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AUTHOR Buniyamin, Norlida; Mohamad, Zainuddin
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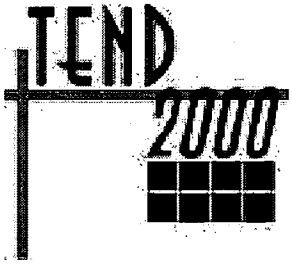
ABSTRACT

The Faculty of Mechanical Engineering at the University Teknologi MARA, Malaysia, developed an undergraduate-level engineering curriculum that balances national interests with those of employers and academics. The curriculum was based on materials posted at the Internet sites of universities in the United States, United Kingdom, and Malaysia itself. The new curriculum calls for 3 or 4 years of study (depending on whether students enter the program before or after earning the equivalent of the United Kingdom's General Certificate of Education A-level). In accordance with the Malaysian government's policy of producing graduates with the English skills needed to compete in the international arena, the curriculum's language of instruction is English (except for certain subjects such as social science and humanities). Because Malaysian employers have expressed interest in engineering graduates who are well-rounded and who possess a multidisciplinary, systems perspective, the curriculum calls for a mix of mathematics and social sciences, humanities and social sciences, engineering and design, and free electives). The extended program calls for an additional 30-32 credit hours, inclusive of technical electives and courses in ethics and professional responsibilities. The model allows students to plan their own program with minimal supervision and includes provisions for international exchange or internship during the extended year. (MN)



Crossroads of the New Millennium

Engineering Curriculum Development: Balancing Employer Needs And National Interest – A Case Study.

Prepared and Presented

By

Mrs. Norlida Buniyamin
Lecturer
University Teknologi MARA
email : buniy@engr.itm.edu.my

Mr. Zainuddin Mohamad
Lecturer
University Teknologi MARA
email : zain@amech.engr.itm.edu.my

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Abstract

In developing engineering curriculum, one has to balance the needs of the employer, academics and the interest of a country. This is especially true for a developing country where the government, rightly or wrongly, has to play an active role in 'shaping' the future graduates. The decision on the content of the curriculum becomes more complex when all the needs above are deemed important and limited material only can be taught within the prescribed duration of an engineering programme. This paper discusses and shares our experience at the Faculty of Mechanical Engineering, University Teknologi MARA, Malaysia in developing the structure of such curriculum for its undergraduate programmes.

Engineering Curriculum Development: Balancing Employer Needs and National Interest – a Case Study

INTRODUCTION

Developing an engineering curriculum is not an easy task. Several aspects need to be looked into before a 'balanced' curriculum can be developed. The expectation of the future employer, the student (prospective as well as current), the perception of the academics, accreditation bodies and the interest of a country all need to be taken into account. We have to be selective to include in the curriculum only materials that are considered useful since the duration for the programme is limited and as such not all material or subjects deemed important by the various groups can be included.

In Malaysia, engineering programmes are generally of three or four-year duration (120 credit hours minimum) after STPM (*Sijil Tinggi Persekolahan Malaysia* which is equivalent to United Kingdom's GCE A-level) or four or five-year duration after SPM (*Sijil Pelajaran Malaysia* which is equivalent to United Kingdom's GCE O-level). There have been much deliberations on the most appropriate and practical total duration for an engineering programme i.e. whether it should be a three or four-year programme after STPM and four or five-year programme after SPM. Recent meeting of the Malaysian Council of Engineering Deans has recommended that the programme be extended to four years after STPM and five years after SPM. Despite this longer duration, the amount of material to be covered is enormous compared to the amount of time available.

This paper shares our experience at the Faculty of Mechanical Engineering (FKM), Universiti Teknologi MARA (UiTM), Malaysia, in developing the curriculum structure for its undergraduate programmes. The discussion is limited to developing the structure of the curriculum only, and not the other aspects of provision of education such as facilities available, quality of lecturers, criteria for selection of students etc. The medium of instruction for the programmes of study offered was originally in English, then changed to the national language (Malay) before finally strongly encouraged to be in English. The curriculum design took into account the developments in the United Kingdom and the United States-e.g. trend towards B.Eng./M.Eng. (three years / four years) and B.S.E./M.S.E. (four years / five years). Accreditation guides and requirements from LJM (*Lembaga Jurutera Malaysia* or Board of Engineers Malaysia), IJM (*Institusi Jurutera Malaysia* or Institution of Engineers Malaysia) and Engineering Accreditation Commission of ABET (Accreditation Board for Engineering and Technology, USA) were widely consulted.

