides recognition at both the national and international levels, ISO QMS makes teaching and learning processes more transparent and traceable. The QMS has proven its worth during the previous EAC (Engineering Accreditation Council) accreditation audit in December 2005. It is also expected that the ISO QMS will again proves its usefulness in the next EAC accreditation audit in 2009 and as well as to meet MQA (Malaysia Quality Assurance) framework that is required by the Ministry of Higher Education. From the aspect of teaching and learning, implementation of QMS has resulted in the following benefits: reduction in subject grade variability within sections, minimize student failure rate, better counseling to students and parents, improve staff student ratio, and continuous improvement through data analysis and management review.

Keywords: quality management system; teaching and learning; engineering education

1. Introduction

Among the challenges that higher education in Malaysia has faced over the recent years includes the reduction in public fundings, competition from other institutions, strict scrutiny from stake holders and globalization. When Datuk Sri Abdullah Ahmad Badawi became the Prime Minister of Malaysia in October 2003, one of the policies introduced in his administration is ‘Belanja Berhemah’ that translates to efficient use of public funds. Public universities being part of the public sector can conform to this requirement by introducing cost cutting measures and generate income through off campus programs, professional courses, consultancy and commercialization of research and development. Public universities have no choice but to adapt to future challenges and manage the necessary changes required in the organization. Further examples of change management for universities are addressed in [1] [2] that involve both internal and external factors.

At present, there are 17 public universities, 20 polytechnic, 34 community colleges and 324 other private institutions [3] that offer a range of programs from certificate, degree to PhD levels. Compared to 30 years ago, there are only 4 public universities in Malaysia. Increase in the numbers means competition for operational funds, research grants, staff, and student enrolment. The academic program must be attractive for the potential students and the industry that will employ the graduate. Strict scrutiny from the stakeholders (students, parents, government and industry) through publications, media and personal contacts determines the winners in the fight for limited operational funds, research grants, staff and student enrolment. To be at the highest ranking, the public university must be able to produce quality academic program through recruitment of the best academic staff and supported by sufficient research grants both from the government and the private sector.

Another factor that comes into the picture recently is the globalization and internationalization of higher education that translates to national policy in higher education. In 2003, Malaysia was admitted to the Washington Accord as a provisional signatory nation alongside Germany and Singapore [4]. As a signatory nation, Malaysia has to demonstrate that its accreditation systems are conceptually similar to those of the full signatory members with respect to quality assurance in their engineering education programmes. The Washington Accord is a multinational agreement initiated by six English speaking countries USA, UK, Canada, Australia, New Zealand and Ireland in 1989. Its main objective is to recognize engineering degree equivalency by responsible accreditation bodies of member countries. The agreement allows mutual recognition of accreditation academic entry requirements and preparation for engineering practice in any member country. Which means a practicing engineering in Malaysia is recognized to practice in Australia or any member country. Admission to the Accord is an endorsement that the engineering education systems of the member nation have demonstrated a strong, long-term commitment to quality assurance in producing engineers ready for industry practice in the international scene. The Washington Accord agreement covers only professional engineering undergraduate degrees.

2. The Need for Quality Assurance in Academic Program

Admission to Washington Accords means the need for outcome based education (OBE) and quality assurance. At the national level, the framework for quality assurance is already established by the Ministry of Higher Education [5] and the Engineering Accreditation Council (EAC) [6] which adopts ABET frame work.

To ensure quality in teaching and learning at the bachelor degree programs as required by Washington Accord, the Faculty of Electrical Engineering, UTM has pursued on a quality management system (QMS) based on the ISO 2001:2000 standard. Part of the quality management system covers supporting activities such as facilities, purchasing and human resources. The road to certification began with an awareness program in the middle of 2002 followed by a series of workshops in 2003 to prepare the necessary procedures and documents. An adequacy audit was conducted in March 2004 followed by a compliance audit a month later that qualifies the faculty for certification. Besides recognition at both the national and international levels, ISO QMS makes teaching and learning processes more transparent and traceable. The experience has proven its worth during the previous EAC (Engineering Accreditation Council) accreditation audit in December 2005. It is also expected the ISO QMS will again proves its usefulness in the next EAC accreditation audit in 2009 and as well as to meet MQA (Malaysia Quality Assurance) framework that is required by the Ministry of Higher Education. From the aspect of teaching and learning, implementation of QMS has result in the following benefits: reduction in subject grade variability within sections, minimize student failure rate, better counseling to students and parents, improve staff student ratio, and continuous improvement through data analysis and management review. The faculty has successfully obtained recertification for the ISO 9001:2000 standard in April 2007.

3. Quality Management System

With a quality management system, a quality policy is adopted where the faculty is committed to provide a quality bachelor degree program in electrical engineering for technology development and technologist to meet customer requirement. The faculty will implement an effective and efficient quality management program that will ensure continuous improvement with the objective of becoming a world class organization. A set of quality objectives were defined according to student academic performance, academic staff performance, human resource requirements and customer feedback to benchmark the performance of the program.

All the necessary processes for the quality management system is summarized in Fig. 1 [7]. The PDCA (Plan-Do-Check-Act) cycle (ISO 9001:2000) is the basis of the quality management system and the process is required to meet the quality policy and objectives. The output of the process are measured and compared with the quality objectives. Management will act on the information measured and allocate the necessary resources to ensure continuous improvement and preventive measures are taken. Quality plan in Fig. 2 describes the main activities: registration, actual running of program, management of final exams and marks, and award of degrees. Supporting activities such as preparation of course materials and exam questions, and infrastructure such as facilities management and purchasing ensures that the main activities are conducted efficiently. The relevant documents necessary to support the quality management system are a quality manual (MK-UTM-FKE-01), 10 management procedures (PK-UTM-FKE-(P)-01:10), and 32 operational procedures (PK-UTM-FKE-(O)-01:32). Additional documents to support the quality management system include log books, check list and supporting documents published by the university and government.

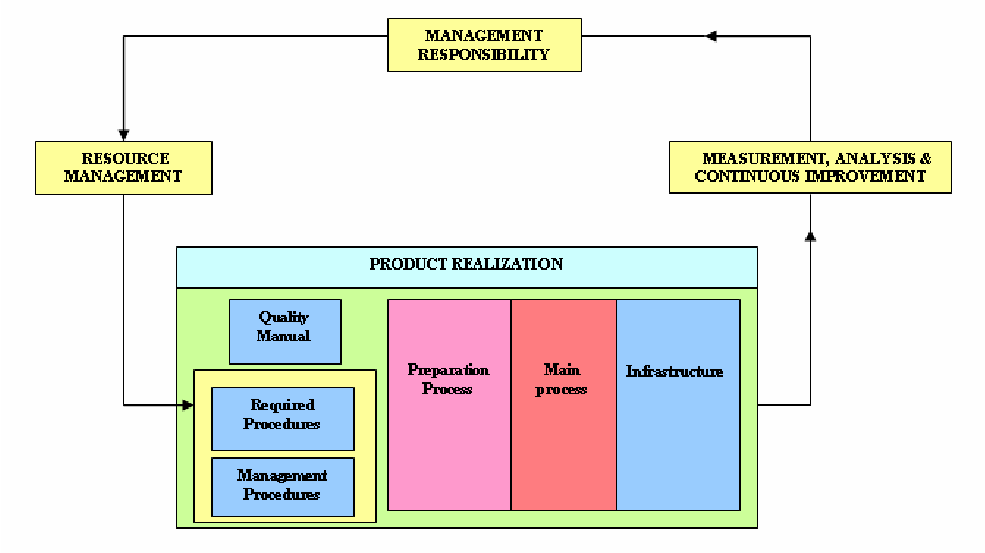

Fig. 1. Quality Management System.

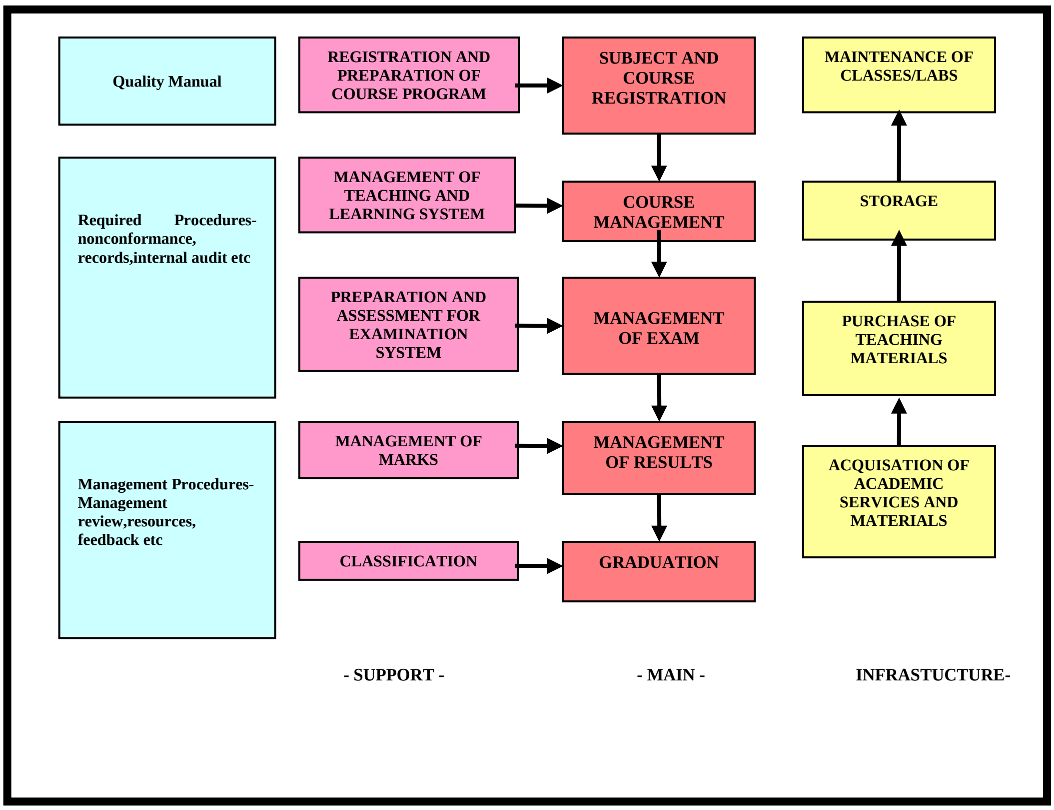

Fig. 2. Quality Plan.

