THE FUTURE OF ENGINEERING EDUCATION IN MALAYSIA

MINISTRY OF HIGHER EDUCATION

THE FUTURE OF

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Department of Institutions of Higher Education Management,
Ministry of Higher Education Malaysia

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PREFACE

The study on the Future of Engineering Education in Malaysia is part of an ongoing effort towards realising the vision of the National Education Philosophy in producing human capital that is resilient, competitive, cultured and intellectually rigorous. These attributes are necessary for the nation's professionals, engineers being the largest group, to face the challenges of globalisation and technological advancement, and contribute towards the socio-economic development of the country and the attainment of national unity.

As an attempt to help chart the future of engineering education, the study covers the specific issues of engineer profiles, curricula and competencies, industrial training, demand and supply of engineers, accreditation, international benchmarking, outcome-based education, and human resource development.

The Director General for the Department of Institutions of Higher Education (IHE) Management, Ministry of Higher Education, Dato' Professor Dr Hassan Said, approved the proposal for the study on 19th October 2005. The Study Committee first met on November 2005 and subsequently the financial resources were mobilised on 13 December 2005. Sub-committees for the secretariat and employer survey and qualitative interviews were formed to facilitate the implementation of the study.

The main study committee met on a monthly basis to review and analyse the collected data and information. Two consultative workshops were held involving various stakeholders of engineering education, such as the Board of Engineers Malaysia, the Institution of Engineers Malaysia, the Federation of Malaysian Manufacturers, the Department of Statistics, Ministry of Human Resource, the Economic Planning Unit, and the Malaysian Council of Engineering Deans. Three workshops were convened to prepare the interim and final reports. The final workshop focused on formulating the final recommendations. Two interim reports were submitted to the Department of Higher Education Management.

A pilot study involving the survey of 30 employers commenced in January 2006. In the main survey, a total of 422 HR managers, CEOs, COOs, MDs and GMs representing employers from across all sectors and regions were interviewed by 18 trained enumerators. Benchmarking visits and discussions with international parties were carried out with 7 universities and 5 accreditation agencies in Germany, Belgium, France, Korea, Japan and Indonesia. Interviews with key and eminent engineers in Malaysia were also conducted to seek their views.

Papers based on the pilot study were presented at two international conferences on engineering education in New York and Greece, and both were subsequently accepted for publication in an international journal.

In formulating the recommendations, the study committee has attempted to ensure that they are reasonably achievable and realistic within the context of the Malaysian scenario. It is hoped that the report will be useful to key stakeholders of Malaysian engineering education such as universities, ministries and professional bodies, for them to chart their way into the complexities and uncertainties of the future.

ACKNOWLEDGEMENTS

The Committee wishes to express its greatest appreciation to the Minister of Higher Education, the Honourable Dato' Mustapa Mohamed, and to the former Minister, the Honourable Dato' Dr. Haji Shafie bin Haji Mohd. Salleh, for their support and generous contribution to the Committee. The Committee wishes to record its heartfelt gratitude to the Director General, Department of IHE Management, Dato' Dr. Hassan Said, for his trust and confidence in commissioning the Committee to carry out this important and timely study.

The Committee also wishes to take this opportunity to record its appreciation to the advisory panel for their advice, ideas and insights, and to the employers who participated in the employer survey. Thanks are also extended to the institutions, universities, agencies and individuals in the countries visited for their participation in the many discussions held and generously shared information and ideas with the Committee.

Special mention is deservedly recorded here to the invaluable contributions of two specific groups, the Secretariat and the Sub-Committee for Employer Survey, for their dedication to the task at hand, working to the very end, well beyond the call of duty, to complete this study. The contribution of Professor Dr. Che Husna Azhari in proof-reading the report is also acknowledged.

Appreciation and thanks are also extended to the Department of Statistics Malaysia for their valuable advice and for supplying data on employers used in the study. We thank also the academic staff and administrators of the institutions of higher education in the country, government officers, various professionals and others who contributed in many ways towards the completion of this study.

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A NOTE ON THE STUDY TEAM

The main Study Committee comprises of academicians from a wide range of related backgrounds. **Prof. Hassan Basri**, chair of the Study Committee, was greatly involved in the national effort to improve engineering education quality to meet Washington Accord standards. **Prof. Zainai Mohamed** is a very senior academic who has been involved in many national studies on education. He and **Prof. Hamid Hamidon** were involved in the planning and setting up of the Technical University Colleges and were senior founding administrators to two of them.

Prof Abang Abdullah is an eminent figure within the engineering profession, and led the study on the Malaysian Engineering Education Model in 2000. **Prof. Nik Abdullah** was trained in both a Fachhochschule and a traditional German university - a unique educational background very relevant to the study. **Dr. Azmi Hassan, Prof Badhrulhisham Abdul Aziz**, **Dr. Zaidi Ripin** and **Dr. Zaidi Omar** represent the government and universities which are key players to the study. **Dr. Azami Zaharim**, Chair of the Employer Survey Sub-Committee, is a statistician with wide experience in many national survey studies.

While several members of the Study Committee do have substantial experience in industrial practice, it is essential that the involvement of engineers who are actively practising the profession be sought. Recognising that most industry practitioners are very much tied up to their daily responsibilities, it would not have been practical for them to be full-fledged members of the Study Committee. Hence a Advisory Panel has been set up comprising of key stakeholders, prominent engineers and industry leaders. The views of its members are solicited through personal interviews as well as special workshops.

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LIST OF ABBREVIATION

ABEEK	Accreditation Board for Engineering Education of Korea
ABET	Accreditation Board for Engineering & Technology
AFAEE	Asian Framework for Accreditation of Engineering Education
APEC	Asia Pacific Economic Cooperation
ASIIN	Accreditation Agency for Study Programs in Engineering, Natural Sciences, Mathematics and Informatics (Germany)
BEM	Board of Engineers Malaysia
CEO	Chief Executive Officer
COO	Chief Operating Officer
CQI	Continuous Quality Improvement
CTI	Commission des Titres de l'Ingenieur (France)
EAC	Engineering Accreditation Council
ECUK	Engineering Council, United Kingdom
EMF	Engineers Mobility Forum
ENAEE	European Network for the Accreditation of Engineering Education
EU	European Union
EUR ING	European Engineers
EUR-ACE	Accreditation of European Engineering Programmes
FEANI	The European Federation of National Engineering Associations
FH	German Fachochschole
GM	General Managers
ICT	Information and Communication Technology
IEM	The Institution of Engineers, Malaysia
IHEs	Institutions of Higher Education
IT	Information Technology
JABEE	Japan Accreditation Board for Engineering Education
KUiTTHO	Kolej Universiti Teknologi Tun Hussein Onn
KUKTEM	Kolej Universiti Kejuruteraan dan Teknologi Malaysia
KUKUM	Kolej Universiti Kejuruteraan Utara Malaysia
KUTKM	Kolej Universiti Teknikal Kebangsaan Malaysia
LAN	Lembaga Akreditasi Negara
MCED	Malaysian Council of Engineering Deans
MD	Managing Director
MMU	Multimedia University

MOHE	Ministry of Higher Education
MQA	Malaysian Quality Assurance
OBE	Outcome-Based Education
Ph.D	Doctor of Philosophy
R&D	Research and Development
SEFI	European Society for Engineering Education
TUCs	Technical University Colleges
UIAM	Universiti Islam Antarabangsa Malaysia
UiTM	Universiti Teknologi MARA
UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UMS	Universiti Malaysia Sabah
UNIMAS	Universiti Malaysia Sarawak
Uniten	Universiti Tenaga Nasional
UPM	Universiti Putra Malaysia
USM	Universiti Sains Malaysia
UTM	Universiti Teknologi Malaysia
UTP	Universiti Teknologi Petronas
VDI	Verein Deutscher Ingenieure
WA	Washington Accord

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EXECUTIVE SUMMARY

In the fast developing economy of Malaysia, the central role of the engineering community is unquestionable. This is precisely why engineering is the nation's largest profession, and engineering education is the biggest sector in tertiary education. Being the biggest warrants that it is done right, especially when it is expanding rapidly under the unique conditions of the nation and region.

What kind of engineers do Malaysia need? Are engineering graduates achieving outcomes that are relevant to stakeholder needs, now and in the future? What needs to be done today to prepare the engineers of tomorrow?

In December 2005, The Ministry of Higher Education (MOHE) commissioned this study of reviewing the status of engineering education in Malaysia and thus recommend actions necessary to ensure Malaysian engineering graduates are adequately prepared for the future, while taking stock of current strengths, weaknesses, opportunities and the anticipated challenges.

METHODOLOGY

In conducting the study, the committee adopted the following strategies:-

- A survey and analysis of related literature.
- A quantitative survey to solicit views from employers of engineers. A total of 422 HR managers, CEOs, COOs, MDs and GMs representing employers across sectors in various regions were interviewed by 18 enumerators.
- Qualitative interviews with eminent members of the engineering profession. This served to provide additional views and insights into the more involved aspects of engineering education and the profession.
- Consultation through workshops with stakeholders of engineering education based on pilot studies and interim findings.
- Benchmarking study visits to selected international organisations. Visits and discussions were carried out with 12 engineering schools and accreditation agencies in Germany, Belgium, France, Korea, Japan and Indonesia.

ENGINEER PROFILES OF MALAYSIA

In the context of the rapid advancement of technology in industry in recent decades, Germany is widely viewed as one of the most successful engineering nations of the world. Malaysia took a bold step in the last decade by establishing four technical university colleges (TUCs) modeled along the German Fachhochschule (FH) engineering education system. The objective of the TUCs is to produce applications and practice oriented engineering graduates that are relevant and ready for industry in both local and overseas job markets. They are differently oriented to those graduating from other conventional Malaysian universities who are traditionally more theoretical and research oriented.

The European Federation of National Engineering Associations (FEANI) recognises two profiles of the professional engineer for the purpose of registration as a European Professional Engineer (EUR-ING), i.e. (1) the theoretical oriented engineer, and (2) the applications oriented engineer. Both categories of engineers, despite having some different competencies, are considered to have the same standing and importance in their role in industry.

The dual profiles of professional engineers exist and recognised in several European countries, notably Germany. There is however, an observed trend where both profiles appear to converge in terms of curricula and designated outcomes. The conventional dual-profile categorisation of the university engineer (theoretical orientated) and the FH engineer (applications oriented) is apparently moving towards a single, more balanced profile.

Based on the analysis of developments both at the national and international levels, three engineer profile categories are considered as relevant for engineering education in Malaysia. They are (1) theoretical and research orientation, (2) applications and practice orientation, and (3) balanced orientation, characterised by a combination of the two profiles.

Results from the employer survey have indicated that Malaysian employers mainly require engineers having two types of competency profiles. While the first and more widely preferred is a balanced profile combining both theoretical/research and applications/practice orientations, the second, i.e. the applications and practice oriented profile, still constitute a very significant component of the national demand for engineers.

The government's decision to set up TUCs in previous years was a correct strategic move to meet this demand.

Another implication of the study findings is that conventional universities should re-orient their engineering programmes to produce engineers with a balanced competency profile. The bigger preference towards a competency profile with a significant theoretical and applications component is in line with the requirements of the national strategic shift from a purely manufacturing-based economy to one that is more knowledge-based in nature.

Purely theoretical and research engineers are required in relatively smaller numbers, i.e. less than 5%, and are presumably required for academia and R&D departments of giant multinationals.

COMPETENCIES OF THE MALAYSIAN ENGINEER

422 employers in this study were sought for their views on two primary questions. What are the engineer competencies really needed by industry and other stakeholders? To what extent are these achieved by engineering graduates?

The competency which shows that the worst score (highest mean gap) from employers' perspective was the ability to undertake problem identification, formulation and solution, followed by the ability to communicate effectively, teamwork, ability to utilise a systems approach to design and evaluate operational performance. The best score (lowest mean gap) was recorded by the competency on theoretical and research engineering.

The views of employers on graduate competencies clearly imply that there is an urgent need for engineering programmes to improve in all areas, particularly in several non-technical aspects of engineering education. Apart from the application of mathematics and the sciences as core engineering subjects, engineering curriculla must place more emphasis on the humanistic, as apposed to the scientific and mechanistic, aspects of problem solving or project implementation. There is agreement among employers and leading engineers that local IHE graduates lack effective both oral and written communication skills. In preparing the student for his professional career, the importance of mastering these soft skills must be duly emphasised.

To face the numerous challenges of the future, the graduate engineer is expected to master new and innovative areas of engineering and be able to solve new engineering problems. While recognising the need to incorporate a wider content into engineering curricula, the normal study period of engineering programmes is a limiting constraint.

Many agree with the view that today's engineering curriculum are too packed with technical courses, and therefore needs a fresh outlook. The current trend for undergraduate degrees that are too specialised has led to graduates that are weak in engineering fundamentals. Such specialised technical courses are more appropriately covered in more advanced postgraduate programmes which are very flexible in responding quickly to market demands. This will also be in line with encouraging continuing professional development as expected of professional engineers.

Engineering fields have evolved into specialty areas such as biomedical engineering, micro-electro-mechanical systems, and many others, which involve interaction between several fields. Knowledge in multidisciplinary engineering is vital since many of the current industrial practices require working in teams of engineers of differing disciplines, and even with non-engineers. Multidisciplinary skills has been identified by the employer survey and leading engineers as a necessary attribute of current and future engineers in Malaysia.

Many of the current and future engineering problems require knowledge of all the fundamental sciences of physics, chemistry and biology. It is observed that matriculation students now are restricted to take only two basic science courses, a practice that inhibits them to be adequately prepared as engineering students

INDUSTRIAL TRAINING

There is a wide consensus among stakeholders on the necessity of incorporating industrial training in engineering curricula. The key objectives of industrial training are to provide students with exposure, experience and familiarity with actual implementation of engineering work. It will also promote closer university-industry understanding and linkages.

Current accreditation standards set by the Engineering Accreditation Council (EAC) require industrial training to be for a minimum continuous period of two months. The analyses of international trends clearly indicate that industrial training is an increasingly essential component of engineering curricula. This is to ensure programme outcomes relating to professional and social skills are achieved by graduates. Discussions with leading figures in the Malaysian engineering community similarly points towards the strengthening of industrial training structures. A survey of employer views, where 79% agrees to the need for industrial training, supports the current position of EAC/BEM in making it a mandatory requirement for engineering programmes. Most employers are willing to participate in industrial training programme. The study also indicates most employers prefer the duration for the training should be at least six months.

