Session 3160

MALAYSIAN ENGINEERING EDUCATION MODEL

**Megat Johari Megat Mohd Noor, Abang Abdullah Abang Ali,
Mohd Rasid Osman, Mohd Sapuan Salit, Mohd Saleh Jaafar**

Universiti Putra Malaysia

Introduction

Engineering programmes that were developed at Universiti Malaya, the first university in Malaysia to offer engineering programmes, adopted the Australian model of 4 years duration of study. Universiti Teknologi Malaysia (UTM) was then set up to produce graduates through a 5-year programme. Other public universities such as Universiti Putra Malaysia (UPM), Universiti Kebangsaan Malaysia (UKM) and Universiti Sains Malaysia (USM) began offering their engineering programmes in the early eighties. Throughout the nineties Universiti Malaysia Sarawak (UNIMAS) and private universities such as the International Islamic University (IIU), Universiti Tenaga (UNITEN), Universiti Teknologi Petronas (UTP) and Multimedia University (MMU) began to offer their engineering programmes.

In 1996, the duration of study in engineering in public universities was shortened from the normal four years to three years, as a result of the directive from the Ministry of Education. The main reason for reducing the study period by a year was to cater for the expanding labour market in the engineering sector. UTM 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 by a year. Before the directive, universities in Malaysia accept students with STPM (equivalent to the British `A' Levels), Matriculation (similar to the Australian Matriculation Programme) and Diploma qualifications into their 4-year engineering programmes [9].

The directive was however, not imposed on private universities and public higher education institutions (without the university status). The reduction in the duration of study was opposed by the Institution of Engineers, Malaysia (IEM) and several institutions of higher learning, as there was no formal study being carried out to support the change. Universiti Putra Malaysia (UPM) though reluctant, abided by the directive and repackaged 4-year programmes into a 3-year period without significant reduction in the total credit loading. The industrial placement, which was normally allocated for a semester was changed to a 10-week industrial training programme to be completed during the vacation. Some of the subjects that were not directly related to the disciplines concerned were removed and thus changing the broad base nature of the curricula. Subsequent to this change, students performance at UPM [12] and also nationwide was seen to be highly affected with sudden increase in the failure rates.

In a study on the "Formation of Engineers in Malaysia" [3] that was completed in 1996 highlighted that the engineering profession has not been contributing sufficiently to the community activities. The report also highlighted that engineering graduates are having a poorer chance of reaching top management positions in both public and private sectors. The study envisaged that Malaysian engineers should be technically competent, well-respected professionals and spearheading technology and wealth creation. Young engineering graduates have also expressed their concerns that engineering is losing its status in the society [1], a perception widely accepted by many in the profession. It was irony that the findings of the study coincide with the reduction of the study period.

In 1999 there was conflicting interpretations of the professional institution guidelines for accreditation of the 3-year programmes, which were undergoing review at that time. This included interpretation of core and non-core engineering subjects as well as compulsory subjects that were outside the curriculum. As a result a 3.5 year programme was formulated to satisfy the requirement of the accreditation body that was imposed retrospectively.

The study on the Malaysian Engineering Education Model (MEEM), commissioned by the Malaysian Council of Engineering Deans (MCED) and the IEM in 1999, was thus timely. The MEEM study was conducted by a team of academics from Universiti Putra Malaysia with the advice of a panel of advisory committee, representing academics from various local universities and representatives from the IEM. This paper thus discusses on the development of MEEM in general and its status of implementation with reference to the civil engineering programme at UPM.

Study Methodology

Reviewing of the Malaysian engineering education and the professional requirement was carried out simultaneously with the reviewing of engineering education models of various countries [10]. Engineering models from three distinctive regions were studied, namely, the United Kingdom, France, Germany and Denmark that represent the British and the European models, the United States of America and Canada that represent the North American model, New Zealand, Australia, Japan, Hong Kong, Singapore and Thailand represent the Australasian model. The selection of the countries was based upon the geographical (or regional) position and the developed status of a country, of which many were English-speaking countries. The Russian and Latin American models were not considered due to the communication and language barriers.