4. Quality Policy and Objectives

For the quality management system, the faculty defines the quality policy and objectives. The quality policy is derived from the university's vision and mission [8] that is translated as

FKE is committed to provide quality Premier Bachelor Degree Program in all fields of electrical engineering at FKE to develop technology and excellent technologist to fulfill the customer need.

FKE will implement a quality management system that is efficient, effective and implement continuous improvement to be a world organization.

A set of quality objectives that is measurable and usable as a yard stick for continuous quality improvement. The objectives are as follows

1. To ensure that 40 % students graduates with CPA > 3.0.
2. To ensure that the % of students passes is at least 80% for each subject.
3. To ensure at least 95 % student achieve good standing (KB-Kedudukan Baik) by 2007.
4. To increase the number of academic staff with PhD to at least 60.
5. To ensure the academic staff student ratio better than 1:15 by 2007.
6. To publish more than 100 academic publications a year.
7. To ensure the mean teaching performance indicator for academic staff better than 4.0 from a scale of 5.0 for each semester.

The quality objectives were derived from a series meetings and workshop at the faculty throughout 2003 and were based on the data collected from academic and research activities from 1995 to 2002. Objectives 1-3 were chosen to reflect the deliverables in based on the academic performance of the students while objectives 4-7 were chosen to measure the performance of the academic staff in terms of academic qualifications, staff-student contacts, publications, and teaching and learning. All of measurements for the quality objectives are self explanatory except that for the staff student ration it is based on the total number of academic staff and enrolled students. Academic staffs include those on study leave. The quality objectives are compared with the actual performance data twice a year at the management review meetings and both internal and external audits. Any discrepancy identified will be highlighted to the management for the necessary corrective actions. Both the quality policy and objectives will be reviewed and changed accordingly once they are achieved.

5. Results and Discussions

The performance of the faculty when compared with the quality objectives are presented in Fig. 3 to Fig. 9. In general, all the quality objectives are met and they are achieved from a series of corrective actions that was conducted beginning from 2002. In addition, the ISO QMS system had greatly assisted in the faculty in getting accreditation for the Bachelor degree programs in electrical engineering in December 2005. The faculty has also successfully obtained recertification in April 2007.

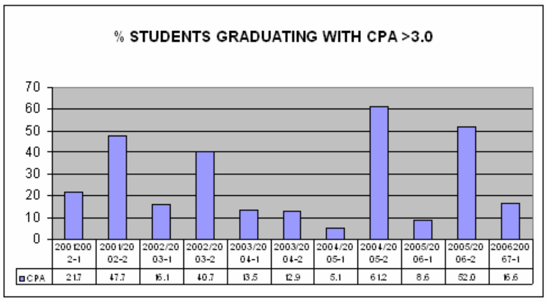

Fig. 3. Percentage of students graduating with CPA>3.0. [Quality objective 1, target is greater than 40 %]

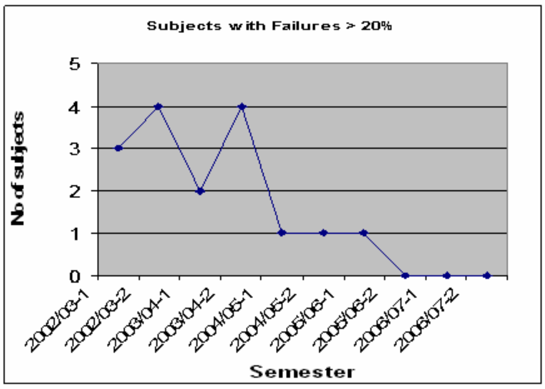

Fig. 4. Subjects with failures of < 20%. [This is to ensure that quality objective 2 is met]

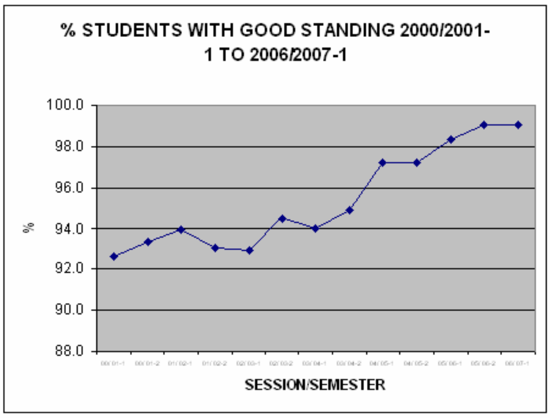

Fig. 5. Percentage of students with good standing. [Related to quality objective 3, target is greater than 95%]

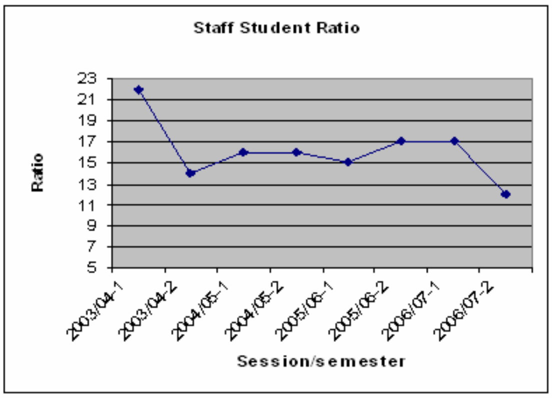

Fig. 6. Academic staff student ratio. [Related to quality objective 4, target is less than 1:15]

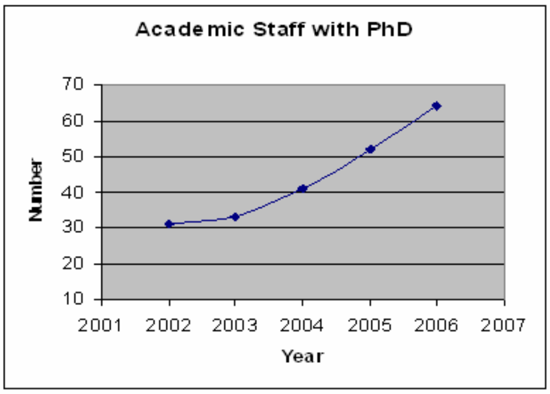

Fig. 7. Academic staff with PhD. [Related to quality objective 5, target is greater than 60]

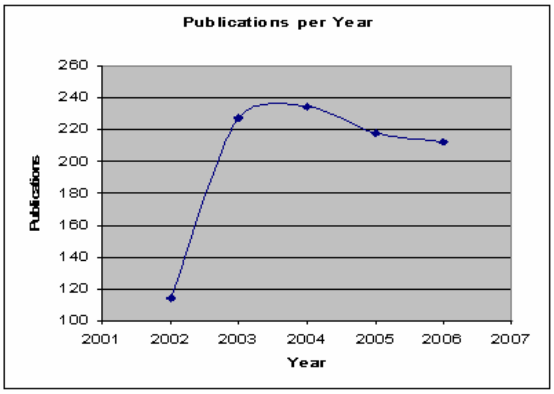

Fig. 8. Number of publications per year. [Related to quality objective 6, target is greater than 100]

To ensure quality objectives 1, 2 and 3 are met, corrective actions taken are

1. Identify problematic subjects those are subjects with high percentages of D and E grades, and highlight them to the respective subject coordinators and lecturers.
2. Utilize alternative ways for teaching through student centered learning such as active learning and problem based learning, and encouraged the use of software such as PSPICE or MATLAB.

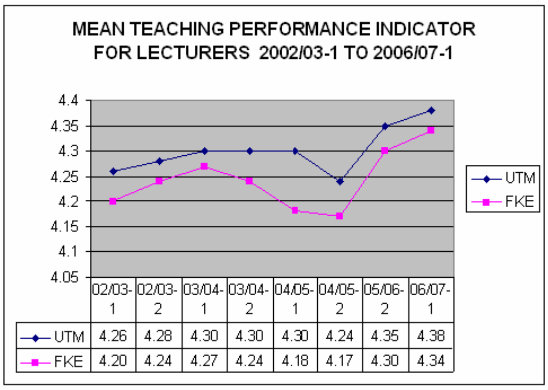

Fig. 9. Mean teaching performance indicator for lecturers. [Related to quality objective 7, target is greater than 4.0]

3. Ensure the choice of questions for tests and final exams conform to Bloom Taxonomy. Distribution of questions depends on the level of subjects; first year should emphasized on questions in level 1 and 2 that us knowledge and understanding while the final year subjects on level 4 and 5 that is synthesis and evaluation.
4. Evaluation of draft final year exam papers must include the marking scheme. This way the evaluation panel can access if the questions are of relevant in terms of content, level of difficulty and the required completion time.
5. The subject coordinators are required to monitor the running of the classes during the semester to ensure that the syllabuses are covered within the required time. Lecturers who needs to go to conferences or out station meeting are required to plan immediate replacement classes and not have it in last minutes. Evaluations such as test or quizzes are required before the mid semester break so that students can decide to continue or drop a subject before the date line in week 10.
6. Students with CPA of less than 2.0 are identified and meeting sessions involving the Dean, the faculty administrations, parents and students are held every semester so that all the options are clearly explained whether to change course, go to diploma program or enroll in the off campus program. Congratulatory letters are sent to parents of students with CPA > 3.5 to ensure the students continue with their good work.
7. Meet the student and parent sessions are conducted as part of the orientation program for new students. This is to explain from the beginning in brief the academic procedure, what it takes to complete a bachelor degree program in UTM, and address any questions and concerns are raised by the parents.

To increase academic staff with PhD qualification, the following steps were taken

1. Dialog session with existing staff who has not pursue their PhD.

2. New staff intake upon graduation with bachelor degree and encourage them to pursue PhD as soon as possible.
3. Offer contract position for retiring staff who holds a PhD qualification.
4. Identify suitable candidates for contract academic staff.