Industrial training could be mutually beneficial. Recognising that there is a significant component of industry who are still hesitant or unwilling to provide industry placements for students, it is imperative that the government plays a more influential role in enhancing university-industry collaboration towards this purpose.

DEMAND-SUPPLY TRENDS AND THE ENGINEERING JOB MARKET

The current number of engineers in Malaysia is estimated at around 80,000. This corresponds to an engineer-population ratio of 1:312, which is far lower than figures for advanced nations. It is thus necessary for Malaysia to intensify her production of engineers at a very significant rate in order to achieve a comparable index with the developed nations. It is suggested that the government could reasonably set an "advanced nation benchmark" at engineer:population ratio of 1:100. This means that the nation would need around 275,000 and 300,000 engineers in 5 and 10 years respectively (assuming population growth at 2% per annum).

The demand for Malaysian engineers is expected to continue to rise and the supply of graduates from local universities must continue to be increased significantly in accordance with government projections. In order to meet this demand, the universities must significantly increase student enrolment. However, as an essential pre-requisite, their resources and capabilities must also be correspondingly improved, particularly with respect to human resource development.

The engineering profession must brace itself for an impending scenario where Malaysian industry have to internationalise their activities and more engineers need to be self-employed. Engineering programmes and curricula must be reviewed to take account of the overseas employment market and self employment/entrepreneurship as alternative career options for graduates. Universities must realise the benefits of study and work experience in foreign environments and initiate efforts to facilitate its implementation.

ACCREDITATION & INTERNATIONAL BENCHMARKING FOR QUALITY ASSURANCE

Engineering education in Malaysia is expanding fast over the last decade as a direct result of the nation's strategy to become an international education hub for the region, as well as providing sufficient manpower for the nation's industrial and technological development. The challenge arising from this phenomenon is quality assurance. This can be achieved if there is a sound accreditation system in place which ensures that accredited study programmes meet a preset minimum quality standard for their resources, processes and outcomes. It is also essential that the accreditation system be formally benchmarked against international standards by involvement in appropriate international accords and agreements.

The Washington Accord is a multinational agreement first signed in 1989, which recognises the substantial equivalency of engineering degree programmes accredited by the responsible bodies in each of the signatory countries. Admission to the Accord is an endorsement that the engineering education system of the member nation has demonstrated a strong, long-term commitment to quality assurance in producing engineers ready for industry practice in the international scene. Malaysia is currently the only developing nation that has secured Provisional Membership of the Washington Accord.

The European Network for the Accreditation of Engineering Education (ENAEE) was recently established in Brussels on February 8, 2006, by a consortium of 14 European accreditation bodies and other institutions in the field of engineering education. ENAEE will establish a European system for engineering accreditation based on a framework of standards developed by the recently completed EUR-ACE project sponsored by the European Commission.

This framework is known as the EUR-ACE Framework Standards for the Accreditation of Engineering Programmes, and accredited programmes will carry the EUR-ACE label. It is envisaged that this label will be a European Label indicating quality engineering programmes. The ENAEE as a European accord represents a new, well-structured and transparent international quality framework. It is also noted that its proponents are very positive in extending their activities to involve non-European nations.

The developments in Europe described above have sparked interest among several Asian countries of creating a similar regional framework by the accreditation bodies in Korea and Japan to strengthen Asian cooperation towards a possible Asian Accord. It would be a strategic move for the nation’s internationalisation objective if Malaysia could play a joint-founding role in the proposed Accord.

CONTINUOUS QUALITY IMPROVEMENT AND THE OUTCOMES APPROACH

The engineering education community in Malaysia is currently engaged in intense efforts towards full membership of the Washington Accord. The most significant requirement for this process is the need for a genuine shift from the conventional prescriptive-based system towards an outcome-based education (OBE) system.

OBE focuses on outcomes in the preparation of graduates for professional practice. This requires documented evidences, which demonstrate that the graduates have achieved the required outcomes, rather than focusing on the process in achieving the outcomes, even though this may also be important. An important and integral component of the OBE approach is Continuous Quality Improvement (CQI). Opinions of stakeholders must be taken into consideration at all stages of quality improvement; at the curriculum design until the execution and implementation of the programme.

The Ministry of Higher Education, EAC, and the Engineering Faculty of Universiti Kebangsaan Malaysia, have embarked on an intensive project aimed at driving the required culture change towards OBE in Malaysian engineering faculties. The desired culture change in the universities was initially driven by and centered on a conscious effort in changing the existing curriculum in line with OBE. The first main objective was for all engineering faculties in Malaysia to design and adopt an outcome-based curriculum and implement it in the academic session of 2006. This exercise will create the necessary initial awareness, understanding and motivation for faculty staff to continuously improve the programme by focusing on outcomes.

It is essential that the new educational practices necessary for this endeavour be solidly founded on rigorous surveys, studies and investigations. This research activity must be reinforced by a strong and reliable institutional support for engineering education research.

ENHANCING CAPABILITIES OF ACADEMIC STAFF

A clear consequence of the proliferation of new engineering faculties and programmes in Malaysia within the last decade is that the limited number of well-qualified, experienced lecturers in the country have been spread too thinly, to the extent of significantly affecting teaching quality. While the number of engineering graduates produced by Malaysian universities increase each year, the quality of these graduates needs to be ensured. Weaknesses that are prevalent need to be identified and rectified. Key findings made by the Washington Accord team on a mentoring visit to Malaysia in 2006 found that the academic staff in a new technical university were much inferior compared to the more established conventional universities.

It is imperative that the serious shortage of capable academic staff in the newer faculties be effectively overcome through resource consolidation to maintain standards across all IHEs. Such resource consolidation will necessarily involve cross-university movement of staff, particularly between the newer and more-established universities. Each university must have a clear plan and a serious, concerted effort to ensure the provision of adequate numbers of qualified and capable academic staff, and to rectify the deficiency in practical experience among them.

While it is acknowledged that the government is already undertaking measures to train and upgrade Malaysian academic staff, they are mostly young, inexperienced, limited in number and still fall short in fully addressing the problems. The other alternative is to tap the international market which demands matching compensation schemes and reasonably fast hiring procedures. However, past experience indicates very serious problems in bureaucracy involving multiple government departments.

PROVISION OF ADEQUATE FACILITIES AND INFRASTRUCTURE

It is important that universities are equipped with up-to-date and advanced facilities, equipment and infrastructure so as to ensure that engineering students receive sufficient exposure to current technology. The view solicited from the qualitative study interviews was that the requirement for upgrading and expansion of facilities and infrastructure has not kept pace with the rapid increase in engineering student intake.

An engineering education environment conducive to the satisfactory attainment of designated graduate outcomes can only be brought about by adequate university facilities and infrastructure.

RECOMMENDATIONS

Based on the preceding discussion, the Study Committee presents the following recommendations. Some of these serve to reinforce views that are already prevailing, but have yet to be addressed satisfactorily. Recommendations considered new are boxed.

1. **The TUCs should continue to consolidate and strengthen the existing programmes to produce applications and practice oriented engineers.**

2. **The conventional universities ensure that their existing programmes are sufficiently provided with applications-oriented content to ensure their graduates achieve an outcome profile that is balanced, i.e. where the applications component is at least as significant as the theory part.**

3. **The demand for theoretical/research-oriented engineers should be met by research-based Masters and PhD programmes currently offered by local universities.**

4. **The learning experience in engineering programmes should be strengthened in all areas, but with greater emphasis on communication skills, teamwork, problem solving, creativity and innovative thinking.**

5. **Engineering undergraduate courses should emphasise more on the fundamental aspect of engineering while the specialised courses be appropriately taught at postgraduate level.**

6. **A multidisciplinary engineering approach should be incorporated as an important component of engineering curricula, not necessarily restricted to the final year of study.**

7. **Engineering faculties should offer programmes addressing new emerging engineering fields at the postgraduate level.**

8. **The Ministry of Education should allow matriculation and STPM students to take all the three basic science courses, i.e. physics, chemistry and biology.**

9. **Engineering programmes should extend the industrial training period to six months.**

10. **The government should introduce legislation and set up an agency to facilitate industrial training placement at the national level.**

11. **Conventional universities, including new ones, should upgrade and enhance their capabilities in order to introduce new engineering programmes and expand student intakes for existing ones.**

12. **Engineering programmes should incorporate entrepreneurial skills and global competitive traits as essential components of graduate outcomes**

13. **Universities should encourage and facilitate cross-border mobility of students and overseas placements for industrial training and subsequent employment.**

14. **BEM should seriously step up its effort towards full signatory status in the Washington Accord by adopting internationally accepted practices of accreditation.**

15. **EAC/BEM should forge closer links with ENAEE and initiate efforts towards securing the EUR-ACE Label, which is an accepted European mark for quality engineering education.**

16. **LAN/MQA/EAC should offer to provide a secretariat for the possible establishment of an Asian Accord for the accreditation of engineering education.**

17. **Universities should endorse research in engineering education as a valued and rewarded activity that is categorically linked to promotional exercises among academics.**

18. **MOHE should allocate grants for research in engineering education from the fundamental research fund.**

19. **MOHE should set up a Centre for Engineering Education Research within the framework of the existing National Institute for Higher Education Research (IPPTN).**

20. **MOHE should set up a task force comprising of senior academics to advise on the necessary actions to upgrade and ensure the quality of academic staff in existing engineering faculties, in particular to facilitate inter-university staff mobility and collaboration.**

21. **The national “brain-gain” project should be facilitated by quickly ensuring the removal of bureaucratic obstacles and provision of salary schemes that are internationally competitive.**

22. Universities should facilitate the promotion of lecturers who do not have postgraduate degrees but possess a wealth of professional experience.

23. Universities should incorporate industry experience gained by academic staff as an important criterion in their appointment and promotion.

24. The Malaysian Council of Engineering Deans, in conjunction with the Ministry of Higher Education, should establish council/s of university-industry leaders to foster closer collaboration between the two sectors.

25. The government should provide adequate funds to upgrade existing library and laboratory facilities for teaching and research, as well as to procure new ones.

26. MOHE should enhance the image of public universities by highlighting the overwhelming preference given by employers to graduates from their engineering programmes.

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Engineering education in Malaysia is rapidly expanding and its direction needs to be charted. Hence the need for this study, entitled *The Future of Engineering Education in Malaysia*, which revolves around several key questions.

- What kind of engineers does Malaysia need?
- Are engineering graduates achieving outcomes that are relevant to stakeholder needs, now and in future? Are they ready to face the impending challenges of a fast changing world?
- What needs to be done today to prepare the engineers of tomorrow?

Engineering has always played a major role in wealth creation. In the fast developing economy of Malaysia, the central role of the engineering community is unquestionable. This is precisely why engineering is the nation's largest profession, and engineering education is the biggest sector in tertiary education. Being the biggest warrants that it is done right, especially in the context of the unique conditions of the nation and region.

1.2 SQUARING UP TO THE CHALLENGES

Engineering graduates will enter the profession in the face of daunting issues such as globalisation, rapid technological advancement, intensive physical development, environmental degradation and its preservation, capacity building as well as ethics and civil obligations. Future engineers of Malaysia will be the agents of technology-driven change. Technologies are being developed to a state where they can be applied commercially and their role is optimised to the benefit of society. ICT is already changing the way engineers work. Products are increasingly developed by multi-disciplinary teams from multiple nations, where team members of projects no longer need to meet to work together.

In view of these developments, universities need to tailor their courses accordingly. They must produce engineers who will develop and use sustainable technology and benign manufacturing processes that will support a healthy economy as well as a healthy environment. They will have to give due regard environmental preservation as well as economic development.

In order to compete effectively in the global economy, developing countries such as Malaysia need to develop their own indigenous technology. This can be achieved by capacity building of their own technical expertise. Engineers must have the sound education and training to be able to design, operate and manufacture products and services that are responsive to local needs. They will have to possess attributes normally expected of professional engineers, plus an ability to deal with unique socio-political constraints. Engineering education cannot afford to be static but must be constantly reviewed and improved. Continuous quality improvement has to be made a culture of engineering education.

1.3 ENGINEERING EDUCATION IN MALAYSIA

Tertiary engineering education in Malaysia began in 1956 with the introduction of the Bachelor of Civil Engineering programme in the University of Malaya. More engineering programmes were later introduced in other public universities, i.e. Universiti Teknologi Malaysia (UTM), Universiti Teknologi MARA (UiTM), Universiti Putra Malaysia (UPM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM), Universiti Islam Antarabangsa Malaysia (UIAM), Universiti Malaysia Sabah (UMS), and Universiti Malaysia Sarawak (UNIMAS).

Engineering programmes are now offered by private Institutions of Higher Education, where the main ones such as Multimedia University (MMU), Universiti Tenaga Nasional (Uniten) and Universiti Teknologi Petronas (UTP), are owned by various government-linked companies. Branch campuses of four foreign universities offering engineering programmes have been set up in recent years, i.e. Monash University, Curtin University, Swinburne University and Nottingham University.

Engineering curriculum in the universities mentioned are mainly theoretical oriented, similar to those in the universities in UK and the Commonwealth countries. Within the last decade, the Malaysian government has taken a bold step with the setting up of four

Technical University Colleges (TUCs) that offer programmes with an applications and practice oriented curriculum along the lines of the successful and proven German *fachhochschule* system. The four TUCs are Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO), Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM), Kolej Universiti Kejuruteraan dan Teknologi Malaysia (KUKTEM) and Kolej Universiti Kejuruteraan Utara Malaysia (KUKUM).

This constitute a major development in the Malaysian engineering profession, the impact of which will be that a large proportion and number of Malaysian engineering graduates produced in the future will be equipped with applications and practice oriented competencies. While the engineering graduates from conventional universities are more theoretical and research oriented, the TUC graduates are expected to be more practical, adaptive, agile and flexible to changes in the working environment (KUITTHO 2005; KUITTHO et al. 2004; NCEE2003 Resolution 2003), and recognised as full-fledged engineers by the engineering professional body.

