A MALAYSIAN OUTCOME-BASED ENGINEERING EDUCATION MODEL

A.A. Aziz*, M.J. Megat Mohd Noor, A.A. Abang Ali and M.S. Jaafar
Department of Civil Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
*E-mail: azlan@eng.upm.edu.my

ABSTRACT

Malaysia is currently a provisional member of the Washington Accord and the Engineering Accreditation Council (EAC) in the country is shifting its paradigm to an outcome-based approach instead of being prescriptive in the assessment. Although the EAC's 1999 published manual listed the generic attributes for graduates, little effort was made to ensure engineering schools appreciate and implement it. The prescriptive mode of evaluation continued until recently where engineering schools are expected to describe their programmes according to the outcome-based mode. In 2000, the Malaysian Engineering Education Model (MEEM) also paved the way for engineering schools to adopt outcome-based education but the spirit of MEEM was not fully comprehended and there was no compulsion to adhere to the recommendations. Since early 2004 the interest in Outcome-Based Education (OBE) began to emerge with several engineering education providers leading the way. This paper enunciates the MEEM and the processes leading to an outcome based engineering education. In addition, a case history of curriculum development at the Department of Civil Engineering of Universiti Putra Malaysia is cited.

Keywords: *outcome-based, engineering education, accreditation.*

INTRODUCTION

Malaysia adopted the Australian model of a four year programme for her engineering programme since inception. In 1996, the programme duration was shortened to three years as a result of a directive from the Ministry of Education, Malaysia and to cater for the expanding labour market demand in the engineering sector. Universities that had been offering a five year engineering programme, due to its entry qualification at SPM (equivalent to the British `O' Levels), also reduced the duration of study to four years. This was done despite opposition from the Institution of Engineers, Malaysia (IEM) and several institutions of higher learning for there was no formal study done to support the change. Despite reduction in the total credit for graduation, the student loading of the repackaged three year programmes in reality was not reduced, but rather reorganised within the curriculum. Subsequently students' performance nationwide was seen to be badly affected with a sudden increase in the failure rates. These programmes were also facing problems during the accreditation exercises which resulted in the engineering schools having to extend their programmes to three and a half years.

The Malaysian Council of Engineering Deans (MCED) and the IEM in 1999 commissioned a study to develop a national engineering education model that was adopted in 2000. The work was expected to resolve the uncalled for intervention in the engineering education of the country. The study focused on the concerns as stipulated in a previous study, "Formation of Engineers in Malaysia" [1], published in 1996, which highlighted that engineering graduates have a poorer chance of reaching top management positions in both the public and private sectors. It was also envisaged that Malaysian engineers should be technically competent, well-respected professionals and spearheading technology and wealth creation.

THE MALAYSIAN ENGINEERING EDUCATION MODEL

Global engineering philosophies and models studied, prior to the development of the Malaysian model, have shown their dynamic and farsighted approaches. However, total adoption may prove to be unfavourable for the progress and sustainability of the nation.

It has been the perception of many practitioners that locally trained engineering graduates are strong technically but are lacking in non-technical or transferable skills, which are necessary for top management or leadership positions. Most engineering education models worldwide have placed importance to transferable skills apart from a continued emphasis on technical competency. Engineers are also having a marginal role in the country's economic development and progress, which is substantiated by the unimpressive number of engineers in the top industrial leadership positions.

There is the need to have a greater emphasis in the knowledge of engineering science so that engineers are flexible and able to move across several engineering disciplines in a fast changing world. Wholesome training of students are necessary in preparing engineers who are capable of performing useful functions in the industry, able to communicate effectively, manage or lead organisation and having innovative thinking skills [2],[3]. With rapidly expanding knowledge, globalisation and the changing emphasis in scientific fields, engineers must be prepared for future challenges [4].