The academic staff student ratio can be achieved by reducing student intake for the bachelor degree program and increase staff recruitment. For the 4 year bachelor degree program, the student intake has reduced by 10 percent compared to the 5 year bachelor degree program. The faculty has embarked on looking for qualified candidates for contract and permanent academic staff.

To increase publications, academic staffs are encouraged to pursue research grants. Based on present performance, the faculty has managed to secure RM 20 million in from government funds and through contract research with the industry such as Intel, Agilent and SCS. Academic staffs with research grants are required to use their research funds for presenting papers at conferences. While, the junior and non funded academic staffs can utilize the faculty budget..

At present the teaching performance index for the faculty is above the set limit of 4.0 but is less compared to the university average. The faculty has identified the non performing academic staff, and counseling are conducted at the department level. Before the forms are filled, the students are explained about the evaluation process and their expectation. Consistent non performers are identified for teaching training courses to be conducted at the university.

6. Conclusions

The implementation of the ISO 9001:2000 quality management system at the Faculty of Electrical Engineering, UTM has greatly improve teaching and learning process. This can be observed in comparison with the quality objectives. On the average, all the quality objectives are met and will be revised accordingly. Since certification in April 2004, the quality management system has greatly assisted in the accreditation of the 5 year bachelor degree program in December 2005. With recertification in April 2007, the quality management system is expected to play an important role in achieving the accreditation of the 4 year bachelor degree program in 2009.

Acknowledgement

The authors would like to thank all the faculty members for their contribution in the success of implementing the ISO 9001:2000 QMS. Indirectly, their efforts ensure the success in the accreditation of the bachelor degree program and recertification of the QMS. Without the faculty members, there will not be excellence in teaching and learning at the faculty.

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Creative Design: Course Implementation and Assessment in UTeM for Outcome Based Education

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Abstract

Creative design is a compulsory course for second year student in design & innovation department of Universiti Teknikal Malaysia Melaka (UTeM). This course is aimed to enrich the creativity of student by imparting them with few established creative techniques particularly in generating ideas for identifying design opportunities and concept development. This course require for combination of both skill and cognitive capability. The teaching approaches and assessment methods of this course are presented in this paper towards outcome-based education (OBE). The outputs from a few of in-class activities are also presented to monitor the effectiveness of teaching approaches. At the end some conclusion are made and future recommendation are proposed for improvement.

Keywords: outcome based education; creative design; teaching experience

1. Introduction

When human face a problem they start to think the way to solve it. They may need a tool to overcome the problem or to reduce the difficulties they face. The tool they need may unavailable yet or available but unsuitable to be used to solve their problem. This situation may lead human to design a new tool or to modify the existing tool which is to suit to their requirement. The term ‘design’ gives different meaning to different people. To some, design is to create or produce something new. To others design is the conscious decision-making process by which information (an idea) is transformed into an outcome, is it tangible (product) or intangible (service) or creation of sophisticated system such as machine. A formal definition of engineering design is found in the curriculum guidelines of the Accreditation Board for Engineering Technology (ABET). The ABET definition states that engineering design is the process devising a system, component, or process to meet desired needs. It is decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective (B.S. Dhillon, 1996). In general, the design can be divided into three main categories: creative design, adaptive design and developmental design (Youseif Haik, 2003). Creative design is the term use when totally new product is produced without any precedent whatsoever. This type of design requires a high degree of competence. However in real environment few design engineers employ this type of design activity. Therefore design courses such as Manufacturing design, Industrial design, Creative design, Element of machine design and etc. are imposed to Mechanical Engineering students.

In this paper the implementation of Creative design course in Universiti Teknikal Malaysia Melaka (UTeM) for Outcome Based Education (OBE) is presented. It also describes the techniques and tool that has been introduced to freshmen student to help them to develop their creativity, interest, thinking capability and skills. At last the learning outcomes of this course are assessing based on the assignments work, projects work, poster making and oral presentation through a suite of systematic assessment forms.

2. Design course in faculty of mechanical engineering UTeM

The elements of design are emphasizing throughout of the Mechanical Engineering curriculum of UTeM which is specializing in design & innovation. As early of second year, students, which are specializing in design & innovation, are exposed to 8 design courses that will contribute to 23 credit hours in total. The design courses offered to students were; Creative design (BMCI 2512), Manufacturing design (BMCI 2523), Industrial design (BMCI 3533), Design & Innovation I (BMCI 4543), Reliability & Quality design (BMCD 4543), Product management (BMCI 4573), Design &

Innovation II (BMCD 4563) and Optimization & Analysis design (BMCD 4533). These courses were introduced to student with the main focus is to introduce students to the engineering profession and creative engineering problem-solving through projects design, presentations, and in-class activities.

3. Development of creative design course syllabus

Creative design is one of the compulsory courses for student in Design & Innovation Department, Faculty of Mechanical Engineering of UTeM. This course is offered in the 1st semester of studies to 2nd year student. The major objectives of this course have been designed as to develop student that is capable to apply creative thinking techniques and strategies in designing pleasing products or structures. Applying ideation methods to brainstorm new innovation, translating it into drawing by manual or digital sketching and presenting the design solution to the audience. Thus the learning outcomes by the time of course completion are developed as follows:

The student should be able

1. Learn and apply all of the steps of the engineering design process in proposing and building working devices or models in design projects.
2. Apply the engineering principles revealed in class exercises on teamwork, creativity, problem solving, and on evaluation, selection, and implementation of solution alternatives
3. Describe the scientific principles and technical background required for the proposed design
4. Develop and apply drawing and sketching skills to communicate design and engineering information graphically
5. Create and deliver team presentations on engineering design projects.
6. Generate a report for the design project that reflects work completed in each step of the design process and presents technical drawings that apply to the approved design.

To achieve these outcomes lecture are emphasized on the following:

1. Defining creativity, innovation and design, to give an overview of the role of creativity in engineering design process,
2. Explaining creative thinking strategies and thinking styles
3. Explaining creative techniques to generate idea or solution
4. Familiarization with Alias Design software as a tool for digital sketching
5. Educate and cultivate student to be a creative person
6. Develop understanding of design definition and innovation and also in relationship with creative design course

This course has been designed to fulfill certain criteria of Program Objectives (PO) of a engineering graduates that has been outlined by Engineering Accreditation Council (EAC) as was published in EAC Manual 2003 and it were: ability to communicate effectively, not only with engineer but also the community at large; ability to undertake problem identification, formulation and solution; and ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member. Anyhow the level of contribution to the stated generic attributes was at level of 2 and 3 if it is ranging from 1 to 3 levels. Table 1 shows the generic learning outcome versus PO of graduate of Creative design course.

To ensure all the above attributes are achieved at the end of the lesson a comprehensive teaching plan of creative design course was designed as such as shown in Table 2.

4. Scenario of course implementation

4.1. Lecturing

The scenario of course implementation in UTeM has a bit different with others conventional universities in Malaysia. In case of Creative design course which is contribute 2 credits hour it take about for 1 hour lecture and 3 hours tutorial per week and run throughout the semester. Meaning that for this course the student needs to spend 4 hours a week. The lecture takes place in lecture room and emphasizing toward to two-way communication style between lecturer and student, project based and in-class exercises. In certain topic student the in-group of sixth has been asked to conduct a brainstorming activity for 20 to 30 minutes. Fruitful of the fantastic idea has been produced from this activity. This activity has been carried out by them with close monitoring of lecturer. Prior to this session the rules of brainstorming session have been explained in the lecture. To ensure this session attractive and able to attract the participation of student the given problem has been focused on social problems rather than to focus on engineering design issue.

Table 1. Learning outcome vs. PO of graduate

No	Learning Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	Delivery	Assessment
1	Learn and apply all of the steps of the engineering design process in proposing and building working devices or models in design projects.												Lecture Class discussion	Progress report Minute of meeting
2	Apply the engineering principles revealed in class exercises on teamwork												Lecture Group discussion	Minute of meeting
3	Describe the scientific principles and technical background required for the proposed design												Lecture Group discussion	Project report
4	Develop and apply drawing and sketching skills to communicate design and engineering information graphically												Lecture Self explore	Project report
5	Create and deliver team presentations on engineering design projects												Lecture	Oral presentation
6	Generate a report for the design project that reflects work completed in each step of the design process and presents technical drawings that apply to the approved design.												Lecture Project based	Project report Poster presentation

Table 2. Summarizes the teaching plan of creative design course

Topic	Lecture emphasize	Activities
Introduction	Definition Problem definition Source of idea	Lecture Case study
Thinking styles	Creatively thinking, definition and creative problems solving, project presentation and documentation	Lecture
Creative Thinking Techniques in concept generation and design process	Brainstorming Why? Why? Why? Analogy Morphology chart	Lecture Case study
Design process	Design problem and brief Analysis Synthesis Planning Research Specifications Ideas Development Solution Evaluation	Lecture Case study
Sketching techniques	Basic drawing equipments Shading technique Perspective drawing Isometric drawing Oblique drawing Orthographic drawing	Lecture Exercise Assignments
Design Communication	Presentation: do and don't Report Writing techniques Structure of Design report	Lecture Assignments

As an example in first brainstorming session the student has been asked to brainstorm for the reasons for unemployed graduates. Amongst the reasons has been highlighted as expected such as; student unable to communicate effectively, student does not has enough skills, student is too choosy in finding a job, student does not have working experience, student weak in English speaking and student course is not relevant to industry requirements. At the end the lecturer make a conclusion about the session as well as explaining the brainstorming session with engineering design problems and also the important to follow the brainstorming rule and applying creative thinking style rather than critical thinking to produce fruitful ideas during brainstorming session. It has shown that through the brainstorming session the student thinking still moving around the box because all the ideas that have been thrown are argued by the student in group itself. This activity is not to address shortcoming of anybody but it has been used to recognize thinking style of student and can be concluded that the majority of the student employing analytical thinking style in the brainstorming session which can be recognized through thinking structure as shown in Fig. 1. In analytical thinking style the problem is decomposed into sub problem and sub of sub problems.