DEFINITIONAL ASPECT.

It is important to know the meaning of the term engineering before proceeding with further discussions. Engineering, according to ABET is "that profession in which knowledge of the mathematical and natural sciences gained by study, experience and practice is applied with judgement to develop ways to utilise, economically, the materials and forces of nature for the benefit of mankind" – Criteria For Accrediting Engineering Programmes, Engineering Accreditation Commission, ABET, Baltimore, USA. Therefore, if one took the above as the definition of engineering, the development of an engineering curriculum should ensure producing engineers with the above qualities as its prime objective. Hence subjects included in an engineering programme (the curriculum) must be selected accordingly. Developing engineering curriculum to closely abide by the lines of the above definition might not be fully satisfactory to the employers, or in the interest of the nation (more so a developing nation). Therefore a good curriculum need to not only satisfy the definition, but also fulfill the designed goal or objectives. In this respect there might be a need to redefine engineering if abiding by the definition fails to produce the required output.

THE ISSUE - EMPLOYER NEEDS VS. NATIONAL INTEREST.

The issue here is whether the engineering curriculum should be developed for the employer's market or so that it can contribute towards the development of the nation. Of course there is an overlap between employer needs and national interest. When this occurs, it is straightforward but, when fulfilling the need of one, means denying the other, a certain approach or methodology needs to be applied in order to come up with a balanced curriculum. The way this is done is shown later under the section The Model Structure. For now, the different qualities of engineering graduates desirable by the above mentioned parties will be highlighted.

Employers are looking for engineering graduates that are well rounded and possess multi-disciplinary, systems perspective. Ideally for them the graduates must be competent technically as well as possessing management, communication and interpersonal skills. The command of English is also considered an asset due to the current trend of globalisation. Further those who, upon graduation, are able to perform jobs assigned to them with minimum or no further training and supervision are more desirable.

On the other hand, a country, especially a developing one, needs to produce graduates that can contribute toward national development agendas. In Malaysia at one point, due to the inadequacy of supply of the engineers, the Government encouraged reducing the duration of

engineering programme from four year after STPM to three years after STPM to ensure the output of engineers is sufficient to meet the demand created by the fast pace of development. The rationale at that time was that the lessened duration would still be equivalent to the United Kingdom's three year B.Eng. programme duration. It is also in the interest of a nation to ensure that the engineering workforce has a high professional conduct, morally upright and ethically correct.

Additionally the government encourages the use of English as the medium of instruction especially for professional programmes. It used to be that the Government promotes the use of the national language in the interest of national unity. The issue here is whether it is better to maintain the language at the expense of people or the people at the expense of the language. Of course this is debatable.

There are several bodies that draw guidelines and/or requirements expected of engineering graduates. These guidelines and/or requirements act as a baseline or basis for institutions to fulfill in designing their engineering programmes. For example, ABET have the following criteria expected of an engineering programmes (ABET 2000 Criteria No. three: Programme Outcomes and Assessment) i.e. *Engineering programmes must demonstrate that their graduates have:*

1) *an ability to apply knowledge of mathematics, science, and engineering*
2) *an ability to design and conduct experiments, as well as to analyze and interpret data*
3) *an ability to design a system, component, or process to meet desired needs*
4) *an ability to function in multi-disciplinary teams*
5) *an ability to identify, formulate and solve engineering problems*
6) *an understanding of professional and ethical responsibility*
7) *an ability to communicate effectively*
8) *the broad education necessary to understand the impact of engineering solutions in a global and societal context*
9) *a recognition of the need for and an ability to engage in life-long learning*
10) *a knowledge of contemporary issues*
11) *an ability to use the techniques, skills and modern engineering tools necessary for engineering practice.*

The same function above is carried out by Engineering Council in the United Kingdom and by LJM (Board of Engineers Malaysia) in Malaysia.

The organisations above attempt to balance the minimum standard expected of engineering programmes and the autonomy that needs to be given to institutions of higher learning in order not to stifle their creativity and purpose. Through accreditation guidelines, these organisations prescribe what are expected of engineers by specifying what engineering programmes should or ought to be. This might not fully coincide with what the employer need and might not be in the interest of a nation.