Five criteria were identified as important in the Malaysia Engineering Education Model [5] and they are:

- ***Scientific strength*,** which provides engineers who are innovative, able to work in research and development activities, and adaptable in different engineering fields.
- ***Professional competencies,*** which provide engineers who are able to identify, formulate, and solve engineering problems, responsible professionally, and able to use techniques, skills, and modern engineering tools for engineering practice.
- ***Multi-skilled*,** which provides engineers who are able to work in different engineering fields and function in multidisciplinary work/teams.
- ***Well-respected and potential industry leader*,** which provide engineers who are able to understand the impact of engineering solutions in a global/social context, knowledgeable of contemporary issues, able to communicate effectively and be involved in community or social projects.
- ***Morally and ethically sound*** which provide engineers who understand ethical and moral responsibility.

Six skills and competencies, as shown in Table 1 are identified as highly necessary in preparing engineering students to satisfy the five criteria mentioned. The table also provides subjects associated with the six components. The model does not restrict nor impose a rigid barrier to the extent and content of a curriculum. There is a freedom to emphasise on scientific or professional skills and competencies or balancing both components. Appropriate emphasis on global and strategic skills, adequate exposure to industrial and practical skills and incorporating humanistic skills also allow completeness in the training. The model recommended that 30% of the curriculum be attributed to non-engineering subjects.

Table 1: Recommended Skills and Competencies in MEEM [5]

Skills & Competencies	**Characteristics**	**Typical Subjects (Civil)**
Global & Strategic	These skills enable students to adapt easily within the borderless world that is experiencing rapid expanding knowledge.	Languages, Strategic Planning, Information Technology, Multimedia, International Business
Industrial	Skills that go beyond the scientific and professional and which are necessary in the advanced phase of the graduate's career.	Environment, Management Finance, Economics, Engineers in Society, Communication Skills, Law, Occupational Safety, Human Resource Management, Innovation
Humanistic	These skills help create a balanced engineer with high ethical and moral standards.	Islamic Civilization, Asian Civilization, Nationhood, Islamic Studies, Moral Education,
Practical	These enable students to be directly involved with hands-on activities or real-life situations, thus providing the basis for integrating the intra and inter engineering and non-engineering knowledge	Final Year Project, Industrial Project, Practical Training, Engineering Design

Professional	Such skills cover technical competency aspects required to perform specific engineering tasks.	Professional Subjects in Civil Engineering e.g. Foundation Engineering, Water & Waste Engineering, Highway Engineering, Concrete Structures, Public Health Engineering, Surveying
Scientific	They enable students to have a firm foundation in engineering science, thus enabling them to realign themselves with the changes in emphasis in the scientific field and to develop an interest in R&D and design.	Engineering Sciences e.g. Engineering Mathematics, Engineering Materials, Fluid Mechanics, Engineering Statistics, Thermodynamics, Engineering Mechanics, Programming

The model implicitly recommended that delivery methods are widen to incorporate such methods as small tutorial groups, an essential component to the formation process. Tutorials would ensure greater understanding of the subject matter, especially when dealing with the scientific component. Engineering studies are recommended to be conducted within 4 years and the semester loading should cater for the average student.

PARADIGM SHIFT IN THE CURRICULUM DEVELOPMENT

Currently Malaysian engineering schools are again at another crossroad. There is a trend for cultural change in these schools where they have been encouraged to consider implementing "outcome-based" learning in their curriculum development. In fact the change is nationwide involving all fields of study and driven by the Quality Assurance Department at the Ministry of Higher Education, Malaysia. However, the engineering field has its own champion i.e. the Engineering Accreditation Council (EAC) under the purview of the Board of Engineers, Malaysia, in steering the way towards the outcome-based education (OBE). These initiatives are also in line with the paradigm shift to OBE in the education sector worldwide.

EAC began introducing the 11 generic attributes for engineering graduates in 1999, as a step towards OBE. However, there was no compulsion to demonstrate the effectiveness of the learning process as desired by the OBE approach. The attributes were only expected to be discussed by the engineering schools during their submission for accreditation. The rationale behind the attributes were not fully understood or practiced by the engineering education providers. Staff-student ratio, number of graduation credits and duration of programmes are among the 'bean counting' that the manual stresses. Curriculum development was to fulfil the relevant courses within the discipline of study and satisfying the minimum credits for completion. The curriculum looks as if well orchestrated on paper but with no indication that the pieces or courses that make the curriculum were well delivered and measurable.