4.2. Project based learning

Project-based learning is one of the essential and effective learning methods. Project-based learning emphasizes peer learning and active participation of team member (Davie & Wells, 1991; Baillie & Walker, 1998; Blicblau & Steiner, 1998). This learning method will provide the hands-on experience to designer in team project and to stimulate curiosity and a desire to student to succeed and also has been used as a tool to foster the creativity of student in Creative design course. In second of the semester student in a group of five has to work in team to carry a creative design project and to produce a working prototype. All the require knowledge such as concepts development, skills and problem solving techniques which is applicable to daily life and design process activities already lectured and discussed during the theoretical class. Since the creative design project is an open-ended solution, each team is free to come out with any kind of product as long as it is within Creative design scope. The design must be in the engineering application while the art design is totally prohibited. However each team is required to obtain supervisor permission before they can proceed with their project. Upon selecting the project theme or project title the team have to submit their project design proposal. A progress report has to be submitted weekly during tutorial class to in-charge project supervisor mainly to brief about the current status and achievement, action taken, future plan, and any sketches if it is necessary. A formal meeting among the team member with the attendance of supervisor has been conducted at least once a week to give an opportunity to team member to discuss further detail about the project. This meeting becomes a platform to student to arise any problems encountered during the execution of project works. All the important decision has been made in the meeting is stated in the minute of meeting. Each team member has an opportunity to become as a chairperson or secretary of the meeting. All individual contribution to teamwork will be assessed through peer assessment method and it will carry certain marks to final grade. Finally formal project report and product prototype are the major outcome at the end of the project works.

4.3. Student design competition

Student design competition becomes an annual event to Faculty of Mechanical Engineering. This event is open to Mechanical Engineering student and mandatory to student who registered to take Creative design course in the particular semester. This event was organized with the aim to expose and cultivate knowledge sharing among the student. They also have an opportunity to sharpen their oral communication skill especially when they need to explain about product to the judges during judging process. Beside oral communication the poster making is an essential as the way of communication. The poster making is has been decided as one of the criteria for assessment during the design competition event. Since the year 2005 the faculty had organized two product design competitions. Fig. 2 shows the student design competition event that was held in November 2006.

4.4. Student works assessment

The assessment method of the Creative design course is based on the author experience and discussion with others colloquies. The expected learning outcomes are always referred in designing assessment scheme. This is to ensure every expected of learning outcomes, which were mentioned to class will be fairly assessed. The main important assessment criteria were; technical content, communication, teamwork and acquired skills. The outputs were assessed was presented in Table 2.

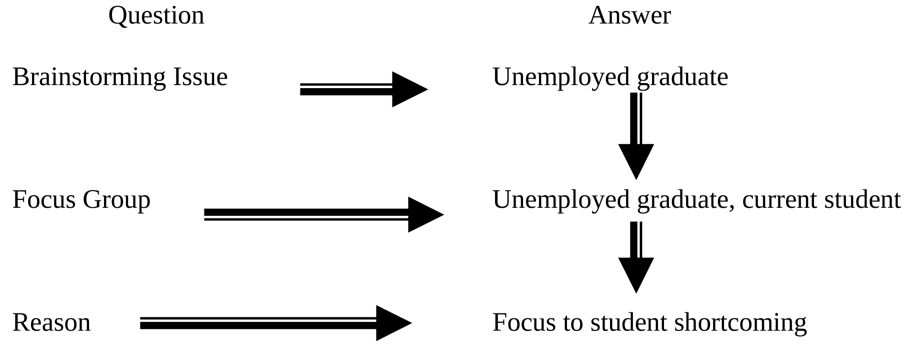

Fig. 1. Flow of student thinking in brainstorming session

Fig. 2. Scenario of product design competition event in 2006

Table 2. Distribution of assessment criteria and weigh for creative design course

Assigned tasks	Output to Assess	Criteria to Assess			
		Technical content	**Communication**	**Teamwork**	**Skill**
Assignments	Report	Yes	Yes	No	Yes
Creative design project	Progress report	Yes	Yes	No	No
	Prototype	No	No	Yes	Yes
	Formal report	Yes	Yes	No	Yes
	Oral presentation	Yes	Yes	Yes	Yes
	Poster making	Yes	Yes	No	Yes
	Minute of meeting	No	Yes	Yes	No
Level of Contribution to generic attributes		**3**	**3**	**2**	**3**

4.5. Formal report

Formal report is a group report and it describes the total process of design activities, which is including introduction, market survey, product design specification, conceptual design, detail design, prototype development, conclusion, and future recommendation. The formal report primarily aimed to develop report writing skill to university student. The marking scheme for formal report writing is shown in Fig. 3.

4.6. Progress report

Progress report was implemented to monitor the status of the project. This is single piece of paper and it should contain the current activities, what was done, problem encountered, future plan and any sketching id possible. This is report was submitted weekly and was assessed based on the group. Fig. 4 shows the marking scheme for the progress report.

Group Name:						
No	**Evaluation Criteria**	**Assessed criteria**				
1.	Current activities, planned activities, achievement	1	2	3	4	5
2	Problem encountered, problem solving	1	2	3	4	5

Fig.4. Marking scheme for progress report

No	Criteria	Given Mark				
1	**Originality** Own sentence; cited when required; presentable	1	2	3	4	5
		6	7	8	9	10
2	**Continuity** Continuity from paragraph to another paragraph; record what ever learned; simple and straight forward; comprehensive and attractive	1	2	3	4	5
		6	7	8	9	10
3	**Quality** Follow as provided guidelines; effectively answer reader's question as they arise; give good impression; read coherently; provide pertinent information; are written clearly and concisely.	1	2	3	4	5
		6	7	8	9	10
4	**Structure and technical content** Each chapter should begin with topic sentence that provide an overall understanding of chapter; Each chapter should end with conclusion; Figures and tables have descriptive caption and carefully plan placement of its.	1	2	3	4	5
		6	7	8	9	10
5	**Language** Sentence length should be kept as short as possible; Simple and readable; free grammatical error and spelling error; no personal pronouns (I, she, he our) are used in report.	1	2	3	4	5
		6	7	8	9	10

Fig. 3. Marking scheme for formal report

Group Name :						
No	**Evaluation Criteria**	**Given Marks**				
1	Is the title clearly stated	1	2	3	4	5
2	Is the content presented in a logical manner?	1	2	3	4	5
3	Is the content clear and easy to understand?	1	2	3	4	5
4	Is the display free of unnecessary detail?	1	2	3	4	5
5	Is there appropriate use of white space to avoid crowding?	1	2	3	4	5
6	Legible (large fonts, good color contrasts, minimum of words)	1	2	3	4	5
7	Proofed (no grammatical or spelling errors),	1	2	3	4	5
8	Coordination of graphics with text, Figures and tables convey results effectively	1	2	3	4	5
9	Does the display attract the attention of the viewers? Coloring, sequence, presentation style,	1	2	3	4	5
10	Logical order, Minimum redundancy, Smooth transitions Effective use of space	1	2	3	4	5
TOTAL SCORE						

Fig. 5. Marking scheme for poster making

4.8. Minutes of meeting

To ensure able to work in team either as a leader or member and play their role effective in team the assessment scheme was implemented through peer assessment form. How the sincerity of student when assessing their team members are required. The lecturer may countercheck the marks awarded by team member by reviewing minutes of meeting. This was done by random selection. Peer assessment form for creative design course was shown in Fig. 6.

Group Name:						
Name of team member		**Marking scales 1-5**				
		Ahmad	Aqilah	Atiqah	Kumar	Wong
Evaluation criteria	Attendance in meeting					
	Contribution to team					
	Commitment to the team goal					
	Communication with others					
	Accept criticism gracefully					
	Meet deadline					
	Responsible					
	Voluntary attitude					
	Listen well					
	Perform significant work					

Fig. 6. Marking scheme for peer assessment

4.9. Presentation

Oral presentations play an important role as a medium to convey the design idea to internal or external clients, investor, or top management. In this course the student has an opportunity to develop their oral presentation skill, as they are required to present the design project in front of class twice in a semester. The emphasizing in the oral presentation is stated in the marking scheme for oral presentation as shown in Fig. 7.

4.10. Prototype

The final output for the design project is shown as a tangible product. The student has to translate the technical drawing into working prototype. They need to fabricate the prototype as similar as to the true product either in actual size or in small-scale product. The important criteria in assessment scheme for prototype are shown in Fig. 8.

4.11. Student Assessment to Course Delivery

At the end of course student assessment to course delivery has been conducted with the help of Quality Assurance & Accreditation Center of UTeM to measure the satisfaction of student the course delivery, content and facilities. This assessment is intended for continuous improvement effort as to rectify and improve the teaching & learning activities in UTeM. Fig. 9. shows the criteria and level of student satisfaction in Creative Design course. In this paper the analysis of the student assessment to course delivery is not presented.

5. Conclusion

The implementations of creative design course for OBE present many challenges. A proper delivery techniques help student to open up their mind and able to develop creative thinking among student. With proper learning outcomes and assessment scheme students are able to focus on the outcome for their works.