The government (represents the nation as it is elected by the people) will also have a set of criteria or rules in order to define what is in line with the interest of a country. This is done through regulations and rules. The government of Malaysia, through its Ministry of Education, for example, has made it compulsory for universities to teach the subject, Civilization, as it deemed as important in promoting understanding between its citizens of different ethnic background. (Similar to the subject United States History in the United States). The Ministry also intends to enhance the standard of English by introducing and making the subject MUET (Malaysia University English Test) compulsory. (Similar to TOEFL in the USA and IELTS in the United Kingdom). At the same time programmes at degree level are encouraged to be taught in English. This is done to defend the interest of the nation (rightly or wrongly) in the wake of internationalisation and globalisation. (Previously tertiary education in Malaysia was taught in Malay to unite the various communities in the country through a single language). Of course, it can be argued as to whether giving way to internationalisation (in education) is really protecting the interest of a nation.

Academics on the other hand tend to emphasise the knowledge aspects-i.e. the causes and root of things. They will stress more the fundamentals, mathematics and sciences. For them the engineering students must be competent in these area first before they move on to the application aspects. Practicing engineers though think differently, that, although mathematics and the sciences are important, they are secondary compared to the application and hands-on experience. This is further substantiated as numerous engineering works these days is solved using powerful application softwares where understanding of the problem to be solved (i.e. the structuring of the problem) is more important.

It is not easy to consolidate these divergent views. This paper takes into consideration all these perspectives before suggesting a suitable curriculum model. The experience of developing the engineering curriculum shows that it is very important to have a clear objective, failing which it will be very difficult to converge the divergent views.

THE APPROACH.

First, other established models were studied to see how they develop the engineering curriculum and balance the various needs and requirements. Most of this model is obtained from the Internet sites of universities in the United States, United Kingdom, and Malaysia itself. More weight was given to the overseas model as it is more established and has stood the test of time.

The Engineering Criteria 2000 by ABET was carefully studied and used as one of the sources of references so that the designed curriculum is comparable to international standards and practices. Malaysian guidelines consulted are:

1) Requirements in Curriculum Design and Review, Lembaga Jurutera Malaysia (Board of Engineers Malaysia),
2) Guidelines on Recognition of Engineering Courses, Institusi Jurutera Malaysia (Institution of Engineers Malaysia) and
3) Requirements of Ministry of Education, Malaysia.

It is proposed that the entry to the undergraduate engineering programme be allowed at both STPM and SPM levels. For entry at SPM level the duration of the programme is one year longer than with STPM qualification. The proposed duration of studies is four years for SPM entry (126-136 credit hours) and three years for STPM entry (110-120 credit hours). This is in accordance with the guidelines provided by the Ministry of Education, Malaysia. As such the degree of B.Sc. (Mechanical Engineering) will be awarded to those who completed the total credit hours (above) and upon satisfaction of the normal graduating criteria. (Students awarded this degree are considered to have satisfied the basic requirements).

The curriculum structure for the B.Sc. (Mechanical Engineering) above was designed so that the requirements of various parties above as much as possible are fulfilled within the stipulated duration. Some of the requirements are found to be too demanding. IJM, for example, requires that the student completes a minimum of 120 credit hours and that engineering subjects shall constitute at least two thirds of the total course content. This minimum requirement on engineering subjects is difficult to fulfill within the timeframe above. The requirement of the Ministry of Education (110-120 credit hours after STPM) however, despite being demanding on students, is still achievable. On the other hand, it is still possible to fulfill demands by the employer within the above timeframe provided some of the subjects deemed important by academics are simplified in their treatment or abridged. Satisfying the requirements of all parties will definitely require longer duration than the

above. As such, an extra year beyond B.Sc. is proposed. Upon satisfactory completion of the programme, the candidate is awarded B.Eng. (Mechanical). This programme is designed to satisfy the minimum requirement of all the parties above and to be a fully accredited programme.

The approach and attempts to fulfill as many criteria as possible as demanded by various interested parties. Students who satisfy basic requirements only will be awarded the B.Sc. (Mechanical Engineering) rather than the B.Eng. (Mechanical). English is proposed as the medium of instruction but students should be given remedial English classes where appropriate to ensure that they can learn optimally in that language. Despite the extra year, still there are subjects demanded by various parties that cannot be fitted into the developed curriculum. For this reason electives are suggested.