1.4 OBJECTIVE OF STUDY

In December 2005, The Ministry of Higher Education (MOHE) commissioned this study with the objective to review the status and chart the course of engineering education in Malaysia. The study will recommend the actions deemed necessary to ensure Malaysian engineering graduates are adequately prepared for the future, while taking stock of current strengths, weaknesses, opportunities and the anticipated challenges.

The study is part of an ongoing effort to achieve the wider objective of the National Education Philosophy in producing human capital equipped with the necessary attributes to face the challenges of globalisation and technological advancement, contribution towards the socio-economic development and the attainment of national unity, towards an advanced nation status by 2020.

1.5 SCOPE OF STUDY

The scope of the study encompasses all engineering programmes at the Bachelor's degree level that are expected to be accredited by the Board of Engineers Malaysia (BEM) for the purpose of registration as a Graduate Engineer as required by The

Registration of Engineers Act (Revised 2002). The study does not cover engineering programmes at Certificate, Diploma, Masters and PhD level. It also does not cover a category of programmes at the Bachelor's degree level known as engineering technology, which are specifically designed to produce mainly skill-based technologists within the wider engineering profession.

The specific elements addressed by the study includes:-

- In Chapter 3, the competency profile for Malaysian engineers, vis-à-vis the dual profile of engineers in Europe; In Chapter 4, programme curricula and outcomes, particularly those relating to soft skills, humanities and socio-environmental, and new engineering fields;
- In Chapter 5, the status of industrial training in engineering curricula; In Chapter 6, the anticipated future demand and supply of engineers;
- In Chapter 7, accreditation in the context of quality assurance and international benchmarking; and in Chapter 8, the outcome-based approach in the context of continual quality improvement of programmes, and the consolidation of human resource and facilities.

In producing this document, relevant government reports, statutes and legislation have been referred to. The contents of these publications are not included here but may be obtained from sources cited in the bibliography.

CHAPTER 2
METHODOLOGY

In conducting the study, the following strategies were adopted:-

1. A survey and analysis of related literature.
2. A quantitative survey to solicit views from employers of engineers.
3. Qualitative interviews with eminent members of the engineering profession.
4. Consultation through workshops with stakeholders of engineering education.
5. International benchmarking study visits.

Sub-committees for the secretariat, employer survey and qualitative interviews were formed to facilitate implementation of the study. The main study committee met on a monthly basis to review and analyse the collected data and information. Three workshops were convened to prepare the interim and final reports. The third workshop focused on formulating the final recommendations.

2.1 LITERATURE SURVEY

Prior to this study, there were at least two Malaysian reports on the same subject. These are:-

- *Halatuju Pendidikan Kejuruteraan* (1999), commissioned by the then Ministry of Education, conducted by Universiti Kebangsaan Malaysia in conjunction the Malaysian Council of Engineering Deans.
- *Malaysian Engineering Education Model: Educating Future Industry Leaders* (2000), commissioned by the Institution of Engineers Malaysia, conducted by the Malaysian Council of Engineering Deans.

On the international scene, a very recent similar study in the US by the National Academy of Engineering (2005b) entitled *Educating the Engineer of 2020: Adapting Engineering Education to the New Century* provided as a very useful reference and benchmark. There were many other essays and studies from all over the world, particularly from Europe and the US, dwelling on the subject of engineering education status, change and reform. The full list of literature used as input to the study and its recommendations are as in the Bibliography.

2.2 EMPLOYER SURVEY

A quantitative survey of employers with engineers in their employ was conducted nationwide in collaboration with the National Statistics Department (*Jabatan Perangkaan Negara*). A pilot study involving 30 sample employers was conducted to obtain an initial indication of the results and to improve the survey design. The full survey was then carried out on a sample size of 422 respondents.

The specific objectives of the quantitative employer survey are:

(i) To investigate the views of employers with regard to the type of engineers and engineer profiles most suited for their organisations.
(ii) To investigate the perception level of employers with regard to the competencies of engineering graduates.
(iii) To investigate the expectation of employers with regard to the importance of the specific competencies of engineering graduates.
(iv) To assess employer views and support in industrial training of engineering students.

2.2.1 Profile of the Respondents

To ensure that the data collected is as accurate as possible, the interviews were conducted with Human Resource Managers or officers of higher rank within the company hierarchies. The distribution of respondents by position is shown in Figure 1. The majority of respondents are Human Resource Managers at 44%, followed by General Managers at 33% and Executive Directors at 12%. The remainder (11%) are Chief Executive Officers, Chief Operating Officers and Chairmen.

The survey focused on employers of engineers located in major cities and towns within regions as in Table 1. The employers are categorised according to the sectors as defined by the Royal Academy of Engineering (2000) as shown in Table 2

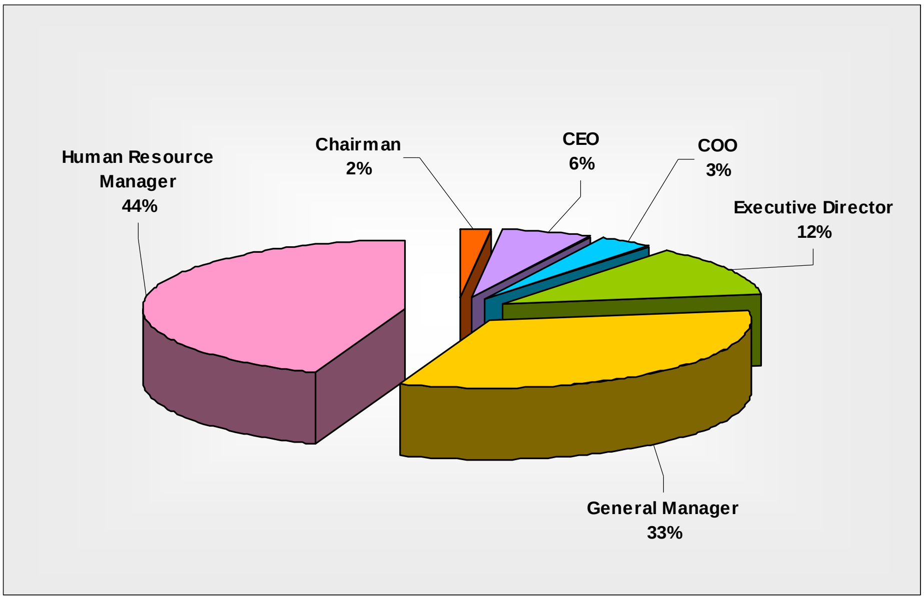

Figure 1: Positions in the Respondent's Company

(Key: CEO = Chief Executive Officer; COO = Chief Operating Officer)

Table 1: Numbers and Percentages of industries based on region

Region	Total	Percentage
Klang Valley	154	36%
Northern Region	69	16%
Southern Region	85	20%
East Coast	60	14%
East Malaysia	54	13%
TOTAL	**422**	**100%**

Table 2: Numbers and Percentages of industries based on sectors groups (category)

Target Group	Total	Percentage
Healthcare, Social, Entertainment & Leisure	39	9%
Education & Consulting	70	17%
Commerce, Trade, Finance, Agriculture & Food	55	13%
Communication, IT, Defence, Security, Transport	43	10%
Engineered Materials, Energy & Natural Sources	102	24%
Built Environment	113	27%
TOTAL	**422**	**100%**

2.2.2 Sampling Design

Sampling for the employer survey relied on a single level stratified random sample to ensure a fair representation based on the following elements:

- Location.
- Engineering sectors.
- Number of workers as the selection variable.

The selected employers were used as sampling units, and the sample size was calculated using the following expression (Cochran 1963; Schaeffer et al. 1986):

$$n = \frac{(\sum N_h S_h)^2}{V + \sum N_h S_h{}^2}$$

where;

n = sample size

N_h = population size on strata h

S_h^2 = variance on strata h

V = required variance

= $(RSE.\hat{Y}/z)^2$

$\hat{Y}$ = the predicted number of workers at the related strata

RSE = relative standard errors targeted

z = confidence interval value targeted

(Note: the variable used for calculation purposes was the number of workers)

The sample size (n) was 422 for an estimated total population of 9000 companies employing engineers. The survey was carried out by the method of 'guided face-to-face interviews' using a set of questionnaires. A pilot survey was carried out in January 2006 followed by the main survey activities from April 2006 until September 2006, covering the state capital cities in Peninsular and East Malaysia.

2.3 QUALITATIVE INTERVIEWS

Findings from the quantitative survey of employers may not be able to cover adequately some of the study scope. Several interviews with key and eminent members of the engineering profession served to provide additional views and insights into the more complex aspects of engineering education and the profession. An advisory panel comprising of such persons was set up. Interviews were conducted with the advisory panel members to garner their views on related issues.

2.4 CONSULTATION SESSIONS

Two consultation sessions with various stakeholders of engineering education were held in the course of this study. The first was a workshop held on 22nd March 2006 where an interim report based mostly on the pilot study of 30 respondents was presented. The discussion during the workshop provided valuable feedback both on the report and on the survey questionnaires. The second session was a workshop conducted on 28th July 2006 to present the second interim findings to the Minister of Higher Education of Malaysia, the Malaysian Council of Engineering Deans, and the Board of Engineers Malaysia.

2.5 BENCHMARKING STUDY VISITS

Study visits to several countries were carried out in order to obtain first-hand information on the direction in engineering education and profession on the international scene. The institutions and the professional bodies visited were:

1. The European Federation of National Engineering Associations (FEANI), Brussels.
2. German Accreditation Agency for Study Programs in Engineering, Natural Sciences, Mathematics and Informatics (ASIIN), Dusseldorf.
3. Fachhochschule Dusseldorf
4. Universitat Duisburg-Essen
5. Commission des Titres de l'Ingenieur (CTI), Paris.
6. Ecole de Mines, Paris
7. Ecole Superior de Telecoms, Paris
8. Japan Accreditation Board for Engineering Education (JABEE), Tokyo.
9. Accreditation Board for Engineering Education of Korea (ABEEK), Seoul.
10. Center for Engineering Education, Korea University, Seoul.
11. Ikatan Nasional Konsultan Indonesia, Riau.

12. Universitas Riau, Pekan Baru

CHAPTER 3
ENGINEER PROFILES FOR MALAYSIA

What kind of engineer does Malaysia really need? This question needs to be addressed in order for the nation's universities to adopt a rational plan on the competency profiles for future engineering graduates.

In the context of the rapid advancement of technology and industry in recent decades, Germany is widely viewed as one of the most successful engineering nations of the world. Malaysia took a bold step within the last decade by establishing four technical university colleges (TUCs) modelled along the German Fachhochschule (FH) engineering education system.

The TUCs are expected to contribute the bulk of Malaysian engineering graduates. The objective of the TUCs is to produce applications and practice oriented engineering graduates that are relevant and ready for industry in both local and overseas job markets (NCEE2003 Resolution 2003; KUITTHO et al. 2004). They are basically differently oriented to those graduating from other conventional Malaysian universities who are traditionally more theoretical and research oriented.

3.1 INTERNATIONAL TRENDS

The European Federation of National Engineering Associations (FEANI) recognises two profiles of the professional engineer for the purpose of registration as a European Professional Engineer (EUR-ING), i.e. (1) the theoretical oriented engineer, and (2) the applications oriented engineer. Both categories of engineers, despite having some different competencies, are considered to have the same standing and importance in their role in industry. FEANI's publication, Competence of Professional Engineers/EUR-ING (FEANI 2005a), explains at great length the attributes and roles of both.

France, Japan, and Korea have always adopted engineering curricula where practice constitutes a large and important part to compliment the theoretical component. The top engineering schools in France, while well-known for their strong theoretical foundation, prescribe extensive and well laid out structures to incorporate practice and applications elements in their curricula. The French accreditation agency for engineering programmes, Commission des Titres d Íngenieurs (CTI), has advanced to the extent of specifying that a minimum of 20 percent of teaching time to be in the form of industry contribution. Discussions with several accreditation agencies and universities in Europe, Korea and Japan generally point towards the direction of a desired engineer profile where both theory and practice are well-grounded.

The dual profiles of professional engineers are present and recognised in several European countries, notably Germany. There is however, an observed trend where both profiles appear to converge in terms of curricula and designated outcomes. The conventional dual-profile categorisation of the university engineer (theoretical orientated) and the FH engineer (applications oriented) is apparently moving towards a single, more balanced profile. In accordance with laws in all states of the German Federation, the traditional degrees known as Dipl.Ing and the Dipl.Ing. (FH) are now being replaced by the universally adopted Bachelor-Master structure. No distinction is made in the degree nomenclature to indicate the profile category. (See Figures 2 and 3) However, each university will have their own set of programme outcomes that may be self-evident in terms of which of the two profiles they belong.

These developments have taken place alongside far-reaching changes within the wider European higher education system. A joint declaration on the harmonisation of the architecture higher education was signed by several European Union member countries on the 25th of May 1998 in Sorbonne, Paris. The declaration, better known as the Sorbonne Declaration (1998), has resulted with the creation of a European area of higher education, where national identities and common interests can interact and strengthen each other. Following this was the joint declaration of the European Ministers of Education in Bologna on the 19th of June 1999 (CRE 1999; SEFI 2002). The declaration, also known as the Bologna process, aims at creating an overall convergence of the higher education systems at European level.

In the engineering education front, FEANI has created a Register to establish, among others, a framework of mutual recognition of qualifications. This is intended to facilitate the movement of practicing engineers among the member states, carrying with them a guarantee of competency. For the same reason, FEANI has adopted the globally accepted Bachelor-Master university degree structure. Similarly, the German education system is moving towards this common standard as shown in Figures 2 and 3.