Group Name:						
Group Members: **1.** **2.** **3.** **4.**						
1.	**Level of preparation** Expressed in the slides' quality and content	1	2	3	4	5
2.	**Level of audience engagement** Eye contact with the audience	1	2	2	4	5
3.	**Level of professionalism** Was the speaker dressed properly, and did he or she act professionally during presentation	1	2	3	4	5
4.	**Communication skill** Was the presentation clear? Was the speaker able to convey the message?	1	2	3	4	5
5.	**Time management** Did speaker leave time for Q&A? How much time really need to convey the message	1	2	3	4	5
6.	**Technical content**	1	2	3	4	5
Total						

Fig. 7. Marking scheme for oral presentation

No.	Criteria	Given marks				
1.	**Innovation** Concept strength in term of technique which benefited to customer	1	2	3	4	5
		6	7	8	9	10
2.	**Functionality** Fulfill the customer needs, meet the aimed function and overcome problems arisen	1	2	3	4	5
		6	7	8	9	10
3.	**Quality** Appearance, manufacturability, material and technology	1	2	3	4	5
		6	7	8	9	10
4.	**Idea** New, original, logic and commercial value	1	2	3	4	5
		6	7	8	9	10
Total						

Fig. 8. Marking scheme for product prototype

No	Criteria	N	Mean	Standard derivation
1	Course Objective is well explained	31	4.03	.795
2	The course cont is well stated	31	3.74	.893
3	The time table was exactly followed	31	4.00	.816
4	The explanation is given with the aid of illustration and example	31	3.81	.792
5	Always ready to deliver	31	3.87	.718
6	The conclusion is given at the end of the lecturing session	31	3.52	.811
7	The delivery is easy to understand	31	3.74	.682
8	Lecturer is easy to meet upon appointment	31	3.58	.620
9.1	Lecture	31	4.03	1.016
9.2	Tutorial/Assignment	31	4.29	.693
9.3	Experiment/Simulation	31	4.17	.791
9.4	Case study/Mini project	30	4.03	.785
10	Course work help to improve my capability in problem solving	30	4.06	.795
11	Illustration and example help for my remembrance	31	3.97	.772
12	Opportunity to interact and to give an opinion in class develop my self esteem	30	4.10	.928
13	I a1m clear the direction of this course	31	3.87	.746
14	In overall I am satisfy with the quality of this course	31	3.87	.957
15	The work load for this course is acceptable	31	2.84	.957
16	Reference material is enough	31	3.35	.1.098
17	Facility in the workshop is enough	31	3.48	1.170
18	The teaching aids is well functioned	31	3.52	1.029
19	Teaching and learning environment is conducive	31	2.55	1.061
20	It faculties is enough	30	3.879	1.121

Fig. 9. Performance report of the Creative design course delivery

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Employers' Perception on Technical Attributes of Engineering Graduates in Malaysia

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Abstract

Feedbacks from employers on the quality of engineering graduates produced by local Institutions of Higher Learning are important, for example to see if there is any need to revise their engineering curriculum. The paper therefore discusses a comprehensive study of employers' perception of Malaysian engineering graduates towards assessing measurable qualities. To have a better overview of this issue, a survey on the needs and perceptions of Malaysian industries towards graduate engineers is conducted. In order to create a smoother transition from education to practice, some argue that engineering education should put more emphasis on the engineering-based knowledge. Thus, this study investigates the perception of the majority of Malaysian industries towards future engineering workforce. For the purpose of this paper, only the technical or engineering-based attributes such as basic engineering knowledge, ability in theoretical and research engineering, technical competency in a specific engineering discipline and others are discussed. Data were gathered from face-to-face interview sessions using a set of questionnaires from a total of 422 companies from various industries in Malaysia. The respondents were mainly from high ranking personnel in their firm. The outcomes of this study will later be used as a guideline to revise the engineering education curricula of Malaysian Institutions of Higher Learning.

Keywords: engineering graduates; Malaysia; employer; perception; technical attributes

1. Introduction

In the fast changing technological and globalised world that we see today, engineers are required to perform increasingly complex engineering tasks. The competencies of future engineering graduates must be identified, assessed and reinforced as necessary. Consequently, it is inevitable that changes in engineering education are required to ensure these competencies remain relevant and are being achieved. In the US, industries perceive that engineering students are not adequately prepared to enter the workforce [1]. In order to create a smoother transition from education to practice, some argue that engineering education need to give more emphasis on teamwork, communication, knowledge retention and the ability to synthesize and make connections between courses and fields [2]. Emphases on developing these professional skills are also highlighted in Engineering Accreditation Council Manual [3]. Specialised technical courses might be more appropriately covered in more advanced postgraduate programs as this will encourage continual professional development as expected of professional engineers [4].

To shed light on this question in the context of Malaysia, a comprehensive survey is currently being conducted on the perception and needs of Malaysian industries towards graduate engineers. Among the objectives of the survey is to investigate the current level of employer perception with regard to existing engineering graduates towards assessing measurable qualities. This paper discusses the perception on some technical attributes, such as basic engineering knowledge, ability in theoretical and research engineering, technical competency in a specific engineering discipline and a few others, of some selected sectors or industries in Malaysia, towards their engineering work force. Discussion on non-technical attributes, or softskills, can be referred to references [5] and [6].

2. Methodology

A total of 422 companies from various industries were selected randomly and purposively using convenience sampling based on firms where engineering students normally undergo industrial placements. The breakdown of selected companies according to industry is shown in Table 1.

Data collection was carried out through face-to-face interviews using a set of questionnaires. The interviewed respondents were mainly high ranking personnel in the firm, i.e. of the 422 companies, 44% interviewed are Human Resource Managers, 33% General Managers, 12% Executive Directors, 6% Chief Executive Officers, 3% Chief Operating Officers and 2% Chairmen.

Table 1: Distribution of respondents by industry

Industry	No. of Responses	%
Healthcare, Social, Entertainment & Leisure	39	9.2
Education & Consulting	70	16.6
Commerce, Trade, Finance, Agriculture & Food	55	13.0
Communication, IT, Defense, Security, Transport	43	10.2
Materials Engineering, Energy & Natural Sources	102	24.2
Built Environment	113	26.8
TOTAL	**422**	**100**

3. Results and discussion

In this study, the level of satisfaction of employers towards a particular attribute as listed in Table 2 possessed by their current engineering workforce required answers on a 5-point Likert's scale. The answers are divided into five categories, i.e. 'most satisfactory', 'satisfactory', 'neutral', 'not satisfactory' and 'not satisfactory at all'. In this instance, in order to simplify the 5-point scale, answers belonging to the first two categories are grouped as 'Satisfactory', while those belonging to the last two categories are grouped as 'Not Satisfactory'. These are shown in Fig. 1.

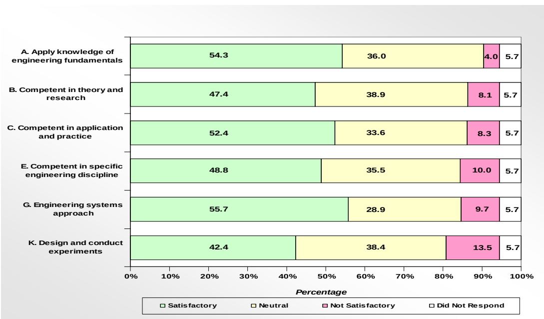

Fig. 1. Employers' satisfaction on technical attributes of their engineering workforce.

Table 2: List of attributes of workforce

A	Ability to acquire and apply knowledge of engineering fundamentals.
B	Having the competency in theoretical and research engineering.
C	Having competency in application and practical oriented engineering.
D	Ability to communicate effectively, not only with engineers but also with the community at large.
E	Having in-depth technical competence in a specific engineering discipline.
F	Ability to undertake problem identification, formulation and solution.
G	Ability to utilise a systems approach to design and evaluate operational performance.
H	Ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member.
I	Having the understanding of the social, cultural, global and environmental responsibilities and ethics of a professional engineer and the need for sustainable development.
J	Recognising the need to undertake lifelong learning, and possessing/acquiring the capacity to do so.
K	Ability to design and conduct experiments, as well as to analyse and interpret data.
L	Having the knowledge of contemporarry issues.
M	Having the basic entrepreneurial skills

Of the thirteen attributes listed in Table 2, this paper will only discuss those considered as the technical attributes, i.e. A, B, C, E, G and K. Figure 1 shows the level of satisfaction of employers of such attributes towards their engineering workforce. The responses signify the importance of knowledge, skills and experience that engineering graduates should possess. This is shown by percentages of the 'satisfactory' level, which is between 42% and 56%. These values were obtained for all the attributes related to knowledge, skills and experience. From this figure, the employers are mostly satisfied with the aspect of engineering system approach (attribute G) of their workforce (56%). They are dissatisfied with the aspect of design and conducting experiments (attribute K) of the workforce, scoring only 42% satisfactory level. Otherwise, other attributes scored approximately 50% satisfactory level.

Fig. 2 to Fig. 7 show the distribution of satisfactory level of the industries on the respective technical attributes of their engineering workforce. Fig. 2 shows the employers' satisfactory level of the workforce with respect to the ability to acquire and apply knowledge of engineering fundamentals (attribute A). This is an important attribute that engineers should have when working in an engineering environment. The engineers' performance with respect to this attribute may be a reflection of their achievements during the tertiary education. It is soothing to see that this attribute scores a high 69% of satisfactory level as given by the Education and Consulting group. The Engineering Materials, Energy & Natural Sources group scores the lowest satisfaction value for this attribute, i.e. at a mere 40%; followed by the Commerce, Trade, Finance, Agriculture & Food, at a low 42%. This study was not designed to investigate the factors that have contributed to this trend. However, perhaps it may be speculated that this trend may be related to the fact that certain subjects particularly finance, trade and commerce are minimally covered in an engineering syllabus at first degree level.

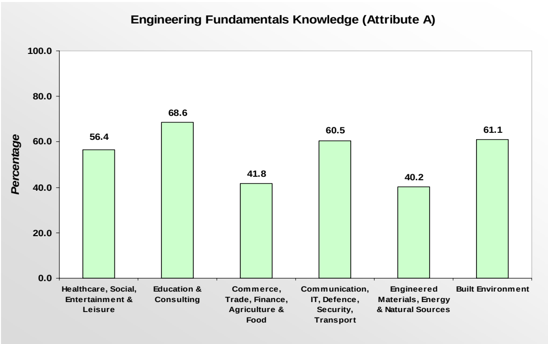

Fig. 2. Employers' satisfaction of their workforce with respect to 'applying knowledge of engineering fundamentals' (attribute A).

Fig. 3 shows the satisfactory level of the workforce with respect to competency in theoretical and research engineering (attribute B). It is striking that four of the groups scored less than 50% satisfactory level, with the Commerce, Trade, Finance, Agriculture & Food scoring the lowest, i.e. 40%. The highest score was given by the Healthcare, Social, Entertainment & Leisure group, of approximately 62%. The trend shows an indication that majority of our engineers across the groups have a relatively low competency level on theoretical and engineering research.