EAC is presently a provisional signatory to the Washington Accord and has to demonstrate that engineering schools in Malaysia are embracing OBE before being accepted as a permanent signatory. Currently EAC is revising its manual to incorporate clearly the OBE approach to curriculum development and provide clear guidelines for its panel to evaluate engineering programmes qualitatively and quantitatively. The paradigm shift is not without problem, as the knowledge regarding OBE is relatively poor among local education providers. Several engineering schools have indeed taken the lead in the OBE approach in curriculum development, thereby producing a variety of models.

As this is the early stage of development, the variation is a blessing in disguise as it allows greater opportunity to innovate, which is in the spirit of OBE itself. This spirit is in line with the requirements of the ISO 9001 management system, which emphasises continual improvement. The ISO 9001 management system has also received a warm welcome by many engineering schools in Malaysia. In fact schools which adopted the ISO 9001 are better prepared to embrace the OBE as such organizations are required to plan, implement, measure and improve their processes. Criteria and indicators within the assessment tools are in fact part and parcel of implementing an effective management system. It is easier to convince those who helped to develop a management system as compared to those who do not believe in a system approach.

THE CASE OF UNIVERSITI PUTRA MALAYSIA

The Department of Civil Engineering, Universiti Putra Malaysia (UPM) has paved the way towards the introduction of an OBE Civil Engineering curriculum in Malaysia. Curriculum development used to be conducted by initially agreeing on the curriculum structure and specifying the allocation of credits. The assumption was that all members of staff are competent in curriculum development. There was the regular enthusiasm to defend the area of domain, and the tendency to maintain the survival of the sub-disciplines. Senior staffs may wish to maintain the status quo but the juniors may want to incorporate new areas and specializations. The interest of the students was assumed to have been taken on board, as the curriculum was developed for them. A phrase like “we are combining the best of the two worlds in the curriculum” was often heard.

Staff within the same sub-discipline would then deliberate on the contents of the syllabi of the sub-discipline. It was entirely a sub-discipline centred exercise with minimal integration done to ensure that the gaps between the sub-disciplines were closed. Benchmarking on the curriculum then fell onto the hand of the external examiners, who are themselves are specialists in their own sub-disciplines.

The Malaysian Engineering Education Model that came later change the way as to how the curriculum can be further enhanced. It encouraged curriculum developers to use a process approach (input-process-output) and groups the curriculum into six categories, namely, scientific, professional, industrial, global and strategic, humanistic, and practical skills and competencies. The outcomes expected are graduates with scientific strength, professional competency, multi-skilled, well-respected and potential industry leaders, as well as morally and ethically sound. It allows flexibility in the curriculum, where one may choose to strengthen the scientific competencies and therefore giving less emphasis on the professional courses.

The thinking at that time was to fill up the gaps found in the six categories with several courses. If communication skill is found to be lacking, than there should be a such a course in the curriculum. If the curriculum is lacking in thinking skill, then a thinking skill course would be included. This was what was meant by a well orchestrated curriculum. However, in reality the synchronization or integration was found not to be there.

The Department took the opportunity to revise the current Bachelor of Engineering (Civil) curriculum at UPM [6] which is based on the Malaysian Engineering Education Model (2000) [5] and the Engineering Accreditation Council Manual [7], according to OBE. This eighth revision was initially expected to be implemented in 2005 but had to be deferred to 2006 to ensure a better understanding among the staff when implementing the curriculum. The tendency to maintain the status quo is great as the OBE approach would demand greater participation by the staff to ensure that the learning process is facilitated effectively.

Despite the vagueness in the interpretation and acceptance of OBE at the national level, the Department took upon itself to provide awareness of OBE amongst the academic staff. A series of seminars by “internal experts” were conducted, which include amongst others, OBE overview, course learning outcomes, problem-based learning, project-oriented learning, cooperative learning and the Malaysian Engineering Education Model. The exposure was expected to enable academic staff to understand and embrace the concept of OBE before undertaking the curriculum review proper. A paper by Felder and Brent [8] was found to be useful in providing guidance and awareness on OBE.