An industrial survey was conducted to gauge the needs and expectations of the Malaysian industries. Several colloquia comprising the academia and industrialists were held at various stages of the study. Three elements were considered when developing MEEM, namely, the ***input*** that refers to the quality of students entering the engineering programmes, the ***output*** that refers to the graduates as the outcome of the ***formation process***, which refers to the university training. The ***formation process*** was arrived at after considering the ***input*** and the ***output*** situations. A framework for the design of engineering curriculum was then recommended. MEEM was finally adopted at the Colloquium on Malaysian Engineering Education - Educating Future Industry Leaders [5].

Engineering Education Scenario

In the study the engineering education models were classified into four, namely, the British, American, European and Hybrid models [6] as follows:

***British Model*:** Specialised and general 3 and 4 years engineering programmes are conducted in the United Kingdom. These are the 3-year programme leading to Incorporated engineering degree and the 4-year programme or 3-year programme with a matching section leading to Chartered engineering degree. Industrial training though not compulsory is desirable. Design and/or industrial projects are included in the curriculum in most universities. Individual final year project is compulsory for both degrees. The transferable skills are embedded within the curriculum, and not as clear subjects [7], amounting to 40% as recommended by the Engineering Council. Graduate engineers from the 4-year programme or those with the matching section after the 3-year programme would be allowed to sit for professional examination after experiencing a minimum of 3 years of relevant working experience.

***American Model*:** The duration of study for an engineering degree in the United States is 4 years. Industrial training is not compulsory at most universities whereas final year project is compulsory at some universities. Social sciences and humanities courses are generally offered at all universities. Graduate engineers also need to sit for the professional examination, organised by the respective state professional bodies.

***European Model*:** In Germany there are three types of tertiary institutions, namely, University and Technical University; Berufsakademie (recently known as University of Cooperative Education); Fachhochschule (University of Applied Sciences). The qualification, Diplom. Ingenieur (Dipl-Ing) is awarded by all institutions, with an additional tag BA and FH for those from Berufsakademie and Fachhochschule respectively. The Dipl-Ing is considered as an equivalent to a Master's degree while the awards from Fachhochschule and Berufsakademie are considered as Bachelor's degrees. The average duration of study at universities is 4.5 years while at Fachhochschule and Berufsakademie are 4 years and 3 years respectively. In France, the duration of study at universities is 5 years, whereas those going for the Grande Ecoles to study engineering need to attend the class preparatory for 2 years and followed by 3 years at Grand Ecoles. Rigorous implementation of project based learning and industrial attachment have enabled the recipients of Dipl-Ing degrees to practice as professional engineers immediately. There is a strong linkage between the institutions, laboratories and industries in the European model. Graduate engineers in Europe can practice or considered as achieving the professional status upon graduation.

Hybrid Model: Countries in the Australasian region adopt either the British or American models or a hybrid, which is a combination of the aforementioned models. The duration of study at most of the universities in this group is 4 years. Most universities generally offer humanity courses apart from the technical courses, and some universities do not include language courses in the curriculum. Some universities give credits to co-curriculum activity. As a whole the core engineering subjects are varied between 50 and 65 % of the curriculum. Final year project is given credits but industrial training, though compulsory is not credited.

The Malaysian Model

In order to realise the vision for Malaysian Engineers that is " Engineers shall be technically competent and well-respected professionals spearheading technology and wealth creation in Malaysia " [3], there is indeed a need for Malaysia to formulate its own engineering education model. Though, regional engineering philosophies and models studied have shown their dynamic and foresight approaches, verbatim adoption may prove to be unfavourable to the development and progress of engineering in Malaysia. Engineering education in Malaysia must ensure that both universities and industries can benefit mutually, for the progress and sustainability of the nation.