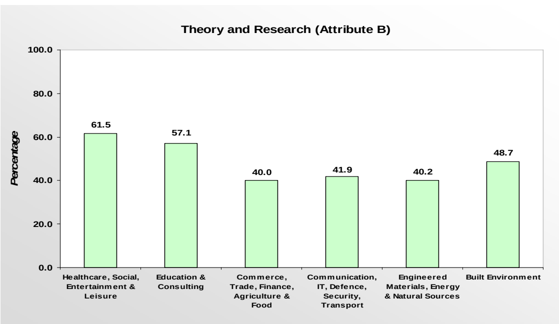

Fig. 3. Employers' satisfaction of their workforce with respect to 'problem solving' (attribute B).

Fig. 4 shows the distribution of satisfactory level with respect to attribute C, i.e. application and practice. Once again the Engineering Materials, Energy & Natural Sources group scores the lowest satisfaction value, this time at 44%. This is understood since tertiary education can only provide limited practical training to their graduates due to various factors such as cost and course duration, to name a couple. The highest score is again obtained by the Education and Consulting group, at 63%. Three other groups also seemed to have received positive perception from the employers interviewed, scoring between 51 to 56% satisfactory values.

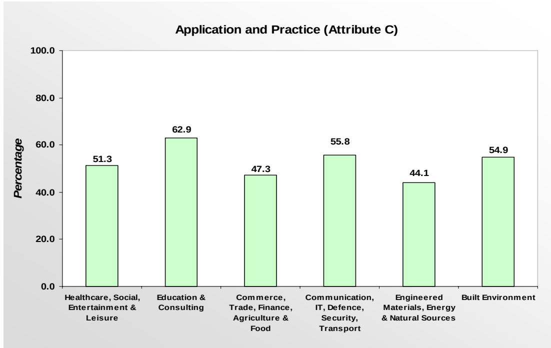

Fig. 4. Employers' satisfaction of their workforce with respect to 'application and practice' (attribute C).

Another interesting observation from this study is on attribute E (competency in specific engineering discipline). As shown in Fig. 5, Healthcare, Social, Environment and Leisure; and Built Environment groups are most dissatisfied with their engineering workforce in this respect, scoring only 44% each, followed by group Materials Engineering, Energy & Natural Sources at 45%. The highest score again was recorded by the Education and Consulting sector.

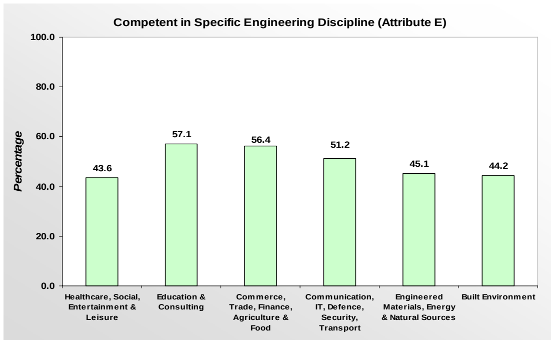

Fig. 5. Employers' satisfaction of their workforce with respect to 'competent in specific engineering discipline' (attribute E).

The fifth technical attribute is engineering systems approach, and this is shown in Fig. 6. For the fifth time, the employers in Education and Consulting are quite satisfied with their engineers, this time scoring a high 61%. The highest score is given by the Communication and IT group, i.e. at 65%, perhaps due to the importance of mastering this approach in this type of business. The lowest score was given by the employers of Commerce, Trade, Finance, Agriculture & Food group to their engineering staff, i.e. at 47%.

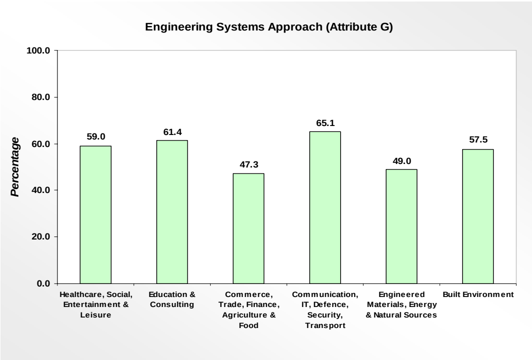

Fig. 6. Employers' satisfaction of their workforce with respect to 'engineering systems approach' (attribute G).

Finally, Fig. 7 indicates that overall, the employers interviewed across the groups are mostly dissatisfied with attribute K (i.e. design and conduct experiment as well as having the ability to analyse and interpret data) of their engineering workforce. The highest score was obtained by the Education and Consulting group, but merely 59% satisfaction level, the second was Communication, IT, Defense, Security and Transport group at 54%. Four other groups scored 41% or lower, with the lowest being Commerce, Trade, Finance, Agriculture & Food group, scoring a disappointing 31% satisfaction level. As most engineers in the market are trained up to first degree level, it is not surprising that they lack design and data interpretation ability as normally given at post degree levels. As such, employers should provide the specific training necessary for their workforce and not rely solely on the training given to the graduates during their first degree university education.

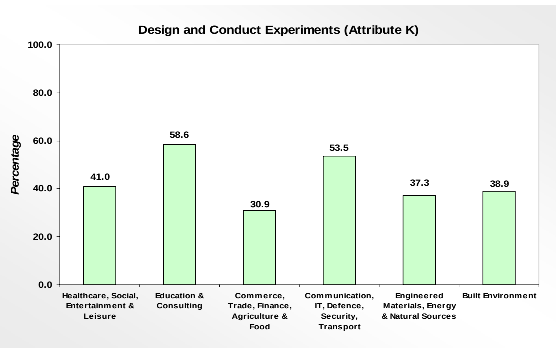

Fig. 7. Employers' satisfaction of their workforce with respect to 'design and conduct experiments' (attribute K).

4. Conclusion

This paper reports perception of employers from 422 companies with regards to technical attributes of their current engineering workforce. The study is important as it can be used to gauge the perception and needs of Malaysian industries towards graduate engineers. In general, the employers' satisfaction of their engineering workforce with respect to the technical attributes can be considered as fair, scoring from about 31% to 69% satisfaction level, with Education and Consulting sector consistently rating their engineering workforce highly, the highest of which is attribute A, i.e. "applying knowledge of engineering fundamentals", scoring a high 69% satisfaction level. However, the employers are most dissatisfied with attribute K, i.e. "design and conduct experiment as well as having the ability to analyse and interpret data" of their engineering workforce, scoring as low as 31% satisfactory level. The outcomes of the comprehensive survey work will be considered in an exercise to improve the engineering education curricula and their deliveries of Malaysian Institutions of Higher Learning.

Acknowledgements

The authors would like to express the highest gratitude to Ministry of Higher Education, Malaysia, for the financial support towards the successfulness of this research.

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Assessment and Evaluation of Programme Outcomes at the Faculty of Civil Engineering, Universiti Teknologi MARA, Malaysia.

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Abstract

Upon receiving the directive for the implementation of outcome-based education (OBE) in Engineering Programmes from Ministry of Higher Education (MOHE) and the Engineering Accreditation Council (EAC), in February 2005 the Faculty of Civil Engineering at Universiti Teknologi MARA (UiTM) embarked on a series of activities to transform the existing programmes towards OBE. One of the most challenging aspects of OBE is the assessment and evaluation of the Programme Objectives and Program Outcomes. This paper discusses the approach adopted by the Faculty of Civil Engineering at UiTM in formulating the assessment tools and performance criteria to evaluate the Programme Outcomes. The approach was based on two major considerations. First, was to categorise the Programme Outcomes based on the Bloom's Domains and secondly, to select appropriate courses and their outcomes that would contribute towards the assessment and evaluation of the Programme Outcomes.

Keywords: assessment and evaluation; engineering education; outcome-based education; programme outcomes

1. Introduction

The transformation of engineering degree programme toward OBE approach at the Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM) began upon receiving the directives from the Ministry of Higher Education (MOHE) and the Engineering Accreditation Council (EAC) in February 2005 [1]. A series of activities was conducted to create awareness, to develop Programme Objectives and Programme Outcomes, to review curriculum and syllabus and finally to train academic staff in the implementation of the syllabus that includes delivery, assessment and evaluation methods [2].

One of the major factors that need to be addressed in the implementation of the OBE-curriculum is the assessment and evaluation of Programme Outcomes (POs). These outcomes were formulated after a series of workshops, consultations with other academic institutions local and abroad and most importantly after consultation with the industry. The purpose of this paper is to describe how these POs can be assessed and evaluated.

2. Programme Outcomes for the Bachelor in Engineering (Civil) programme at UiTM

As a result of the activities previously described, the following POs were established [3];

PO1	Ability to acquire and apply basic knowledge of science, mathematics and engineering.
PO2	Ability to communicate effectively, not only with engineer but also with the public.
PO3	Ability to identify, formulate and solve engineering problems.
PO4	Ability to use a system approach to design and evaluate operational performance
PO5	Ability to act effectively as an individual and in a group, with leadership, managerial and entrepreneur capabilities
PO6	Understanding of the social, cultural, global and environmental responsibilities and ethics of a professional engineer and the need for sustainable development
PO7	Recognizing the need to undertake lifelong learning and possessing/acquiring the capacity to do so
PO8	Ability to design and conduct experiments, as well as to analyze and interpret data
PO9	Ability to function on multi-disciplinary teams
PO10	Having technical competency and ability to apply to specific Civil Engineering discipline
PO11	Having the knowledge of contemporary issues.

These POs, are very much similar to the basic generic outcomes stipulated by EAC in their latest accreditation Manual [4]. It must be noted, that at least six of the attributes, namely PO2, PO5, PO6, PO7, PO9 and PO11 constitute what is commonly referred to as soft skills. It is the assessment and evaluation of these generic attribute that pose a challenge to engineering educators. In order to satisfy the requirements set by the Regulators, namely MOHE and EAC, the Faculty had developed strategies in implementing the OBE curriculum including assessing and evaluating the POs.