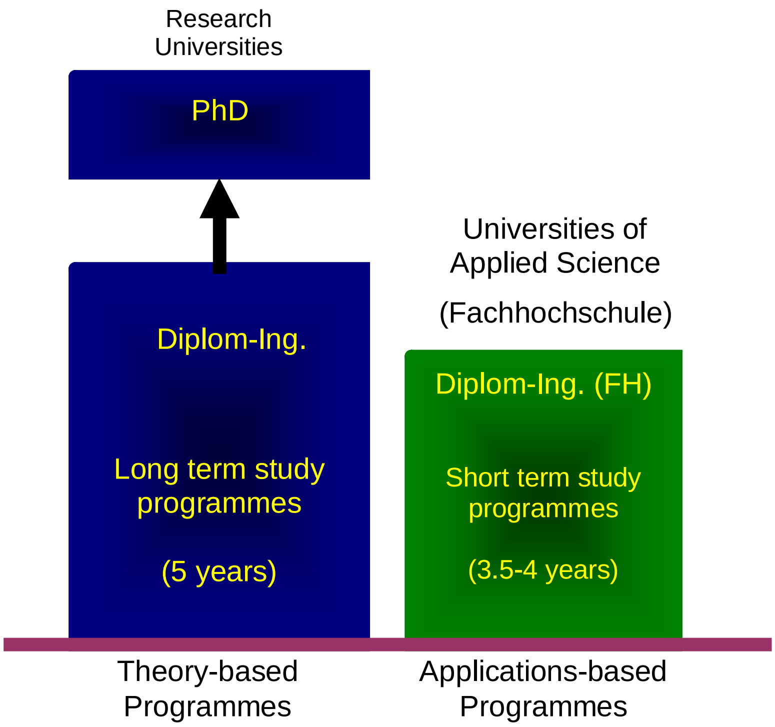

Figure 2: Traditional education system in Germany

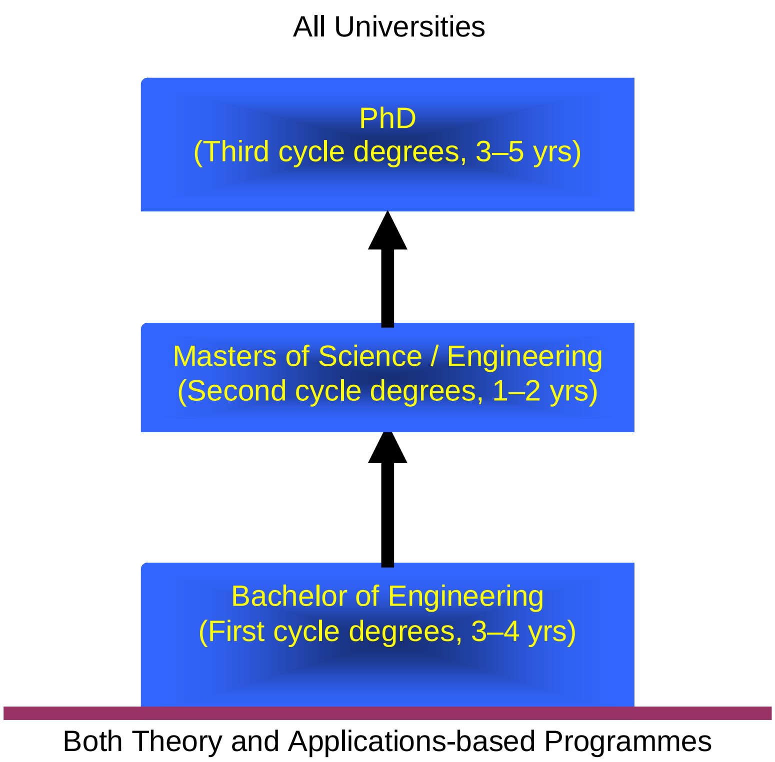

Figure 3: Future university degrees in Germany based on European standard

3.2 THE SUB-PROFESSIONALS

The competencies of the labour force within the engineering profession, following a period of education and training, vary greatly. The European Federation of National Engineering Associations (FEANI) has listed four categories of sub-professions within the whole spectrum of engineering practice, i.e. from a highly theoretical individual at one end to a craftsman at the other. These are Professional Theoretical Engineers; Professional Application Engineers; Engineering Technicians; and Craftsmen (FEANI 2005b).

In Malaysia, apart from the professional engineer level, there are three other categories of competency profile levels i.e. engineering technologists (typically technology degree level graduates), technical assistants (typically diploma level graduates), and technicians (typically certificate level graduates). The main part of this study deals only with the professional engineer profile, typically referring to graduates of accredited 4-year engineering programmes.

The employer survey, as depicted in Figure 4, showed that among the four categories of the engineering profession, engineers are the most needed. A total of 58% of respondents ranked the engineers as their first choice of employment. This clearly indicates the importance of engineers in playing a major role in the current and future development of Malaysian industries.

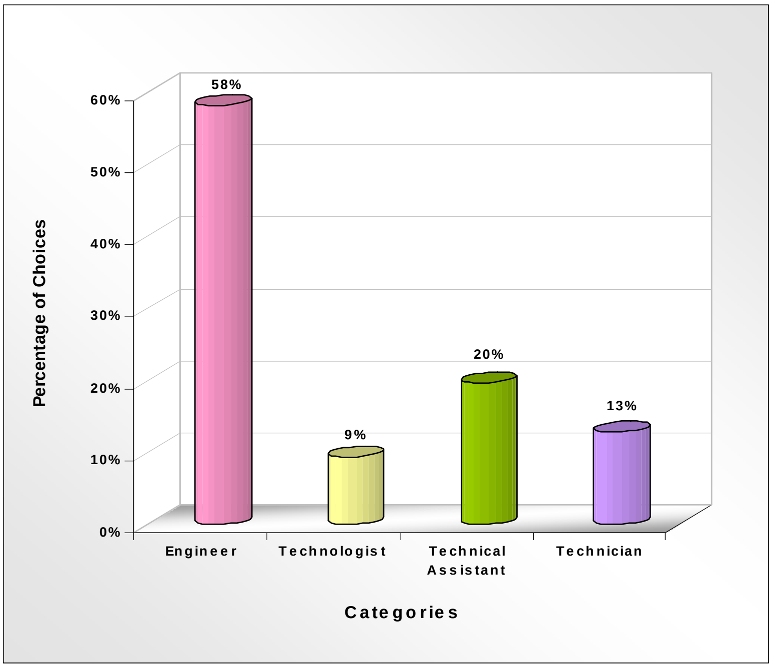

Figure 4: Engineering Workforce Ranking

Technical assistants are a distant second choice, followed by the technicians category. Technologists are the least demanded where only 9% of employers prefer to employ them. For the sub-professional levels, the more preferred category is the technical assistant level. The preference for technologists was notably low. A possible reason for this is the uncertainty as to the real capabilities of technologists when compared to engineers in solving the complex problems and performing the challenging tasks in the engineering domain.

3.3 PROFILES OF THE PROFESSIONAL ENGINEER

Based on the analysis of developments both at national and international levels, three engineer profile categories are considered as relevant for engineering education in Malaysia. They are:-

<u>Theoretical and research orientation:</u> A profile characterised by proficiency in the more theoretical aspects of engineering work, dealing with research, original concepts and innovation. FEANI (2005a) describes the competencies of a theoretically-oriented EUR-ING engineer as, among others, "an ability to maintain a sound theoretical approach" and to apply "a significant range of fundamental principles, enabling him to develop and apply new technologies, promote advanced designs and design methods, introduce new and more efficient production techniques, marketing and construction concepts, and pioneer new engineering services and management methods."

<u>Applications and practice orientation:</u> A profile characterised by the ability to apply the theoretical fundamentals of engineering and current technology to perform complex technical duties in a wide variety of contexts. FEANI (2005a) describes the competencies of an applications-oriented EUR ING engineer as, among others, an ability to exercise "independent professional judgment through developing techniques and procedures by the application of engineering principles", and in "designing, developing, manufacturing, commissioning, operating and maintaining products, equipment, processes and services."

<u>Balanced orientation:</u> A profile characterised by a combination of the two profiles described above. This profile has both the theoretical/research and applications/practice competencies.

All three engineer profiles will however include competencies as prescribed in the EAC Manual (2006) as minimum requirements. They are:-

a) ability to acquire and apply knowledge of science and engineering fundamentals;
b) acquiring in-depth technical competence in a specific engineering discipline;
c) ability to undertake problem identification, formulation and solution;
d) ability to utilise systems approach to design and evaluate operational performance;
e) understanding of the principles of sustainable design and development;
f) understanding of and commitment to professional and ethical responsibilities;
g) ability to communicate effectively, not only with engineers but also with the community at large;
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) understanding of the social, cultural, global and environmental responsibilities of a professional engineer, and the need for sustainable development; and
j) recognising the need to undertake life-long learning, and possessing/acquiring the capacity to do so.

3.4 EMPLOYER VIEWS ON ENGINEER PROFILES

RESULTS FROM THE EMPLOYER SURVEY HAVE indicated that 59% of the respondents from industries preferred a balanced competency profile of engineers. This is followed by the applications and practice oriented profile preferred by 38% of employers, while the theoretical/research oriented engineer was the least favoured choice at 3% (See Figure 5).

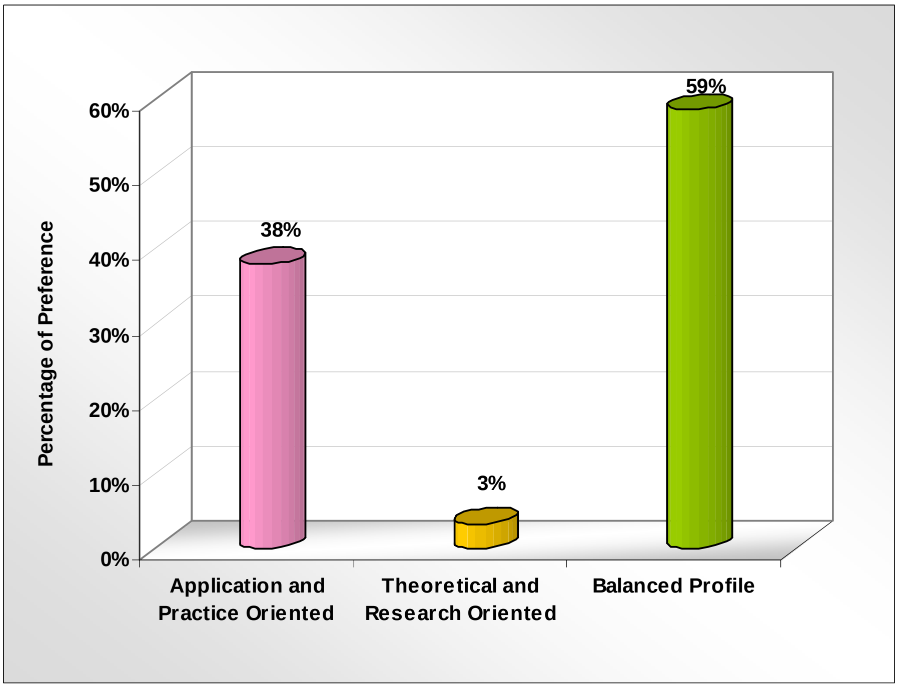

Figure 5: Preference of Engineer Profile

This finding is further validated by employer ratings of two contrasting graduate outcomes related to the engineer profile, as given in Table 3.

Table 3: Employer views on two outcomes related to engineer profile

Graduate Outcome	**Important**	Neutral	Not Important	Did not respond
Competency in theoretical engineering and research	**47.3%**	38.9%	8.1%	5.7%
Competency in application-oriented engineering	**52.4%**	33.6%	8.3%	5.7%

The table indicates that while a bigger percentage of employers (52%) regard applications and practice orientation is important, a fairly large proportion (47%) thinks the same way for theoretical and research orientation. This finding supports the conclusion that Malaysian employers mostly prefer engineers with a balanced competency profile, incorporating both theoretical/research applications/practice orientation.

Interviews with key members of the engineering community in Malaysia indicated the need of a high number of applications oriented engineers, while at the same time, acknowledging the necessity of a smaller number of theory-based engineers, to contribute to the economic growth of the nation.

3.5 RECOMMENDATIONS

It is clear that Malaysian employers require engineers with mainly two types of competency profiles. While the first and more widely preferred is a balanced profile combining both theoretical/research and applications/practice orientations, the second, i.e. the applications and practice oriented profile, still constitute a very significant component of the national demand for engineers. The government's decision to set up TUCs in previous years was a correct strategic move to meet this demand. Thus we recommend that

1. **The TUCs should continue to consolidate and strengthen the existing programmes to produce applications and practice oriented engineers.**

Another implication of the study findings is that conventional universities should re-orient their engineering programmes to produce engineers with a balanced competency profile. The bigger preference towards a competency profile with a significant theoretical and research component is in line with the requirements of the national strategic shift from a purely manufacturing-based economy to one that is more knowledge-based in nature. Thus we recommend that

2. **The conventional universities ensure that their existing programmes are sufficiently provided with applications-oriented content to ensure their graduates achieve an outcome profile which is balanced, i.e. where the applications component is at least as significant as the theory part,**

Purely theoretical and research engineers are required in relatively smaller numbers, i.e. less than 5%, and are presumably required for academia and R&D departments of giant multinationals. Recognising that the established universities are already capable of offering programmes at the post-graduate level, we recommend that

3. **The demand for theoretical/research-oriented engineers should be met by research-based Masters and PhD programmes currently offered by local universities.**

CHAPTER 4
COMPETENCIES FOR MALAYSIAN ENGINEERS

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.

What are the engineer competencies really needed by industry and other stakeholders? To what extent are these achieved by engineering graduates? These questions are at the heart of efforts towards changing and improving engineering education.

4.1 THE NEED FOR CHANGE IN ENGINEERING CURRICULA

Engineering programmes and their curricula have traditionally been packed with technical and theoretical content. There has been a prevailing perception that Malaysian engineering graduates are not competent enough in the aspects of teamwork, communication, lifelong learning, and entrepreneurial skills.

In response to industry needs and other stakeholder demands, engineering faculties have been motivated to re-engineer their programmes significantly. Engineering programmes have been encouraged to promote the ability to synthesise and relate courses to real world application in order to facilitate a smooth transition from education to practice. The roles of non-technical competencies such as communications, ethics, and knowledge of contemporary issues are being enhanced. The increasing emphasis on these outcome elements has also been demanded by national and international accreditation bodies for engineering programmes, including most recently by the EAC in Malaysia.

When serious efforts at accreditation of engineering education was first undertaken by the Board of Engineers Malaysia (BEM), the criteria that were typically used centred around curriculum content, manpower capabilities and the academic facilities being provided. In later years, BEM laid out a list of graduate competencies (or programme outcomes) that are desired of engineering graduates, but still fell short of a clear requirement that these competencies need to be demonstrated with evidence.