The approach was to start from ground zero in the curriculum development despite having the the eighth revision BE (Civil) curriculum [9] that had been produced based on the feedbacks from a series of meetings conducted since January 2004 by the following entities: teaching staff; external assessor (Prof. John B. Burland from Imperial College, UK); advisory panel with members from the industry; and students. Figure 1 shows the schematic diagram of the approach taken in the development of the curriculum.

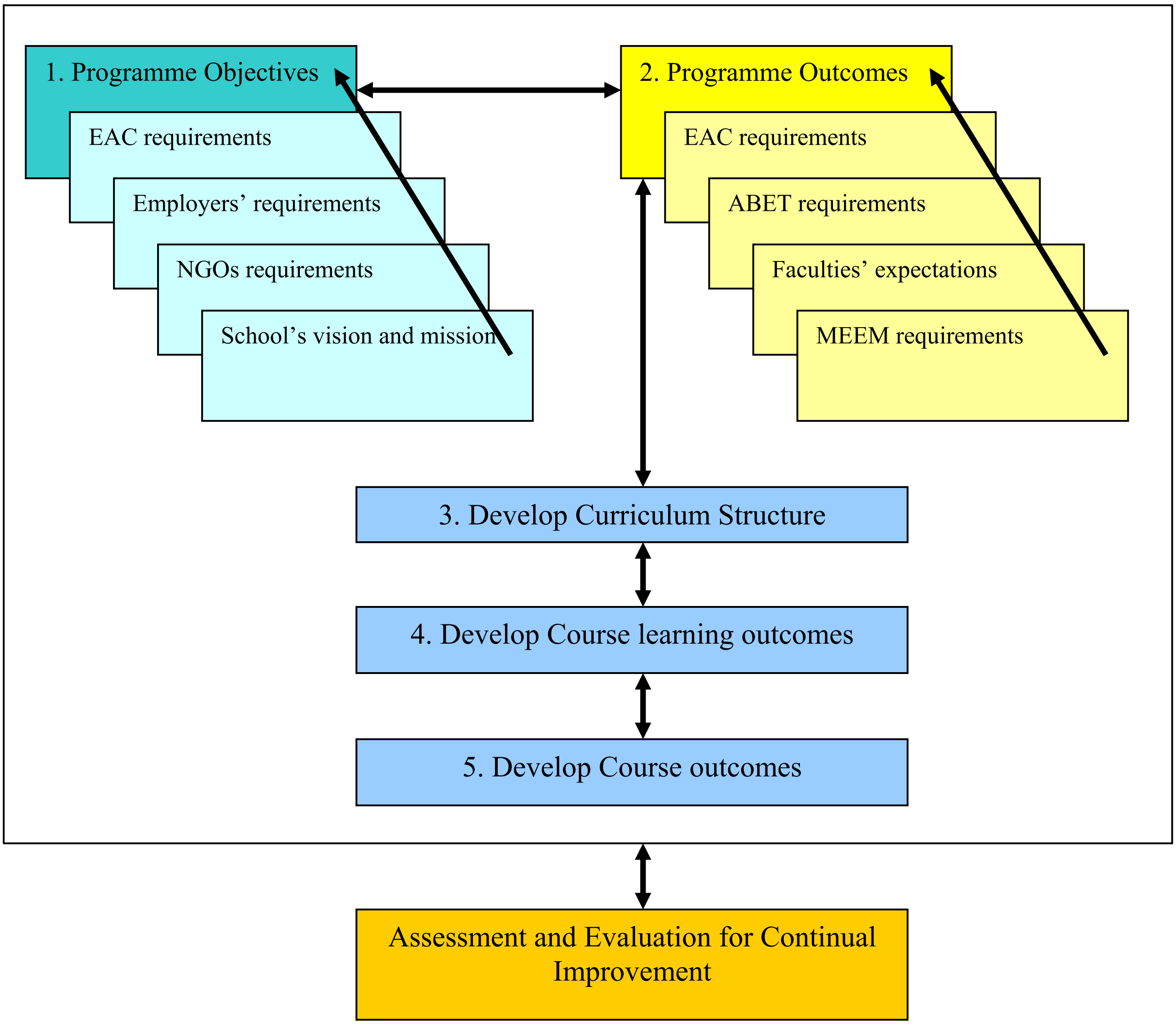

Figure 1: Development Concept of Outcome-based Education

Starting from ground zero means staff must remove all biasness and tendencies to defend territories but merely looking at the interest of the students. "What kind of graduates is the Department trying to produce?" was the question staffs have to address. This was basically an experiential learning process as OBE was relatively new to all staff. The requirements of three major constituencies or stakeholders of the programme comprising: accreditation body (EAC), potential employers (consultant and construction companies, government agencies, research institutions, institution of higher learning, developers, manufacturing and sales companies) and non-governmental organisation (may include professional and non-professional organizations) requirements were interpreted based upon the relevant documents [7],[10],[11] and feedback from the role play by the staff as stakeholders. The objectives have to be in line with the vision of the Department.

Having identified the programme objective, which is what the Department would like to see in its graduates the attributes during the early years (about 5 years) in their career, then came the question "What would be the suitable attributes or outcomes they must have during their student years at the Department?" The Department decided to refer to the EAC attributes, Malaysia Engineering Education Model and those listed by the American Accreditation Board of Engineering and Technology (ABET) when formulating the programme outcomes. Programme outcomes state the attainment of students' abilities and the Department has to ensure that the stated outcomes are achieved before they are allowed to graduate. These have to suit the programme objectives derived earlier. The task then became more challenging as to how these programme outcomes can be integrated within the curriculum and demonstrated later.