3. Developing Methods for the Assessment and Evaluation of Programme Outcomes

The Faculty held a two day workshop where academic managers and selected academic staff brainstormed to resolve methods for assessing and evaluating POs. Fig. 1 illustrates the procedures adopted during the two-day workshop. It was recognized that different levels of achievement can be best described through Bloom's Domain and Taxonomies. Thus, the faculty resolved to classify the POs into use Bloom's Domain and later use Bloom's Taxonomy to formulate the performance criteria for the evaluation of the POs.

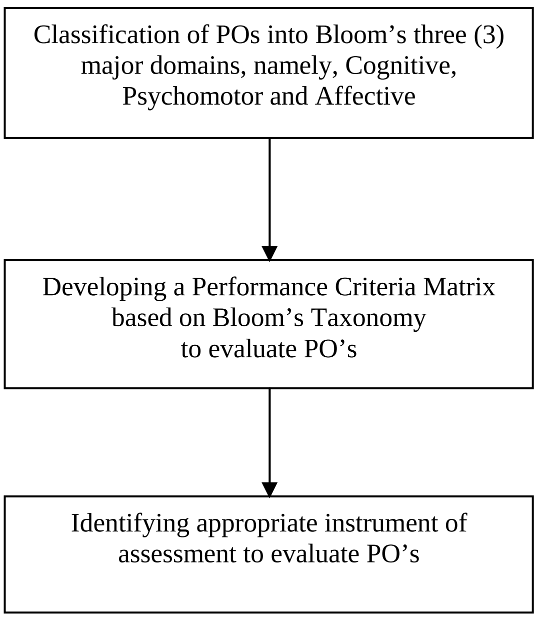

Fig. 1. Approach adopted in developing assessment tool and performance criteria matrix for the evaluation of Pos at the Faculty of Civil Engineering, UiTM.

The first task was to classify the POs into the three Domains introduced by Bloom [5], namely cognitive, psychomotor and affective. It was recognized that the development of all PO's depended on students having the required knowledge (cognitive), appropriate skills (psychomotor) and the right attitude (affective). However, the PO's were classified based on the most dominant domain that will ensure significant development of the attribute associated with the PO.

Table 1 shows the classification of the PO's into three (3) main domains. The Faculty classified three (3) of the POs into the cognitive domain, three (3) POs into the psychomotor domain and the remaining five (5) POs into the affective domain. It is not surprising that 45% of the POs is classified under the affective domain. Traditionally, engineering programmes have been assessing and evaluating students on the knowledge and skills component. The attitude component is assumed to have been acquired once students had completed the programme, thus it was not explicit assessed. The introduction of the OBE-curriculum demands the affective or attitude component be assessed and evaluated. This constitutes the challenge in implementing the OBE-curriculum.

Table 1. Classification of POs into Bloom's Domains

Bloom's Domain	**Programme Outcomes**
Cognitive	PO1,PO3, PO11
Psychomotor	PO4, PO8,PO10
Affective	PO2, PO5, PO6, PO7, PO9, PO11

4. Developing the Performance Criteria for evaluating Programme Outcomes

Once of the POs were classified into Bloom's Domains, the performance criteria matrix was developed for each PO. The key verbs used were taken from Bloom (1956). Table 2 illustrates the performance criteria matrix that has been developed. The matrix will be very useful in the evaluation of POs that are in the psychomotor and affective domains. It will contribute towards focusing towards the same understanding of keywords being used and minimizing the variation in evaluation of the POs.

Table 2: Performance Criteria Matrix based on Bloom's Taxonomy for Evaluation of Programme Outcomes

PO	Domain	1	2	3	4	5
PO1	Cognitive	Able to define and identify	Able to discuss	Able to apply and solve	Able to analyze	Able to design and evaluate
PO3		Able to identify some of the engineering problems only	Able to identify and explain some of the engineering problems	Able to identify, explain and solve most of the engineering problems	Able to identify, explain, solve and analyze most of the engineering problems	Able to analyze, formulate and evaluate most of the engineering problems
PO11		Aware and appreciate contemporary issues	Demonstrate understanding of contemporary issues	Understand and discuss contemporary issues	Able to analyze the contemporary issues	Evaluate the implications of contemporary issues
PO4	Psychomotor	Able to recognize	Able to duplicate	Able to operate and produce	Able to organize and manage	Able to adapt and design
PO8		Able to recognize the experiment	Able to recognize and conduct experiment under constant supervision	Able to conduct and execute experiment under guided supervision	Able to conduct and execute experiment without supervision	Able design and conduct experiment, analyse and interpret data
PO10		Able to recognize the various technical requirements of the different civil engineering disciplines for a given task	Able to carry out tasks in an engineering discipline under supervision	Able to execute and complete with confidence a given task in a specific engineering discipline	Able to adapt a given design concept and perform automatically	Able to produce original design concept based on abstract requirements
PO2	Affective	Able to acknowledge	Able to response	Able to express	Able to organize	Able to justify
PO5		The student acknowledges his/her responsibilities as individual but does not contribute.	The student cooperates and participates as individual but shows poor leadership and managerial qualities	The student participates actively as individual and exhibits some leadership and managerial qualities	The student is able to organize and conceptualize and exhibits good leadership and managerial qualities	The student is able to organize, conceptualize and integrate
PO6		Show awareness and accept the responsibilities of civil engineer towards social, culture, global and environmental responsibilities and ethics.	Show that they understand and comply the responsibilities of civil engineer towards social, culture, global and environmental responsibilities and ethics.	Ready to adopt and show concern the civil engineering responsibilities towards social, culture, global and environmental responsibilities and ethics.	Willing to adopt and adjust the responsibilities of civil engineer towards social, culture, global and environmental responsibilities and ethics.	Committed to act upon the responsibilities of civil engineer towards social, culture, global and environmental responsibilities and ethics.

Table 2. Performance Criteria Matrix based on Bloom's Taxonomy for Evaluation of Programme Outcomes…(cont.)

PO7	Affective	Aware and accept the need to acquire and undertake lifelong learning	Agree to the needs of acquiring to undertake lifelong learning	Committee to acquire the need to undertake lifelong learning	Willing to embrace the concept of lifelong learning	Ready to practice a lifelong learning and ability to do so
PO9		Be aware of and accept the collective agreements made in a multi-disciplinary team	Participate and contribute to the collective agreement in a multi-disciplinary team	Able to commit to the collective agreement of a multi-disciplinary team and assume responsibilities for the agreement	Able to organize and adapt resources available to meet the collective agreement	Able to influence the decision making process in a multi-disciplinary team and justify the collective agreements to members not in the team

5. Identification of Assessment Tools for evaluating Programme Outcomes

Having established the performance criteria matrix, the appropriate assessment tools were identified. Table 3 gives the various tools for evaluating Programme Outcomes at the Faculty of Civil Engineering, UiTM. It must be noted that assessment and evaluation is done by parties that are external to the programme. The tools selected enable the major stakeholder, i.e. the industry to assess the products of the programme. There are at least three different tools being used to assess and evaluate the POs. "Triangulations" will be used in order to confirm the results of assessments from different tools. The indirect method, consist of student entry and exit survey, this will provide an insight as to how the students perceived the effectiveness of the programme in developing attributes that are manifested in the POs.

Table 3. Assessment Tools for evaluating Programme Outcomes

PO	Domain	Assessment Tools	
		Direct	Indirect
PO1	Cognitive	EE, ITS, ES	EES
PO3		EE, ITS, ES	EES
PO11		ITS, ES	EES
PO4	Psycho-motor	ITS, ES	EES
PO8		EE, ITS, ES	EES
PO10		ITS, ES	EES
PO2	Affective	EE(interview), ITS, ES	EES
PO5		ITS, ES	EES
PO6		ITS, ES	EES
PO7		ITS, ES	EES
PO9		ITS, ES	EES

Key:
EE External Examiner's Report
ITS Industry Training Survey
ES Employer Survey
EES Entry-Exit Survey

6. Concluding Remarks

The approach adopted by the Faculty may not be the best approach available. Nevertheless, in the current scenario in Malaysia, where engineering educators are struggling to understand the concept of OBE, the Faculty believe that a starting point needs to be establish. Furthermore continuous improvements must be made not only on the shortcomings of the evaluation results on the achievements of the POs, but more importantly on the relevance and effectiveness of the assessment tools and the performance criteria matrix.

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An Outcome-Based Learning Project: Producing Sustainable Construction Materials from Soft Soil

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Abstract

Engineering subject teaching has almost always been considered as dry and complicated, with much emphasis placed on the definition of principles and derivation of formulae. It is indeed essential for engineering students to understand and learn the fundamental principles and theories of the subject, but that does not suggest any less importance in the application of the knowledge. This is especially important to prepare the undergraduates for the industry, where they are expected to apply their knowledge and skills in practice. Therefore an outcome-based learning project was introduced in the teaching of Geotechnics in the Faculty of Civil and Environmental Engineering, UTHM. The project involved designing and producing construction materials from clay retrieved from the university's grounds itself. The project was tailored to encourage creative thinking in solving technical problems, while allowing students to apply basic Geotechnics knowledge as well as practical laboratory skills they have learned throughout their degree programme. It was found that incorporating project-based learning in the subject not only achieved the intended goals, but also promoted team work and sharpened problem-solving skills among the students.

Keywords: problem-based learning; engineering subject; creative thinking; problem-solving skills

1. Introduction

In teaching engineering subjects, it is very easy to fall into the trap of delivering excellent lectures which, unfortunately, fall on deaf ears. Traditionally, engineering subjects mainly revolves around giving lectures and tutorials, with active discussions involving students which usually arise from question and answer sessions. Detailed explanation on engineering fundamental principles and founding theories, as well as the derivation of formulae and equations, are perhaps the central part of teaching an engineering subject.

Such approach are effective to a certain extent, provided the students come for lectures prepared with some background reading. However it does not provide room for the students to exercise their creativity or put into practice the knowledge gained from the lectures. Considering that engineering is the application of scientific knowledge and technology, it is of utmost importance that students are exposed to real-life situations in which to apply their lessons learned.