4.2 ENGINEER COMPETENCIES

In August 2005, BEM adopted a new Manual for the Accreditation of Engineering Programmes (EAC Manual 2005). This new Manual shifted the basis for accreditation from inputs and processes, such as what is taught, to outcomes - what is learnt, or what competencies has been attained. The Manual specify 11 programme outcomes and require engineering programmes to assess and demonstrate student achievement for each one of them. Previous criteria on programme resources and technical content still remain, but it also emphasises developing other professional skills such as teamwork, effective communication and socio-ethical considerations.

In this study, the 13 programme outcomes form the core of competencies that employers were asked to assess; firstly on their importance, and secondly, on graduate performance. Table 4 shows the list of programme outcomes used in this study.

Table 4: Programme outcomes used in the study

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 practice 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 contemporary issues.
M	Having the basic entrepreneurial skills

4.3 EXPECTATIONS AND SATISFACTION LEVELS OF EMPLOYERS

The 422 employer respondents in this study are highly diverse in their geographic location, industry type and company size. The employers were sought for their views on two primary questions. The first was on employer expectation on each programme outcome for graduates that they would employ, i.e. how important are each of these competencies? The second was on employer perception on attainment of programme outcomes, i.e. what is their level of satisfaction on each of the competencies in the graduates that they have employed?

4.3.1 Employer Perception Towards Achievement of Programme Outcomes

The survey results for employer perception towards achievement of programme outcomes are shown in Figure 6.

Generally about half of the 422 respondents are reported to be satisfied with all, except one, programme outcomes demonstrated by engineering graduates in their workplace. The least rated outcome, and exception, is basic entrepreneurial skills, with only 24% satisfied employers.

54% of the employers are satisfied that their engineers are able to apply the fundamentals of engineering in their work. Only 4% register a clear dissatisfaction, while the remainders of 42% are either neutral or did not give a response. Since only a very small number of employers are dissatisfied, this appears to be a partial endorsement of the quality of the particular graduate outcome. Programme outcomes with similar ratings are outcomes G, i.e. the ability to utilise a systems approach to design and evaluate operational performance (engineering systems approach), and outcome H, i.e. the 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 (teamwork).

The remaining 7 outcomes receive positive ratings by less than 50% of employers. The overall implication of the findings depicted in Figure 6 is that universities in general need to do a lot more to upgrade their programmes in order to improve satisfaction ratings by employers in the future.

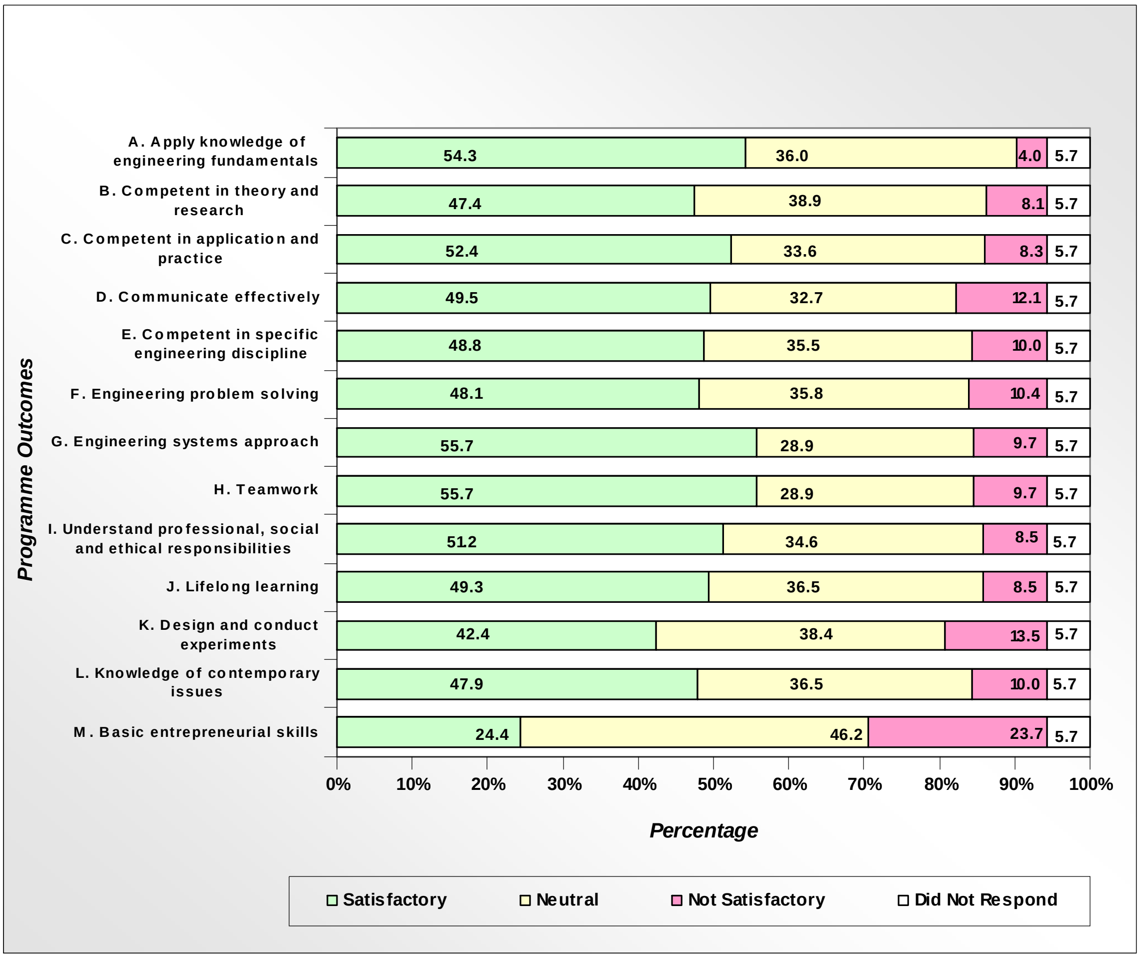

Figure 6: Employers' perception towards engineering graduates

4.3.2 Employer Expectation on Importance of Programme Outcomes

The survey results for employer views on the importance of programme outcomes are shown in Figure 7.

The results signifies that a large majority of employers are in agreement with the EAC manual on the importance of the programme outcomes, i.e. on what engineering graduates should be able to do. This is exhibited by the high scores for the rating of "important". Between 73% and 87% of respondents responded positively on the importance of all outcome statements, except for basic entrepreneurial skills, which obtained a moderate score of about 57%. The highest of score of 87% was by attribute D (effective communication) followed by C (competency in application and practice oriented engineering) with 86%. This indicates the high degree of importance that employers place on these attributes.

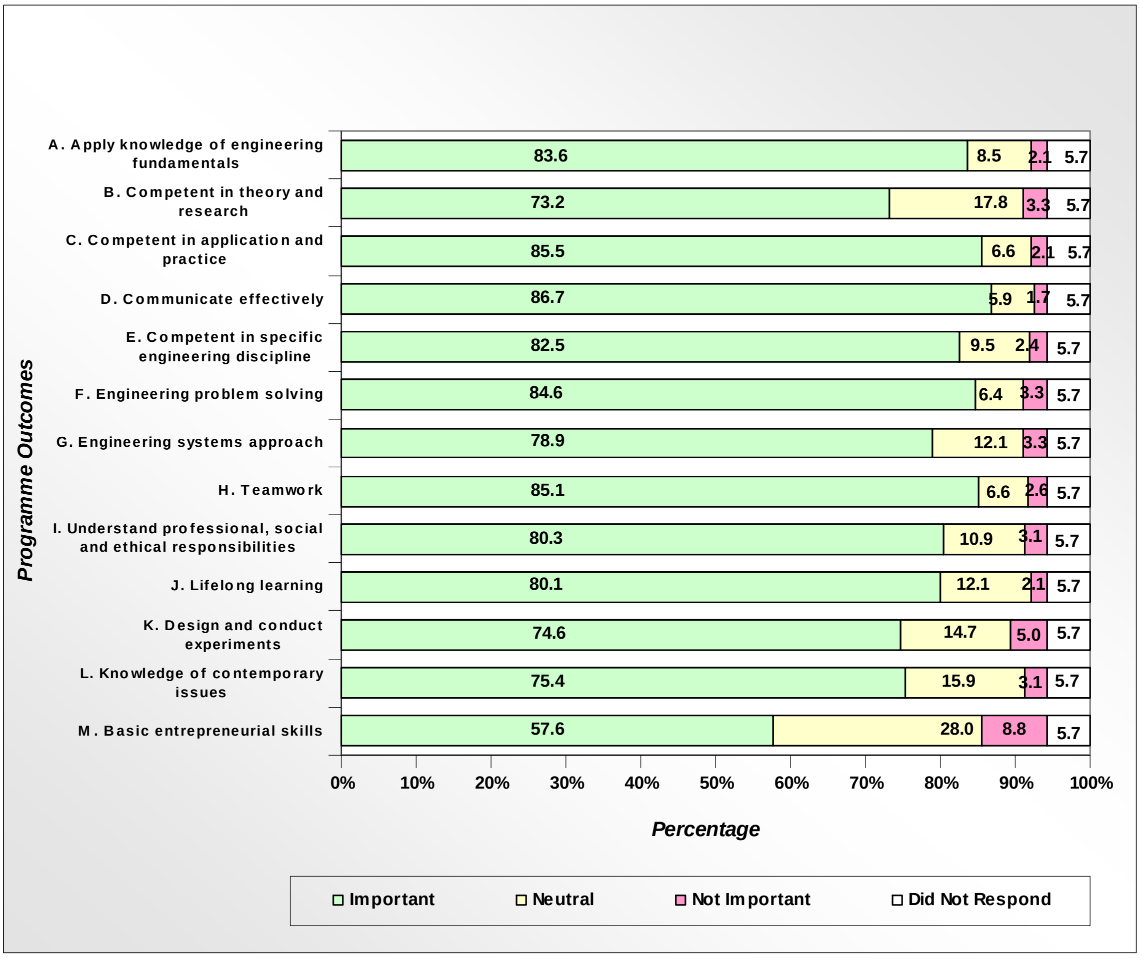

Figure 7: Employers' expectation towards engineering graduates

4.3.3 Gaps between Expectation and Satisfaction Levels of Graduate Outcomes

A measure of the degree of deficiency in achievement for each of the programme outcome is given by the mean gap, as shown in Figure 8. The mean gap is defined as the average difference between the expectation and perception for all respondents, i.e.

$$Mean\ Gap_p = \frac{\sum_{i=1}^{n}\left((Expectation)_i - (Perception)_i\right)}{n}$$

Where i refers to the i th respondent, i.e $i = 1, 2, 3, \ldots\ldots\ldots, n$

p refers to the p th programme outcome, i.e $p = A, B, C, \ldots., M$ and,

n refers to the total number of respondents

A higher mean gap value indicates a bigger discrepancy between what is expected of the work force and their performance as perceived by the employers.

The programme outcome which shows the worst score (highest mean gap) was the ability to undertake problem identification, formulation and solution (0.94), followed by the ability to communicate effectively (0.92), teamwork (0.82), ability to utilise a systems approach to design and evaluate operational performance (0.81). The best score (lowest mean gap) was recorded by attribute B (0.57) on theoretical and research engineering, indicating that employers are the least concerned about improving this particular outcome.

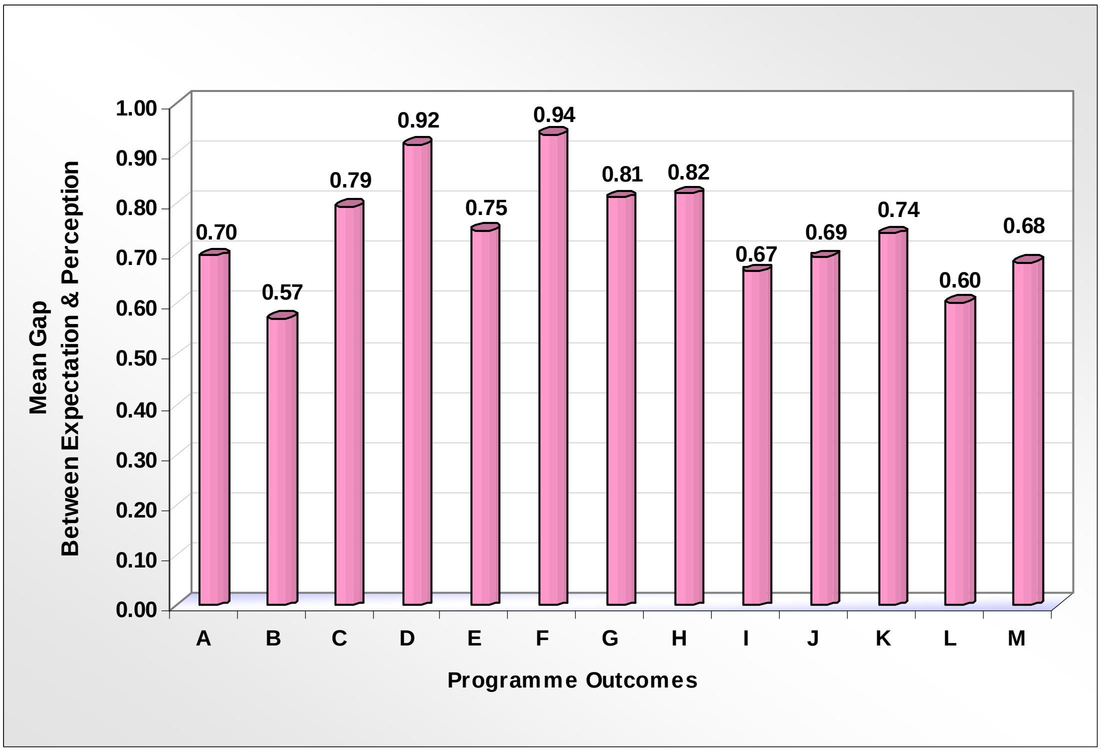

Figure 8: Mean gap between employers' expectation and perception

4.4 NEW ENGINEERING FIELDS

Traditionally, there are five main engineering disciplines, namely mechanical, civil, electrical, electronics and chemical engineering. As science, technology and engineering advance to meet the ever-increasing needs of society, the engineering knowledge corpus inevitably expands to include wider and newer fields. It has been said that such knowledge doubles every 10 years (Wright 1999), but this could well be an understatement. New disciplines need to be created to prepare graduate engineers to meet new challenges and integrate new developments into the technological economy.