In Malaysia, there is a perception that engineers have a marginal role in the country's progress, which is substantiated by the unimpressive number of engineers in the top industrial leadership positions. Lack of the non-technical or transferable skills, which are necessary for top management or leadership positions have been identified as the possible reason for this. Most of the engineering education models worldwide have placed importance to transferable skills apart from continued emphasis on technical competency.

There is no contention that it is essential for engineers to possess the necessary technical competencies. Currently, the traditional disciplines are being eroded, making ways for new disciplines, which will be a trend in the future. Thus, there is a 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.

Completeness in the training of engineers are necessary in preparing engineers who are capable of performing useful functions in the industry, and these include emphasising communication, management and innovative thinking skills [2],[4]. Globalisation, rapidly expanding knowledge and the changing emphasis in scientific field are important areas to be considered when preparing engineers for future challenges [8].

Having observed the regional engineering models and Malaysia's needs, the following five criteria that were identified as important in producing graduate engineers, which formed the basis for developing the engineering education model for Malaysia, 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.

The model recommended the following six skills and competencies, as shown in Table 1, as highly necessary in preparing engineering students to satisfy the five criteria as listed above.

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

Skills & Competencies	Characteristics
Global & Strategic	These skills enable students to adapt easily within the borderless world that is experiencing rapid expanding knowledge.
Industrial	Skills that go beyond the scientific and professional and which are necessary in the advanced phase of the graduate's career.
Humanistic	These skills help create a balanced engineer with high ethical and moral standards.
Practical	These enable students to be directly involved with hands -on activities or re al-life situations, thus providing the basis for integrating the intra and inter engineering and non-engineering knowledge
Professional	Such skills cover technical competency aspects required to perform specific engineering tasks.
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.

Table 2 shows a basic guideline in designing an engineering curriculum where the minimum credit allocations for the respective skills and competencies are assigned. Typical subjects classified under the different skills and competencies are also listed in the table as a guide in preparing engineering curricula.

Variation in the content of a programme is allowed, subject to availability of expertise. There is also a freedom whether to give greater emphasis to scientific or professional skills and competencies or balancing both. Appropriate emphasis on global and strategic skills, adequate exposure to industrial and practical skills and incorporating humanistic skills in the model provide the completeness in the training of engineers.

Table 2: Typical Subject Structure of the Malaysian Engineering Education Model [5]

Skills & Competencies	**Typical Subjects**	**Minimum No of Credits**
Global & Strategic	Languages, Strategic Planning, Information Technology, Multimedia, International Business	15
Industrial	Environment, management Finance, Economics, Engineers in Societ y, Communication Skills, Law, Occupational Safety, Human Resource Management, Innovation	15
Humanistic	Islamic Civilization, Asian Civilization, Nationhood, Islamic Studies, Moral Education,	10
Practical	Final Year Project, Industrial Project, Practical Training, Engineering Design	15
Professional	Professional Subjects in Civil Engineering e.g. Foundation Engineering, Water & Waste Engineering, Highway Engineering, Concrete Structures, Public Health Engineering, Surveying	30 -50
Scientific	Engineering S ciences e.g. Engineering Mathematics, Engineering Materials, Fluid Mechanics, Engineering Statistics, Thermodynamics, Engineering Mechanics, Programming	50 -30

The model recommended that 30% of the curriculum be attributed to non-engineering subjects. Subjects classified under the scientific, professional and practical skills and competencies are regarded as core-engineering subjects. However, some of the subjects classified under industrial skill could also be regarded as core-engineering subjects depending upon the engineering programme.

The model also recommended that tutorials in small groups be an essential component to the formation process. This is to follow through the existing system that has been implemented at the school level. All these while the mode of deliveries at Malaysian universities were generally through lectures and laboratories. Implementation of tutorials would ensure greater understanding of the subject matter, especially when dealing with the scientific component.