Geotechnics is a subject on the application of engineering mechanics to problems with soils as a foundation and a construction material, and it is used to understand and interpret the properties, behaviour and performance of soils. It is therefore obviously a subject that requires the students to grasp the theories and principles first, and then use them to deal with soil problems. The scope of study encompasses laboratory and field work techniques as well, most of which students are unable to perform and relate to the lectures, despite the fact that Geotechnics Laboratory Practice is a subject by itself. Students more often than not see the laboratory work as a separate entity from the body of lecture notes and examples.

The project-based learning concept introduced in the subject teaching was aimed to bridge the gap between theories and principles with application, with laboratory and field work acting as the channels. As described in the next section, the project was conceived to gather the lectures, laboratory tests and field work into one, where students were required to apply relevant knowledge and skills that they have gained from the subject.

2. Project background

The project was based on a case scenario, where students were taken as consultants to solve the particular problems presented. Description of the project and the group tasks were given in a handout. Outline of the project is given below:

The Research Centre for Soft Soils (RECESS) Malaysia (based in UTHM) would like to help the local council to develop a low-cost residential area using sustainable materials, specifically the soft soil available in Parit Raja.

As sustainable geotechnics is a new field in the country, RECESS has enlisted the help of five (5) consultants to achieve the main aim of this development project, which is to produce renewable, reusable and relatively cheap products for the construction.

The five consultants have different specialisations and expertise as listed below:

1. building blocks- structural and non structural 2. slabs and flooring
2. road pavement
3. pedestrian / sidewalk pavement
4. decorative and ornamental components

Being young and upcoming consultants eager to prove your engineering skills, you are expected to fulfill the following requirements:

1. design and produce prototypes of the construction materials;
2. use only sustainable raw materials - e.g. soft soil (from RECESS test site), oil palm waste, rubber chips, rice husks, etc.;
3. determine the relevant engineering properties of the composite materials- compressive and tensile strength, durability, resistance to weathering, abrasion, etc.;
4. deliver a final product that has enhanced qualities compared to the conventional construction materials- e.g. lightweight, inter locking system, economical, environmental friendly, low production cost, etc.

The handout also includes a reminder on the key issues to be addressed: to reduce costs in all ways possible, yet not compromising the safety and quality of the products. The products must be strictly 'sustainable' too.

The sustainability theme was highlighted in the project to create awareness among students on the threat engineering and technology could be causing nature, a rather heated issue at the moment, particularly concerning the construction industry. As the Sustainability Development Unit of the British Department of Environment, Food and Rural Affairs (DEFRA) rightly addressed the current state of "sustainable development", noting that far from catering for the future generation, we indeed struggle to meet the needs of present [DEFRA 2006]. Our excessive dependence on Mother Earth are clearly shown in the significant climate change, depletion of natural resources, damage of the environment as well as loss of biodiversity [DEFRA 2005].

Having been briefed on the project, students then had eight (8) weeks to organize and execute the project. Regular meetings were arranged to help the students along, such as suggestions on the materials and test methods, samples preparation procedure and curing processes.

3. Project execution

Five groups of 5 - 6 students each were formed for the project. A rotational system saw that the leadership of each group was held by a different student every two weeks. This was to optimize the effectiveness of team work, where the members were prepared to lead as well as to be led, for the good of the team.

Students first retrieved bulk soil samples from the RECESS test site, followed by identifying the engineering properties via appropriate laboratory test methods. This required students to revise on the test procedures based on established standards (e.g. British Standards). Next designs on the product mixtures were obtained via brainstorming sessions, where creativity and innovation of the students were put to test. Once the design mixes were determined, they had to outline an execution plan to prepare the trial samples. This involved critical thinking in identifying the relevant topical background knowledge (e.g. engineering properties of construction materials) and laboratory techniques (e.g. compaction). They were also required to manage their limited resources in terms of time, money and labour, exercising their project management skills.

When the recipe and flow of work were decided, full swing laboratory work was carried out. More creativity was observed at this practical stage. For instance, improvising existing compaction tools to fit into the smaller and irregular shape moulds. Details of the methodology and experimental work can be found in Chan (2007).

With the product finally ready, a compilation of the work done was reported in writing and an oral presentation slot. Here, students were trained to prepare concise and precise technical reports based on their findings. In addition, the oral presentation gave students the opportunity to express their scientific discovery and invention verbally, with the aid of suitable media like computer simulation, posters and flyers.

4. Project evaluation

Evaluation of the project was based on the report as well as the oral presentation. The oral presentation was judged by a panel which consisted of lecturers from various disciplines of Civil Engineering, namely Construction Management, Geotechnical Engineering, Highway Engineering, Environmental Engineering and Building Services. The multi-discipline panel was to ensure an all-round assessment towards the products, in terms of feasibility, practicality and relevance in the construction industry. The question and answer session after each presentation was a lively exchange of views and suggestions. Students were trained to be receptive of comments and criticisms for continuous improvement, and at the mean time prepared to defend one's work in a rational manner, in these at times grueling sessions.

The panel was impressed with the students' achievements, made even more so by the demonstration of their products and highly creative brochures for 'selling'' the products (Fig. 1). One group even came up with a complete design and conceptual model for a roadway section based on the laboratory tests conducted with the various mixes (Fig. 2). This was an excellent example of the resourcefulness of the students, turning unexpected results of their research into useful products or designs, instead of simply discarding unexpected or 'unfavourable' experimental data.

(a)

(b)

Fig. 1. Examples of the products: (a) Pebble decorated paver (b) tile with coloured leaf imprints.

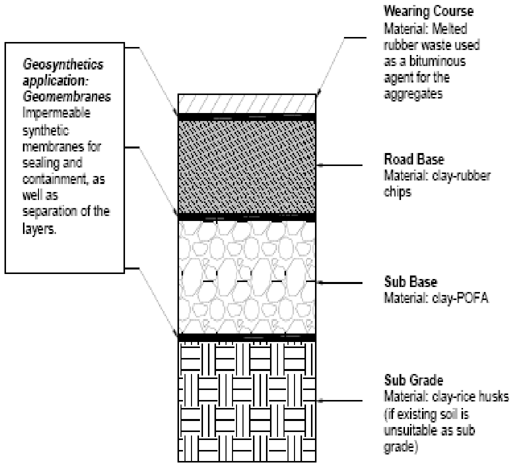

Fig. 2. Conceptual model of a roadway section using clay-based materials

5. Discussions

5.1. Programme Educational Objectives (PEOs)

The Programme Educational Outcomes (PEOs) of Bachelor in Civil Engineering, as offered by the Faculty, was undoubtedly supported with implementation of the project in the subject teaching. Given below are the four (4) PEOs:

1. Knowledgeable in various civil engineering disciplines in-line with the industrial requirements.
2. Technically competent in solving problems through critical and analytical approaches with sound facts and ideas.
3. Effective in communication with strong leadership quality.
4. Capable of addressing engineering issues and able to conduct their professional responsibilities ethically.

For PEO 1, with the project, students were trained to fulfill the construction industry's need for new, sustainable and environmental-friendly products, using their knowledge and skills learned from Geotechnics and other related subjects. The systematic and scientific approach adopted in the project clearly built on the students' competency as a practicing engineer (PEO 2). As for PEO 3, team work to make the project a success was a good exercise by itself to nurture leadership and communication skills, further enhanced by the written and oral presentation training at the end of the project. Besides, students were taught to be alert of current issues and problems in their field, and to address them in an ethical and professional manner (PEO 4).

In a nutshell, it is clearly shown that the project-based learning concept incorporated in the subject was effectively supporting the PEOs in producing graduates of high credibility and quality to serve the industry.

5.2. Programme Learning Outcomes (PLOs)

Following are the five (5) out of ten (10) Programme Learning Outcomes (PLOs) of the Faculty that are expected to be achieved by students through the project:

1. Apply knowledge of science, mathematics and engineering.
2. Identify problems and formulate systematic solutions in Civil Engineering practices innovatively.
3. Apply scientific methods in research and development for engineering practices.
4. Recognize the roles and ethics of professional engineer in fulfilling social, cultural and environmental obligations.
5. Display leadership, entrepreneurship and team working skills effectively.

At the end of the project, a survey was conducted among the students as their self-reflection on how the project assisted them in achieving the PLOs. The survey revealed that majority of the students perceived that through the project they achieved all the PLOs significantly (Fig. 3). It was obvious from the study that the first three PLOs which are revolves around the fundamental technical skill as an engineering graduates can be acquired significantly through this kind of project.

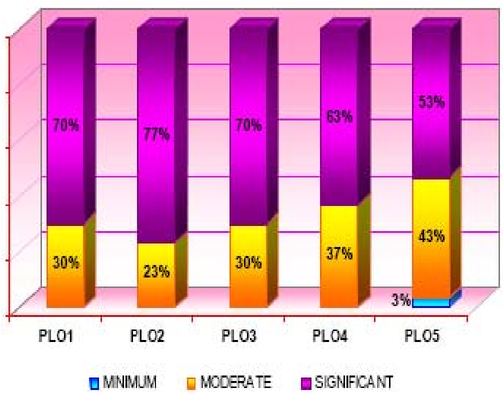

Fig. 3. Students' Self Evaluation on PLOs Achievement through the project.

4. Conclusions

Project-based learning was successfully incorporated in the teaching of Geotechnics, one of the core Civil Engineering subjects. The end-of project survey clearly indicated an effective knowledge transfer and training process, which may not have been achieved with traditional spoon feeding classroom method. Students were also found to be positively responsive to the project implementation as part of the coursework, which created more room for creativity, innovation and imagination. Finally, similar projects could be implemented in other engineering subjects, but the scope and time requirement must be carefully planned to avoid overloading the students.

Acknowledgements

The Authors would like to acknowledge the sterling effort demonstrated by students of BFC3033 Geotechnics (Semester 1 Session 2006/07) in conducting the project.

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