Engineers of the future are expected to anticipate and prepare for potential disasters such as biological catastrophe; water and food contamination; infrastructure damage to roads, bridges, buildings, and the electricity grid; and communications breakdown in the internet, telephony, radio, and television (National Academy of Engineering, 2005a). Engineers will also be asked to create solutions that minimise the risk of complete failure and at the same time prepare backup solutions that enable rapid recovery, reconstruction, and deployment.

The scenarios described require the body of knowledge and skills incorporate new and innovative fields, which will effectively constitute a significant component of engineering education in future. The National Academy of Engineering (2005a) in the US identified five new engineering fields that should be consolidated and improved for the future, i.e. :-

1. Information technology
2. Nanoscience
3. Biotechnology
4. Materials science, and
5. Photonics.

In Korea (ABEEK 2005), despite information technology and electronics still being considered as the biggest industries, four new engineering fields have been identified and supported by the Korean government, i.e.

1. Aerospace
2. Biotechnology
3. Nanotechnology, and
4. Robotics.

The engineering education scenario in Malaysia has seen a trend of diversification and specialisation of the engineering disciplines. Presently the fields of engineering have expanded into many different specialised areas, with more than 40 engineering categories (Lee 2006). Two Malaysian reports recommended several new fields of engineering which are expected to be dominant in future. A report commissioned by the

Ministry of Education (Fakulti Kejuruteraan UKM 1999) identified six prospective fields, i.e.

1. Food engineering,
2. Biochemical and biological engineering,
3. Systems engineering,
4. Multimedia engineering,
5. Ecological engineering, and
6. Energy engineering.

In the latest study by MOHE (Malaysia 2006c), four new engineering fields have been recommended, i.e.

1. Bio based engineering (bio-technology, bio-engineering),
2. Microtechnology (nanotechnology, precision engineering),
3. Natural resources (petroleum, water, maritime, solar energy, wind), and
4. Palm oil based engineering.

Some of the employers surveyed in this also suggested several new areas of engineering should be addressed by engineering faculties, i.e.

1. Biomedical engineering
2. Instrumentation engineering
3. Marine engineering
4. Mechatronics
5. Software engineering

Leading engineers in Malaysia have suggested that the undergraduate programmes focus on the essential basics and fundamentals of engineering curricula. This is necessary to provide a strong foundation for the graduate engineers to continually expand, upgrade and renew the expanding range of knowledge and competencies required for current and future engineering work.

More content is additionally required to ensure the graduate engineer has a firm understanding of the new and more specialised engineering fields mentioned above. However, it is not possible, for this purpose, to include such additional content in the already packed curriculum of a 4-year bachelor programme in engineering. Hence, it would be more appropriate for the new fields of engineering to be offered in advanced degree programmes, which are more flexible in their design and implementation.

4.5 RECOMMENDATIONS

The views of employers on graduate competencies clearly imply that there is an urgent need for engineering programmes to improve in all areas, particularly in several non-technical aspects of engineering education. Engineers must be educated to think broadly in fundamental and integrative ways about engineering. Apart from the application of mathematics and the sciences as core engineering subjects, engineering curriculla must stress more on the humanistic, as apposed to scientific and mechanistic, aspects of problem solving or project implementation. There is also agreement among employers and leading engineers that local IHE graduates lack effective communication skills, both orally and in writing. In preparing the student for his professional career, the importance of mastering these soft skills must be further emphasised.

Thus, in the interest of promoting competitive engineering graduates, we recommend that

4. **The learning experience in engineering programmes should be strengthened in all areas, but with greater emphasis on communication skills, teamwork, problem solving, creativity and innovative thinking.**

While recognising the need for wider and new content to be incorporated into engineering curricula, the normal study period of engineering programmes is a limiting constraint. Leading engineers and employers agree with the view that today's engineering curriculum are too packed with technical courses, and therefore needs a fresh look. The current trend for undergraduate degrees that are too specialised has led to graduates that are weak in engineering fundamentals. Grasso (2005) suggests that such specialised technical courses might be more appropriately covered in more advanced postgraduate programs. This will also be in line with encouraging continuing professional development as expected of professional engineers. In line with this approach, we recommend that

5. **Engineering undergraduate courses should emphasise more on the fundamental aspect of engineering while the specialised courses be appropriately taught at postgraduate level.**

Engineering fields have evolved into specialty areas such as biomedical engineering, micro-electro-mechanical systems, and many others, which involve interaction between several fields. Knowledge in multidisciplinary engineering is vital since many of the current industrial practices require working in teams of engineers of differing disciplines, and even with non-engineers. Multidisciplinary skills have been identified by the employer survey and leading engineers as a necessary attribute of current and future engineers in Malaysia. Thus we recommend that

6. **A multidisciplinary engineering approach should be incorporated as an important component of engineering curricula, not necessarily restricted to the final year of study.**

In facing the numerous challenges of the future, the graduate engineer is expected to master new and innovative areas of engineering in order to be able to solve new engineering problems. Recognising that Masters programmes are very flexible in responding quickly to market demands, we recommend that

7. **Engineering faculties should offer programmes addressing new emerging engineering fields at the postgraduate level.**

Many of the current and future engineering problems and projects require knowledge of all the fundamental sciences of physics, chemistry and biology. It is noted that current practice restricts matriculation students to take only two basic science courses. In order to be adequately prepared as engineering students, we recommend that

8. **The Ministry of Education should allow matriculation and STPM students to take all the three basic science courses, i.e. physics, chemistry and biology.**

CHAPTER 5
INDUSTRIAL TRAINING
IN THE ENGINEERING CURRICULA

A key element in an engineering curriculum is exposure to professional engineering practice through industrial training, or sometimes known as internship. Industrial training has traditionally been seen as a useful preparation for the professional career of an engineering graduate.

With the recent development and changes occurring in the engineering education scenario, the status of industrial training in engineering curricula needs to be reviewed. This study reviews the background of industrial training and surveys employer views on willingness towards the industrial placement of engineering students, duration for industrial training, government involvement in implementing industrial training, and potential employment opportunities arising from its implementation.

5.1 OBJECTIVES OF INDUSTRIAL TRAINING

The key objectives of industrial training that are commonly accepted are as follows:-

1) To provide students with exposure to and/or experience with actual implementation of engineering work.
2) To provide an understanding of and familiarity with actual working environment, its people, offices and sites.
3) To assist students in adjusting to the world of work.
4) To promote closer university-industry understanding and linkages.

5.2 INTERNATIONAL TRENDS

In the traditional Anglo-Saxon model of engineering education, industrial training is encouraged but not compulsory. Some programmes are indeed very theoretical in nature, but this situation is compensated in the engineering profession by the mandatory supervised work experience before a graduate engineer can attain professional engineer status. In the European model, rigorous implementation of industrial training within the study period have enabled the recipients of 5-year Dip-Ing degrees to be generally regarded as a professional engineers immediately upon their graduation.

In Germany engineering students are required to undergo industrial training for six months while in France they need to attend the training for three to four months. Industrial training is also required for other countries such as Singapore, Thailand, South Africa, Canada, Denmark, New Zealand and Australia in order to fulfill the requirements of the various degree regulations. The details of industrial training implementation in several countries can be found in Salit et al. (1999).

5.3 INDUSTRIAL TRAINING IN MALAYSIA

The Malaysian Engineering Education Model (MCED 2000) has recommended that a structured industrial training be part of curricula but does not insist it should be compulsory. In addition to this, other structured industrial projects within the engineering curriculum are required to strengthen the practical skills of the students.

The Professional Engineer status accorded by BEM requires a substantial experience in industry after the completion of an accredited academic programme. However, it is still desirable that over the critical formative years in university, the student's perceptions of engineering be allowed to develop in conjunction with the realities of professional practice. Thus, in its effort to better prepare graduating students when entering the workforce, BEM has imposed industrial training as a mandatory requirement for all engineering degree programmes.

Based on current accreditation standards set by the Engineering Accreditation Council (EAC), industrial training shall be for a minimum continuous period of two months. Industrial training carry academic credits dependent on the period of training. One credit hour is granted for every two weeks of training subject to a maximum of six credit hours (EAC Manual 2006). The training shall be adequately structured, supervised and recorded in a logbook.

Seven out of 12 public universities, namely USM, UKM, UiTM, UM, UMS, UPM, and KUiTTHO adopt ten weeks of industrial training. Others specify industrial training for longer durations, i.e. 3 months for UIAM, 5 months for UTM, 16 weeks for UNIMAS, 16 to 24 weeks for KUKUM, and 20 weeks for KUTKM. For private universities such as MMU, UNISEL and UNITEN, the duration for industrial training is for 12 to 14 weeks, while for UTP it is for 32 weeks (Nordin 2006).

5.4 THE NECESSITY FOR INDUSTRIAL TRAINING

The analyses of international trends clearly indicate that industrial training or internship is an increasingly essential component of engineering curricula to ensure programme outcomes relating to professional and social skills are achieved by graduates. Discussions with leading figures in the Malaysian engineering community similarly points towards the strengthening of industrial training structures. A survey of employer views, where 79% agrees to the need for industrial training, supports the current position of EAC/BEM in making it a mandatory requirement for engineering programmes.

5.5 EMPLOYERS' WILLINGNESS TO ACCEPT STUDENT TRAINEES

Employer views on willingness to accept student trainees are summarised in Figure 9. A very large proportion of employers (79%) showed their willingness, while a smaller percentage of 15% were unwilling to accept student trainees. The remaining 6% of the companies did not respond.

The reasons for willingness of taking students for industrial training are shown in Figure 10. Most companies agree to accept students with the reason to assist students through industrial training (79%). Others cited reasons of social responsibility to the nation (53%) and of student trainees as useful additional labour force (50%).

Reasons cited for unwillingness to receive student trainees are summarised in Figure 11. They are (1) not in the company's interest (38%), (2) lack of financial budget (30%) and (3) not a company's policy (14%).

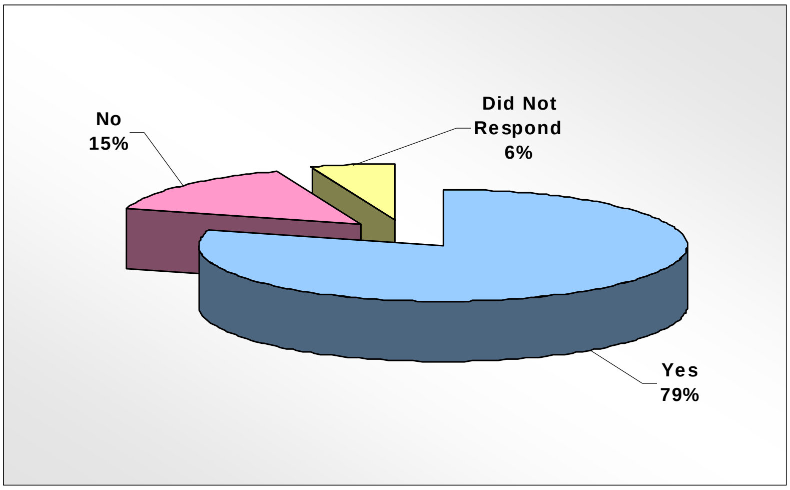

Figure 9: Willingness to accept students for industrial training

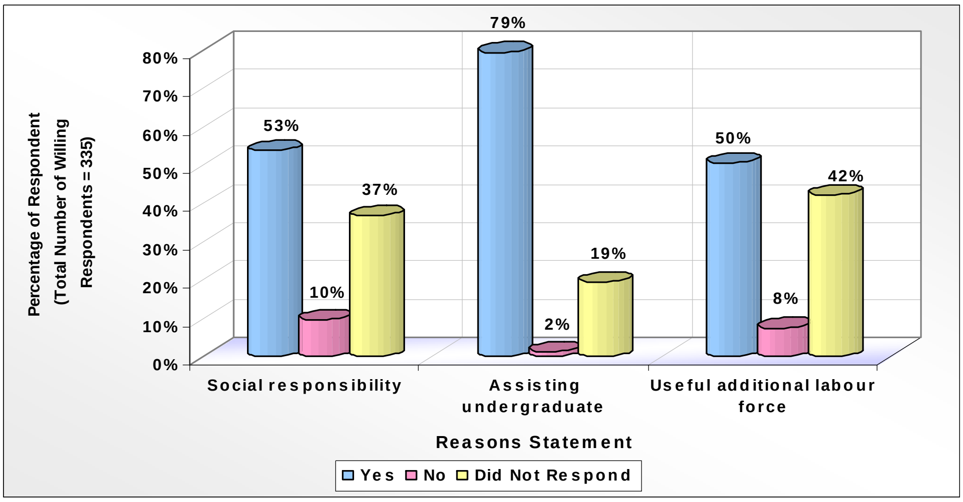

Figure 10: Reasons for accepting students for industrial training

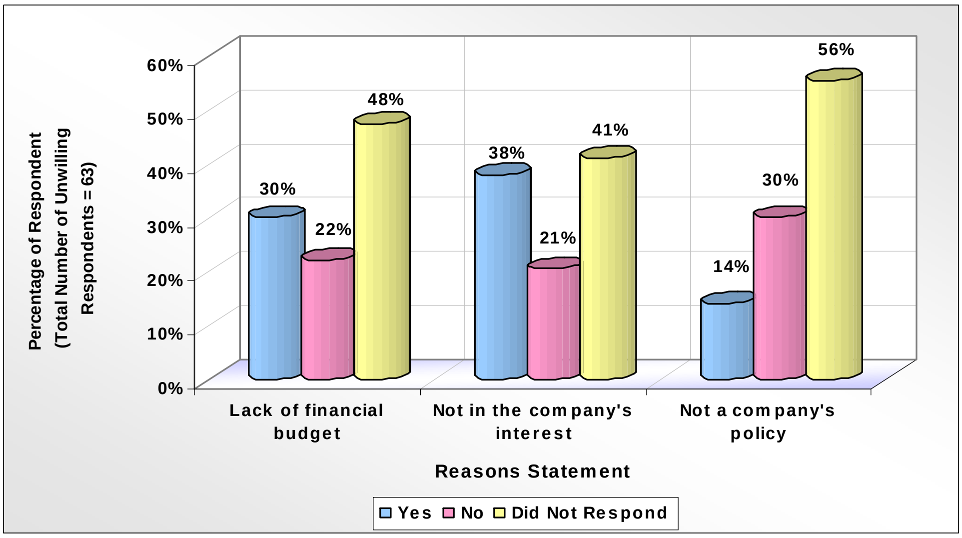

Figure 11: Reasons for not accepting students for industrial training

5.6 DURATION OF INDUSTRIAL TRAINING

Undergraduate students normally undergo industrial training for periods ranging from 10 to 32 weeks depending on the requirement of each individual university. The duration for the training preferred by industries based on employer survey are summarised in Figure 12. Most employers indicate that three months are too short for training to be meaningful or to be in the position to contribute to the organisation. Only 27% out of the 335 willing respondents agree that three months are sufficient for industrial training. 57% of the respondents felt that industrial training should ideally be for six months, and another 5% of respondents preferred a year for this purpose. The longer period will allow the companies sufficient time to train and gain returns from the students.