THE OUTCOME – THE MODEL STRUCTURE.

It is proposed that the faculty offers both the basic (B.Sc. (Mechanical Engineering)) and the extended programme (B.Eng. (Mechanical)). While it is not possible to include all the subjects demanded by various parties even with the extended programme, the minimum requirements set under each programme are nevertheless met within the prescribed duration. The electives made available to the student will consolidate and reinforce their knowledge in a particular area so that they are able to explore their interest and inclinations better. The result is a curriculum structure that not only fulfills the minimum requirements of accrediting bodies but also fills the remaining time with subjects that contribute towards fulfilling the planned objectives of students. The basic programme (four years after SPM or three years after STPM) satisfies the most basic requirements while the extended programme (five years after SPM or four years after STPM) attempts to satisfy all the requirements for accreditation. The requirements include employer needs, the national interest as well as the perceived requirements by parties that think they know the subject best. A summary of the outcome follows.

THE MODEL STRUCTURE.

Medium of instruction:

English except for certain subjects such as social science and humanities. This is consistent with the national interest where the government wants the graduates to be able to compete in the international arena.

Programme Proposal – Two-tier system:

Basic programme (four years after SPM and three years after STPM) to be named B.Sc. (Mechanical Engineering) for government accreditation.

Extended programme (five years after SPM and four years after STPM) to be named B. Eng. (Mechanical) for accreditation by both the government and the accrediting bodies within and outside Malaysia.

Academic load:

Between 15-17 credit per semester.

Programme content:

Basic programme

Mathematics and sciences:	32 - 36 credit hours
Humanities and social sciences:	25 - 31 credit hours
Engineering and design:	60 credit hours
Free electives:	9 credit hours
Total:	126 – 136 credit hours.

Extended programme

Total of 30-32 credit hours inclusive of technical electives, ethics and professional responsibilities, and free electives in addition to the basic programme above.

Special programme: Interdisciplinary programme should be offered to good students only and at B.Eng. level (extended) only.

Feature:

- The model allows students to do their own planning with minimum supervision.
- Allows for international exposure through provision for international exchange or internship during the extended year.
- Specialisation allowed only in the extended year.

RATIONALE OF THE MODEL

The model developed above attempts to ensure that the intended goal of the curriculum is achieved. It provides the required flexibility while at the same time is comprehensive enough to cover the whole range of needs or requirements from employer, national interest, academics, students themselves and other interested parties. The model also took into account the effect of globalisation by recommending that the programme be conducted in English and opening up opportunities for international exchange and internships.

It is, of course, not possible for the curriculum to include everything that is deemed important. The best that can be done is to satisfy as much as possible the needs and requirements within the duration of the programme. Balancing of the various requirements is reasonably achieved without losing sight of the main objective of producing graduates that can contribute towards the development of the country.

CONCLUSION

Employers are looking for engineering graduates that are well rounded and possess multi-disciplinary, systems perspective. Ideally for them these graduates must be competent technically as well as possessing management, communication and interpersonal skills. On the other hand, academics emphasise on the knowledge aspect. A country, especially a developing one, needs to produce graduates that can contribute toward national development agendas.

It can be concluded that it is possible to develop a curriculum that can address the above provided one decides the programme educational objectives from the onset. In this regard, therefore, one should expect that the details of the curriculum would be different from one university to another depending upon their educational objectives and priorities. However the content of the programme should still be recognisable as Mechanical Engineering. The government, in order to fulfill its development agenda could still have a hand in 'shaping' the graduates through the introduction of a group of compulsory courses/subjects that must be offered by all degree-awarding institutions. It is hoped that the above experience will be of benefit to this seminar. The experience in designing the curriculum for engineering programme can be directly applied to the development of curriculum in technological programmes.

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Printed Name/Position/Title: ANTHONY BILLINGSLEY
SUPERVISOR, PUBLIC RELATIONS

Organization/Address: PO BOX 25026
ABU DHABI, UAE.

Telephone: (971-2) 681 4600 FAX: (971-2) 681 0830

E-Mail Address: anthony.billingsley@hct.ac.ae

Date: 22.10.00

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