The model recommended that engineering studies be conducted within 4 years and the semester loading should cater for the average student. It welcomes a structured industrial training but not making the training compulsory. However, structured industrial projects within the engineering curriculum are required to strengthen the practical skills.

UPM Civil Engineering 2000 Curriculum

The Civil Engineering 2000 curriculum was designed within the framework of MEEM's recommendations. The comparative distribution between the curriculum and MEEM's recommendation is as shown in Table 3. The global & strategic components were slightly less by 2 credits. These skills are expected to help produce graduates who are capable to communicate effectively, perform well in the global context, and enhanced in business capability.

There is a return to a stronger scientific background, with nearly 50 credits allocated to the scientific competency, which is the higher range of MEEM's recommendation on scientific competency. Specialisation is maintained through elective subjects but with limited credit hours. Substantial professional skills and a strong scientific background would make R&D an important agenda in the engineering fraternity. This would propel a greater thrust into innovative technologies and ensure that the country becomes technologically sufficient.

The Final Year Project (FYP) is retained as an independent study as it seeks to prepare students with R&D experience. Communication capabilities are thoroughly assessed within the FYP implementation and thus complemented the global & strategic skills. The FYP is also expected to create the R&D culture. Group design based courses are expected to provide the necessary interface between engineering principles and the design world, essentially a problem-based learning.

The deficiency in the humanistic component can be resolved by encouraging students to take related courses outside the curriculum. The subject of information technology (IT) is adequately covered and embedded within the programme. Students shall have to acquire IT skills in discharging their works.

The 2000 curriculum has included tutorials, which have not been addressed in the previous three curricula. Scientific and professional courses that require tutorials are covered in the early stages of the study. Lectures and tutorials are conducted in small class size so as to ensure a greater understanding on the subject matter. Such actions would also cushion the impact of transferring from school's cultures to university's cultures, where class sizes are smaller and greater personal attentions are given at schools.

Table 3: Civil Engineering Curricula at UPM in comparison with the Malaysian Engineering Education Model (MEEM) [11]

Skills & Competencies	2000 Curriculum Courses	MEEM CL	1984 CL 4-year	1988 CL 4-year	1996 CL 3-year	2000 CL 4-year
Global & Strategic	English Language Writing Interactive Speaking Thinking Skills Communication Principles & Practices	15	9	2	2	13
Practical	Workshop Training & Management Final Year Project Engineering Design Survey Camp Industrial Training	15	20@	19@	18*	16#
Industrial	Engineers & Society Construction Project Financial Management Construction Law & Contract Principles of Economy Project Management Introduction to Environmental Engineering	15	11	9	9	18
Humanistic	Asian Civilization Islamic Civilization Malaysian Nationhood	10	4	8	7	7
Scientific	Electrical Technology & Electronics Engineering Mathematics I & II Engineering Statistics Computer Programming Engineering Mechanics Strength of Materials Structural Analysis I & II Engineering Geology Soil Mechanics I & II Fluid Mechanics Hydraulics & Hydrology I Construction Materials Computational Methods	50 -30	61	60	41	48
Professional	Structural Design I & II Foundation Engineering Water & Wastewater Engineering Geomatic Engineering Traffic Engineering Highway Engineering Technical Electives (4 Courses)	30 -50	40	38	44	33
	TOTAL	135	145	136	121	135

* 10 weeks industrial training allocated 10 credits
# 10 weeks industrial training allocated 5 credits
@ 6 months industrial training allocated 12 credits
CL Credit loading