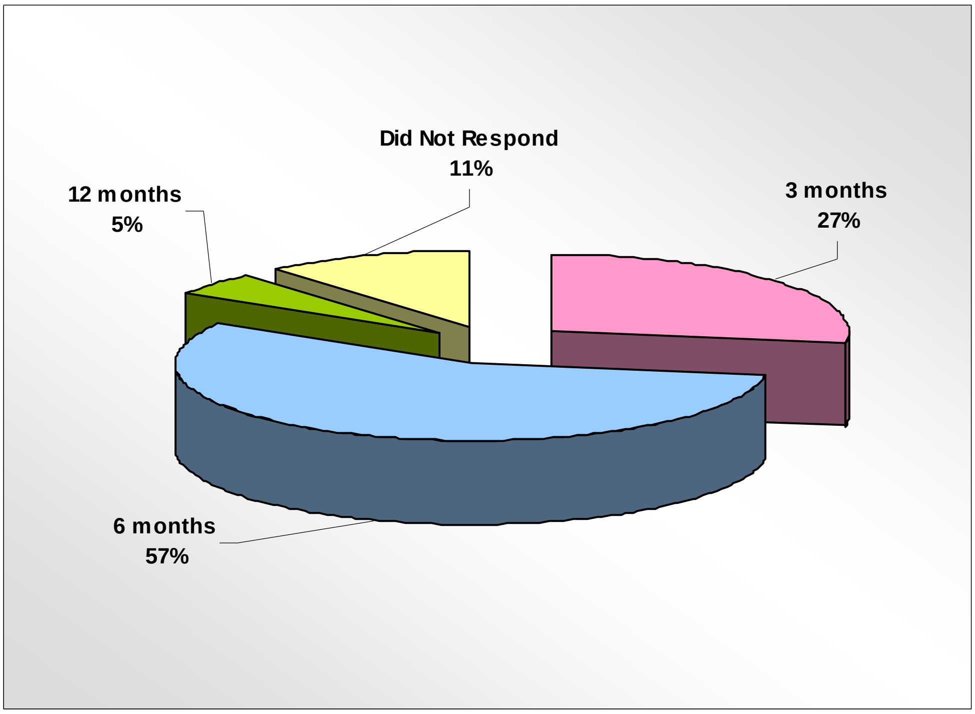

Figure 12: Preferred duration for industrial training

Some of the advisory panel members interviewed felt that a well-structured training programme is more important than a long training duration. It was further noted that the main objective of the industrial training is to give the exposure to industry practice, and not for real job training. It is also noted that it is difficult to find an appropriate project that can be completed in the given limited period.

5.7 POTENTIAL EMPLOYMENT OPPORTUNITIES

Apart from enhancing student learning experience, it is noted that there are benefits for the companies participating in industrial training programmes. Student trainees do help out in getting things done in the organisation and to complete small projects. It also makes recruitment and training more cost-effective by providing on-the-job performance as a basis for permanent hiring decisions. Furthermore, a closer relationship between universities and companies pertaining other collaboration areas such as research and commercialisation will be enhanced.

The employer survey showed that 282 (67%) out of 422 of the respondents are willing to employ the student trainees upon graduation. 32% of these respondents are willing to absorb the industrial trainee as a permanent staff, while 44% and 19% of the respondents are willing to employ the trainees on contract and temporary basis respectively. However, 5% of the 282 respondents did not indicate the type of employment they would offer. It can be concluded that industrial training provides a good opportunity for companies to select and recruit suitable graduates for employment. The results are summarised as a pie chart in Figure 13.

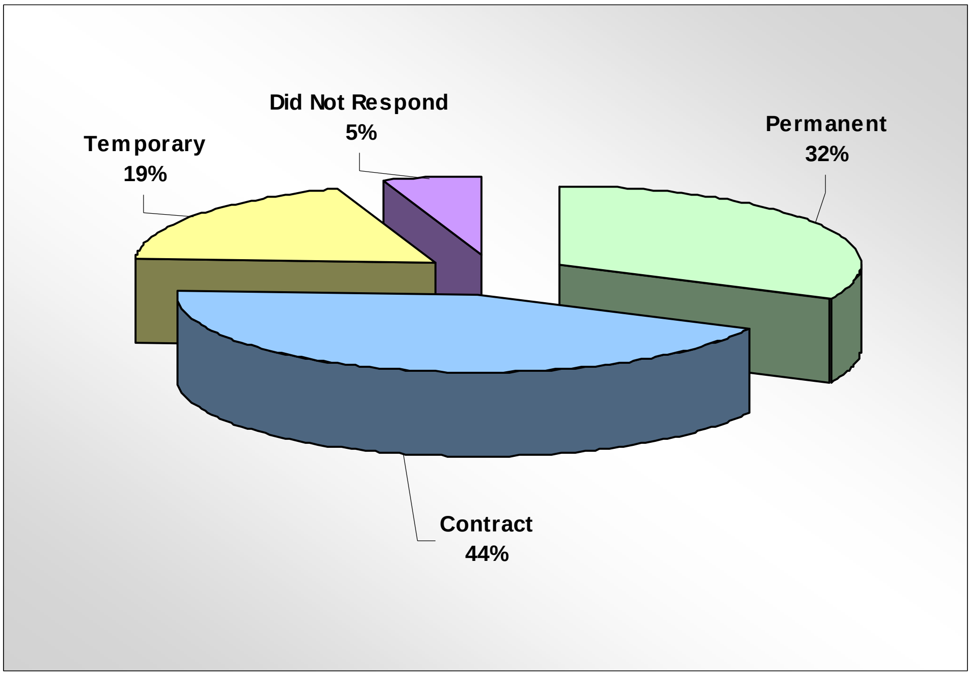

Figure 13: Potential Employment Indicated by 282 (67%) out of 422 respondents

5.8 GOVERNMENT INVOLVEMENT IN INDUSTRIAL TRAINING

Given the very large number of students applying for industrial training placements, several problems have surfaced. They are:-

1. Perceived insufficiency of industrial training places,
2. Uncoordinated applications by students, where some companies receive too many applications while others receive none, and
3. Unproductive training experiences.

Consequently, there have been suggestions for government to play some kind of role to facilitate an efficient and effective placement mechanism at the national scale. Employers were surveyed on their views on three industrial training issues. They are:-

A - All engineering companies are imposed by government to accept students for industrial training

B - Placement of industrial training students will be coordinated by the Ministry of Higher Education

C - Industrial training students should be paid an appropriate amount of allowance

Figure 14 summarises employer views on these issues. 46% of the respondents agreed that all engineering companies are imposed by government to accept students for industrial training, while 22% respondents did not agree. On the issue of coordination by the Ministry of Higher Education, a higher proportion of 52% out of 304 respondents agreed while 17% showed disagreement. On the payment of an appropriate allowance for student trainees, 48% respondents agreed while 19% disagreed. The remainder of the respondents were either neutral or did not respond to the statements. The majority of employers participating in the survey do provide financial allowance, indicating their support for the industrial training programmes.

Besides the Ministry of Higher Education, the involvement of other relevant ministries such as the Ministry for Human Resource Development, the Ministry of Science, Technology and Innovation and the Ministry of International Trade and Industry are essential to ensure that the departments, agencies, organisations under their jurisdiction participate in providing quality industrial training opportunities for students (Nordin 2006).

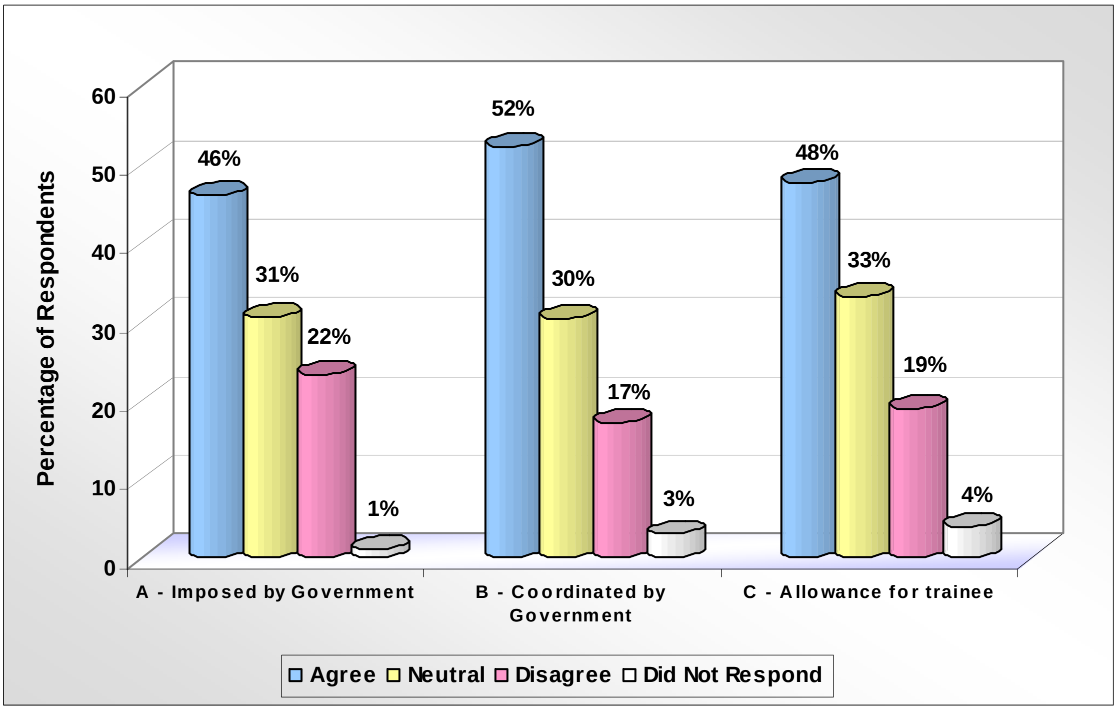

Figure 14: The agreement of statements regarding industrial training

5.9 RECOMMENDATIONS

There is a wide consensus among stakeholders on the necessity of incorporating industrial training in engineering curricula. This is consistent with the current mandatory status of industrial training for the accreditation of engineering programmes.

Overall, employers are mostly willing to receive students for industrial training at their company premises. The study also indicates most employers prefer the duration for the training should be at least six months. This will provide sufficient exposure for the trainees with real working experience in order to better achieve the desired programme outcomes. Thus we recommend that

9. **Engineering programmes should extend the industrial training period to six months.**

Industrial training could be mutually beneficial. Recognising that there is a significant component of industry who are still hesitant or unwilling to provide industry placements for students, it is appropriate that the government play a more influential role in enhancing university-industry collaboration for this purpose. Thus we recommend that

10. **The government should introduce legislation and set up an agency to facilitate industrial training placement at the national level.**

CHAPTER 6
DEMAND AND SUPPLY TRENDS
AND THE ENGINEERING JOB MARKET

How many engineers will Malaysia require as a developed nation? Will the nation's universities be able to meet the demand? Precise future projections are unrealistic, but these two questions need to be addressed by providing an indicative estimate to be used as a basis for engineering education planning.

6.1 INTERNATIONAL BENCHMARKS

As a leading engineering nation, Germany has an estimated 1 million engineers for a population of 82 million (engineer:population ratio of 1:82). France has an estimated 800,000 for a population of 60 million (engineer:population ratio of 1:75). Currently the Board of Engineers Malaysia has a total register of 52,000 graduate and professional engineers. Taking into account that a very substantial number of engineers are not registered with BEM (around 50%), it is estimated that there are around 80,000 engineers currently in employment, i.e. still registering a very poor engineer:population ratio of 1:312 (assuming a current national population of 25 million).

Table 5 shows engineer-population ratios for Malaysia and several advanced countries.

Table 5: Engineer-population ratios for Malaysia and several advanced countries

	Population	Estimated number of Engineers	Engineer-Population ratio
Malaysia	25 million	80,000	1:312
France	60 million	800,000	1:75
Germany	82 million	1,000,000	1:82
Canada	30 million	250,000	1:120
United Kingdom	60 million	425,000	1:141

It is thus necessary for Malaysia to intensify her production of engineers at a very significant rate in order to achieve a comparable index with the developed nations. It is suggested that the government could reasonably set an "advanced nation benchmark" at engineer:population ratio of 1:100. This means that the nation would need around 275,000 and 300,000 engineers in 5 and 10 years respectively (assuming population growth at 2% per annum).

It is thus notable that in the Ninth Malaysia Plan presented by the Prime Minister of Malaysia in March 2006, the government plans to increase engineering student enrolment for public and private universities with the target annual growth rate of 12.2% and 20.8% respectively (Malaysia 2006a). In 2006, an estimated 10,571 students entered first year engineering studies in public and private universities. Hence with the expected growth, the government is projecting that more than 77,000 and 222,000 engineering graduates will be produced cumulatively from Malaysian universities in the next 5 and 10 years respectively. If this projection is met, even after accounting for retirements, Malaysia will be able to match engineer:population ratios with those of advanced nations within 10 years. (See Figure 15)

Figure 15 shows the trend of the total demand of engineers by Malaysian industries and the total supply of Malaysian engineers, having considered the annual contribution of graduates from local universities. As expected, the trend shows that the demand for engineers are more than the supply for the current period as well as for the most part of the next 10 years. From the findings, it is clear that Malaysia should produce more engineers in the future.