The next step was to develop the curriculum structure to support the programme objectives and the programme outcomes. The curriculum structure was based on broad areas of civil engineering identifying what constitute core civil engineering courses and what constitute as support courses. This is where the Department departed from the norm of having the sub-discipline to determine their portion of the curriculum. Having ironed out the differences on the content of the curriculum which include the university courses, a curriculum structure was agreed upon. The programme objectives, programme outcomes and curriculum structure so far developed were expected to be organic and therefore subject to change based on the iterative process.

The real test was to develop the courses to support the programme objectives and outcomes. This is where the staff may depart from the OBE concept to only apply the traditional way of doing things i.e. giving lectures. The Department decided to approach it from “bottom-up”, i.e. developing the course learning outcomes, and then group them into course outcomes based on their similar categories as defined by pedagogical taxonomy for cognitive, psychomotor and affective learning. To reduce the complication of having too many categories, the taxonomy was recategorised into three to reflect the depth of the competencies required. Staff were told “to consider” all the programme outcomes when developing their course learning outcomes. Off course if all courses were to include all the programme outcomes then there will be the problem of overloading the students.

The idea to ask staff to consider all the programme outcomes was to ensure that they depart from the traditional thinking of lecturer-student relationship and to explore other delivery and assessment methods. The rule was “What cannot be measured should be ignored.” This was why the “bottom-up” approach was used. Staff could still employ the typical assessment techniques of examination, quiz, reports, oral presentation, observation etc.

The grouped learning outcomes or also known as course outcomes would then be compiled in a matrix against the programme outcomes. The matrix was arranged as per Table 2. From the matrix one is able to see whether all or several outcomes are addressed by each course and the summation of all courses in the first semester would again reflect whether all or several programme outcomes are addressed.

A guiding principle has to be drawn here, that is how the Department would like to approach in getting the programme outcomes infused in the students. Several operational models could be developed as in Figure 2. If Model A of Figure 1 is adopted then all the programme outcomes must be addressed from the first semester. This matrix would enable the Department to redistribute among the courses on which programme outcomes would be more appropriately adopted by each course, but the summation would result in all the programme outcomes be addressed for the semester. This process would have to be repeated thereon.