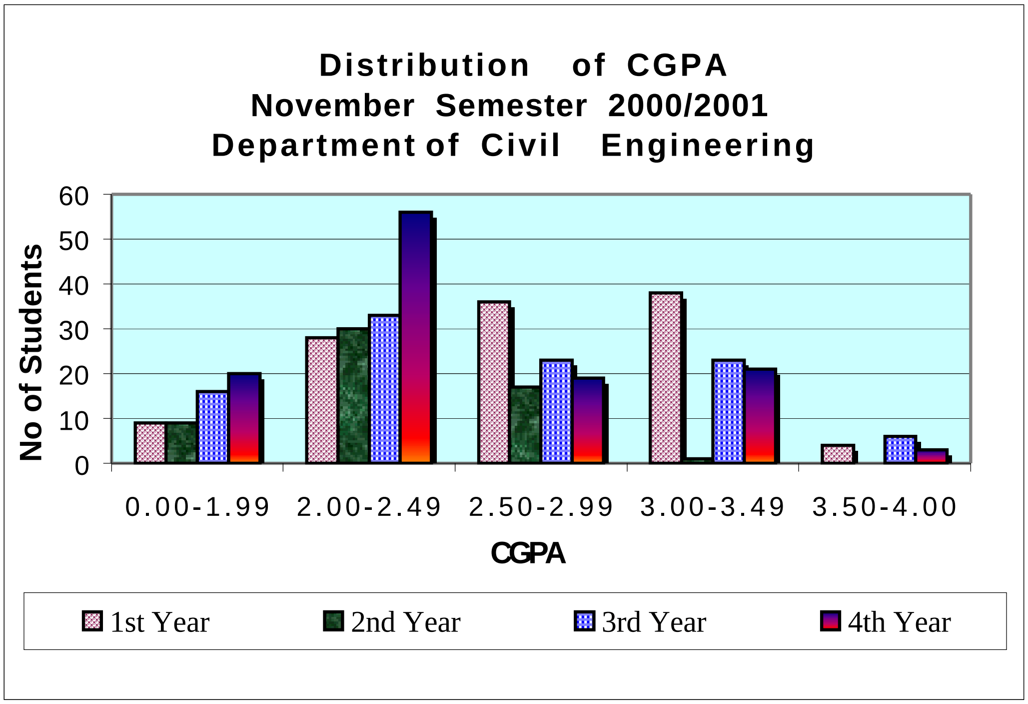

Figure 1: Civil Engineering Students Performance for Semester November 2000/2001 [12]

Figure 1 shows the distribution of cumulative grade point average (CGPA) of civil engineering students at UPM for the November Semester 2000/2001. The first year students are those doing the 4-year programme whereas the second, third and fourth years are those taking the 3.5-year programme. The 3.5-year programme was basically a 3-year programme that was extended by a semester i.e. which included an additional of 9 credits as required by the Accreditation Board to satisfy their latest revision in 1999. Looking at the bar chart, the skew is on the left for those taking the 3.5 year programme whereas those taking the 4-year programme are performing better with greater number of students getting CGPA of higher than 3.0. Although it is quite early to determine the effectiveness of the 4-year programme but the smaller class size and inclusion of tutorials in the early years are showing a good progress. Random enquiries through dialogues and discussion are suggesting that these factors are making a great difference. It is expected that students who are able to digest the subjects from the early stages would highly likely make into the envision engineers. Currently, the philosophy behind the development of the civil engineering curriculum is being explained to students so that they can appreciate more and strive towards excellence in their study.

Conclusion

MEEM aims at producing graduates with a strong scientific base and are innovative, professionally competent, multi-skilled and well-respected. Their progression to successful industry leaders would become a natural consequence. The engineering degree programme was enhanced to a 4-year programme and begins with a strong emphasis in scientific competency (engineering sciences) and on this strong scientific foundation shall be built the global and strategic, industrial, humanistic, practical and professional skills and competencies. The achievement of the Civil Engineering programme at UPM testifies in itself to the early success of the model, i.e. producing better quality graduates from the early years for the more challenging phases of the curriculum and upon graduation.