Table 2: Typical matrix for course outcomes against programme outcomes

Course Outcomes	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
1st Semester Courses										
Course 1										
Outcome 1	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3
Outcome 2	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3
Outcome 2	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3	1.2 or 3
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Course 2										
↓										
Course 3										
↓										
2nd Semester Courses										
3rd Semester Courses										
4th Semester Courses										
5th Semester Courses										
6th Semester Courses										
7th Semester Courses										
8th Semester Courses										

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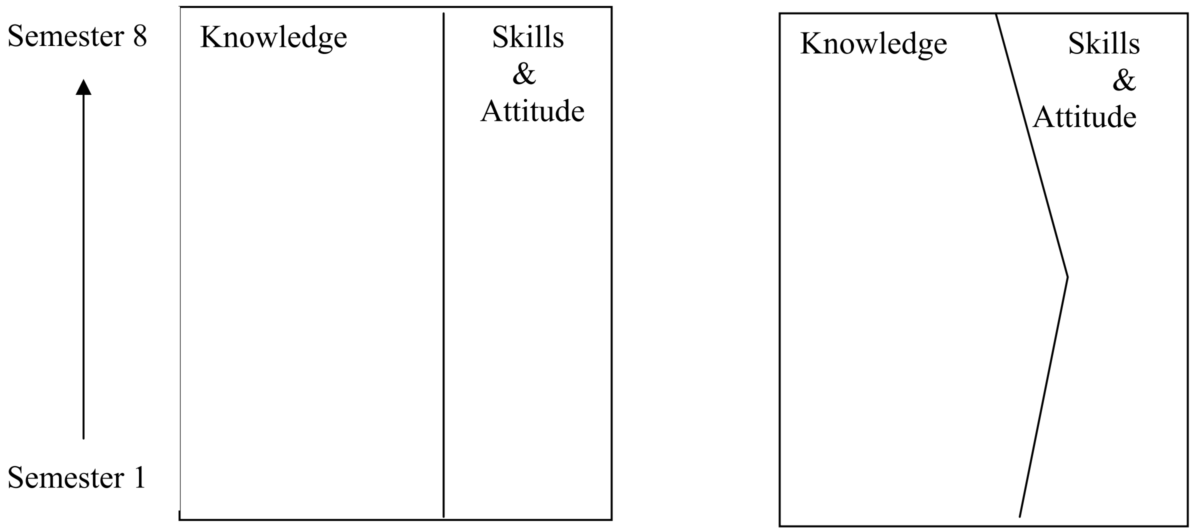

Model A: Equal emphasis on the knowledge, skills and attitude from the early years until graduation

Model B: Greater emphasis on skills and attitude at the early years but lesser toward the middle years and back to greater emphasis near graduation

Figure 2: Two operational models when implementing OBE curriculum

Having developed the programme objectives, programme outcomes, curriculum structure, course outcomes and course learning outcomes, the Department has to ensure the assessment and evaluation processes are in place to demonstrate that the outcomes are measurable and thereby allow for intervention. The question, "Should evaluation be carried out periodically and for all courses?" The Department chose to conduct periodical (semester basis) evaluation of the courses but grouping the programme outcomes into four categories, namely knowledge, hard skills, soft skills and attitude. The reason for this is that not all courses are addressing each of the programme outcomes but all courses would be expected to address all the four categories. The four categories or dependent variables are to be evaluated by the staff. The independent variables, such as delivery method, class environment, etc are to be evaluated by the students. Intervention could be made on the cohort based upon the relationship model to be established between the independent and dependent variables.

Other sets of evaluation, which act to verify the overall aspects of the programme, such as alumni, employer and exit surveys would be carried out. This would enable the Department to further intervene or improve the programme objective and outcomes, and subsequently the learning outcomes of the courses.

This tremendous task of guiding the Department towards OBE is not without obstacles. Getting all members of staff to be committed to the paradigm shift at a time when academic staff reward has not been explicitly associated with teaching and learning is difficult and must be quickly addressed.

CONCLUSIONS

Malaysia is currently experiencing a paradigm shift to outcome-based education (OBE) at the tertiary level. The Malaysian Engineering Education Model (MEEM) paved the way for engineering schools to adopt outcome-based education although there was no compulsion to follow the recommendations. The experience at UPM in developing the curriculum from first principles can be seen as an initiative and example of an institution embarking on a road towards OBE, but not without its own problems. The spirit of continual improvement should be the driving force to keep institutions on the road to curriculum excellence, which is in consonance with the ISO 9001 quality management system.

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