References

1. Anon.1999. Engineers – Losing Status in Society. *Bulletin IEM* **10**: 4-5.
2. Goonatilake, P.C.L.1982. Some factors to be studied in engineering curriculum design for developing countries. *International Journal of Mechanical Engineering Education* **11** (4): 227-231.
3. IEM.1998. An Enquiry on the Formation of Engineers, Malaysia - Towards the Engineering Vision, Report. The Institution of Engineers, Malaysia.
4 Johari, M. 1999. Malaysian Engineering Education Model for the Next Millennium. In *Colloquium on the Malaysian Engineering Education Model for the Next Millennium*, 5 August, Putrajaya, Selangor.
5 MCED/IEM. 2000. Malaysian Engineering Education Model - Educating Future Industry Leaders. Report.
6. Megat Johari, M.M.N., Abang Abdullah, A.A, Osman, M.R., Sapuan, S.M., Omar, H., Jaafar, M.S & Mariun N. 2000 The Proposed Malaysian Engineering Education Model. IMS Tripartite Meeting & Conference, 2-6 March 2000, Pekan Baru, Riau Indonesia.
7. Megat Johari, M.M.N., Osman, M.R., Omar, H & Muniandy, R. 2000. Engineering Education in the UK. MCED/IEM Report.
8. O'Kane, M. 1999. Engineering Education: Trends and Challenges. Keynote Address. *World Engineering Congress*, 19-22 July, Kuala Lumpur.
9. Sapuan, S.M, Osman, M.R. & Megat Johari, M.M.N. 1999. Summary of Global Engineering Education Models. In *Colloquium on the Malaysian Engineering Education Model for the Next Millennium*, pp. 1-20, 5 August, Putrajaya, Selangor.
10. Sapuan, S.M., Osman, M.R., Megat Johari, M.M.N. & Ahmad, D. 1999. *A Review of Engineering Curricula*, Serdang: UPM Press
11. Megat Johari, M.M.N., Abang Abdullah, A.A., Osman, M.R., Sapuan, M.S., Omar, H., Amin, M.S.M., Ismail, N., Shahbudin, R.K.Z., Ahmad, D. & Abas, F. 2000. The Modeling of Civil Engineering 2000 Curriculum at Universiti Putra Malaysia According to the Malaysian Engineering Education Model. In *CAFEO 18.* Hanoi. Vietnam.
12. Jabatan Kejuruteraan Awam. 2001. Keputusan Peperiksaan Semester November 2000/2001.

Biography

MEGAT JOHARI MEGAT MOHD NOOR is an Associate Professor at the Department of Civil Engineering at Universiti Putra Malaysia and also a registered Professional Engineer. He obtained his BSc(Hons) in Civil Engineering and MSc in Water and Waste Engineering at Loughborough University in 1982 and 1984 respectively. He is an Executive Director of the Federation of Engineering Institutions of Islamic Countries.

ABANG ABDULLAH ABANG ALI is a Professor at Department of Civil Engineering at Universiti Putra Malaysia and also a registered Professional Engineer. He obtained his BSc(Hons) in Civil Engineering at Brighton and MSc in Structural Engineering at UMIST. He is the Deputy President of the Institution of Engineers Malaysia and Secretary General of the Federation of Engineering Institutions of Islamic Countries.

MOHD RASID OSMAN is a Senior Lecturer at the Department of Mechanical & Manufacturing Engineering at the Universiti Putra Malaysia. He obtained his BSc(Hons) in Mechanical Engineering and MSc in Manufacturing Engineering from the United Kingdom. He is presently heading the Quality Assurance Unit at the Faculty of Engineering at Universiti Putra Malaysia.

MOHD SAPUAN SALIT is a Lecturer at the Department of Mechanical & Manufacturing Engineering at the Universiti Putra Malaysia. He obtained his PhD from in United Kingdom.

MOHD SALEH JAAFAR is the Head at the Department of Civil Engineering at Universiti Putra Ma laysia. He holds a PhD degree from Sheffield University, United Kingdom.