In this study, the total supply of local engineering graduates was obtained based on the current (2006) and the projected student intake numbers in the next 10 years. Data on the public universities was acquired from Malaysian Council of Engineering Deans (MCED), and data on the private IHEs was based on EAC/BEM records of registered engineering programmes. The total demand of engineers for the current and projected (5 and 10 years) were obtained from the employer survey.

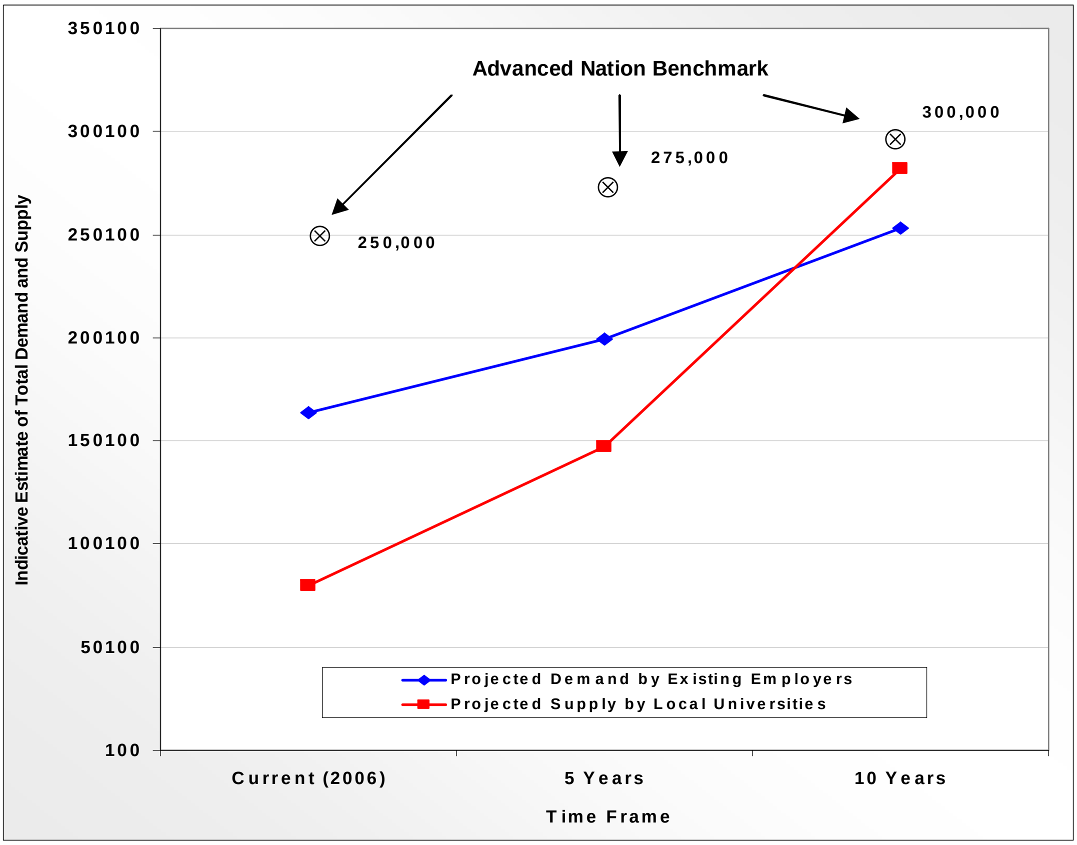

Figure 15: Demand and supply for engineering graduates for the next 5 and 10 years

6.2 SUPPLY AND DEMAND TRENDS ACCORDING TO ENGINEERING FIELDS

Figure 16 shows the results from a survey of demand for engineers projected by Malaysian employers for the next 5 and 10 years. For the five major engineering fields, i.e. civil, chemical, electrical, electronics and mechanical engineering, the demand of engineers continue to increase for the next 5 to 10 years.

Mechanical engineering is viewed as the field of engineering most highly demanded in the future with a projected increase of 24% from 5 to 10 years (from an estimated number of engineers of 58000 to 72000). About 8% of the respondents indicated a demand for other engineering fields, such as biomedical, computer engineering, instrumentation and technology, marine technology, mechatronic, software engineering and process engineering. However this demand indicated a declining trend (15%, i.e. from an estimated number of engineers of 13000 to 11000) from 5 to 10 years.

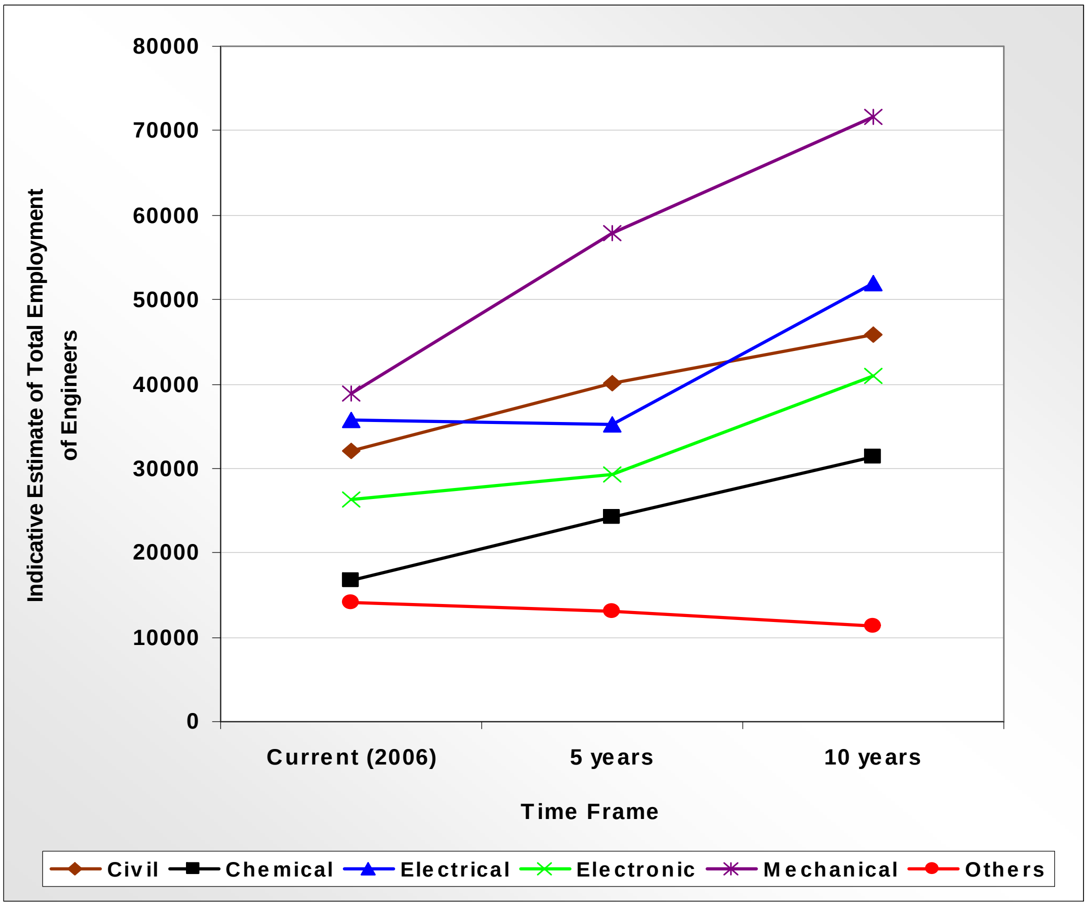

Figure 16: Demand trend of engineers projected by Malaysian industries

Table 6 shows comparison data between the supply of engineering graduates by fields by public universities and the demand of engineers by Malaysian industries for the next 5 to 10 years. Data on the supply of engineering graduates was obtained from each engineering faculty/school in public IHE and Ministry of Higher Education (MOHE). Data on demand of engineers was obtained from the employer survey of 422 respondents. There is no available data based on engineering fields for private universities. As such, a comparison of supply and demand according to fields can only be made on relative numbers, not absolute numbers.

In five years, the projected supply of civil engineering graduates was estimated to be 26% of all engineers produced. However, the percentage demand of civil engineering graduates was only 20%. For mechanical engineering, the demand is more than supply percentages with a difference of 5 percentage points.

Table 6: Comparison between Supply and Demand Trends According to Engineering Fields in the next 5 to 10 years

	Civil	Mechanical	Chemical	Electrical	Electronic	Other
Percentage of Graduates in 5 Years Period (Supply)	26%	24%	8%	19%	19%	3%
Percentage of Engineers in 5 Years Period (Demand)	20%	29%	12%	18%	15%	7%
Percentage of Graduates in 10 Years Period (Supply)	25%	25%	10%	18%	18%	4%
Percentage of Engineers in 10 Years Period (Demand)	18%	28%	12%	21%	16%	4%

This indicates that the demand increase by Malaysian industries is relatively less for civil engineers (but the absolute number of civil engineers required will still be higher as indicated in Figure 16), but more for mechanical engineers in the next 5 years. An implication of this observation is that the expansion of mechanical engineering student enrolment should be relatively more compared to chemical, electrical and electronic disciplines. For civil engineering, there should still be expansion, but on relatively smaller scale.

For other disciplines, the proportions are reasonably stable in the next 5 years. For the next 10 year projection, a similar trend is observed.

6.3 POTENTIAL OVERSEAS MARKETS FOR MALAYSIAN ENGINEERS

It can be seen from Figure 15 that within 10 years the projected supply of engineers will slightly exceed employment opportunities that are expected to be provided by existing employers. To ensure that there will be no surplus of supply, graduate engineers should look for alternatives to the traditional option of being employed by a Malaysian employer. Three alternative options have been identified as follows.

1. Graduate engineers becoming self-employed entrepreneurs.
2. Graduate engineers getting employment in overseas markets.
3. Employment opportunities provided by newly formed companies due to new investment and economic growth.

Several countries in different regions have been identified to be the potential markets for future Malaysian engineers as shown in Table 7. Details of these possible markets can be found in (Malaysia 2006b). Notwithstanding this, Malaysian engineers must still be trained to compete at the global level. It has been noted that industries that cannot compete today in the international scene are unlikely to survive in the domestic markets (Clough ___).

Table 7: Potential overseas markets for Malaysian engineering graduates

No.	Region	Countries	Main industries
1	ASEAN	Indonesia	Oil and gas, mining (bauxite, silver, copper, etc.)
2		Vietnam	Oil and gas, energy
3		Cambodia	Textile industry
4	Middle East	Saudi Arabia	Oil and gas, mining (bauxite, zinc, copper, etc.)
5		United Arab Emirates (UAE)	Oil and gas, chemicals, construction materials, etc.
6	Far East	People Republic of China	Manufacturing
7	Africa	Sudan	Oil and gas, construction

6.4 RECOMMENDATIONS

The demand for Malaysian engineers is expected to continue to rise and the supply of graduates from local universities must continue to be increased significantly in accordance with government projections. In order to meet this demand for their graduates, the universities must significantly increase enrolment. However, as an essential pre-requisite, their resources and capabilities must also be adequately improved, particularly with respect to human resource development. Thus we recommend that

11. **Conventional universities, including new ones, should upgrade and enhance their capabilities in order to introduce new engineering programmes and expand student intakes for existing ones.**

However, the engineering profession must brace itself for an impending scenario where Malaysian industry have to internationalise their activities and more engineers need to open up their own businesses. Engineering programmes and curricula must be reviewed to take account of the overseas employment market and self employment/entrepreneurship as alternative career options for graduates. Thus we recommend that

12. **Engineering programmes should incorporate entrepreneurial skills and global competitive traits as essential components of graduate outcomes**

Recognising the benefits of study and work experience in foreign environment, we recommend that

13. **Universities should encourage and facilitate cross-border mobility of students and overseas placements for industrial training and subsequent employment.**

CHAPTER 7
ACCREDITATION AND INTERNATIONAL BENCHMARKING FOR QUALITY ASSURANCE

In Malaysia, the accreditation of engineering programmes falls under the jurisdiction of the Engineering Accreditation Council (EAC). The EAC was instituted by the Board of Engineers Malaysia (BEM), the government body with the legal responsibility of registering engineers and regulating the engineering profession in the country. EAC derives its membership from the Institution of Engineers Malaysia, the National Accreditation Board of Malaysia, the Public Services Department of Malaysia, The Malaysian Council of Engineering Deans, and several members appointed by the President of BEM from among industry practitioners and academia.

7.1 A NEED FOR QUALITY ASSURANCE

BEM currently has a register of 309 engineering programmes in various disciplines offered by 23 institutions of higher learning (IHEs). This represents a very significant increase in number over the last decade, which is a direct result of Malaysia's strategy to become an international education hub for the region, as well as providing sufficient manpower for the nation's industrial and technological development.

The challenge arising from this phenomenum is quality assurance. Stakeholders, both national and international, must be assured that engineering graduates from Malaysian IHE's are sufficiently competitive for the local as well as the global job market. Quality assurance is thus an essential element to instill confidence among prospective employers. This can be achieved if there is a sound accreditation system in place, which ensures that accredited study programmes meet a preset minimum quality standard for their resources, processes and outcomes. It is also essential that the accreditation system be formally benchmarked against international standards by means of involvement in appropriate international accords and agreements.

7.2 INTERNATIONAL ACCREDITATION ACCORDS

7.2.1 The Washington Accord

The Washington Accord is a multinational agreement signed in 1989, which recognises the substantial equivalency of engineering degree programmes accredited by the responsible bodies in each of the signatory countries. The agreement paves the way for mutual recognition of accredited programmes, establishing the notion that graduates have met the academic requirements for entry to the practice of engineering in any signatory country. Admission to the Accord is more importantly an endorsement that the engineering education system of the member nation has demonstrated a strong, long-term commitment to quality assurance in producing engineers ready for industry practice in the international scene.

The Washington Accord currently has ten full signatory member nations represented by their respective accreditation bodies for engineering education shown in Table 8.

Table 8: A list of current members of the Washington Accord

Country	Signatory Organisation	Entry Year
United States of America	Accreditation Board for Engineering & Technology (ABET)	1989
United Kingdom	Engineering Council, United Kingdom	1989
Canada	Canadian Engineering Accreditation Board	1989
New Zealand	Institution of Professional Engineers New Zealand	1989
Australia	Institution of Engineers Australia	1989
Ireland	Institution of Engineers Ireland	1989
Hong Kong	Hong Kong Institution of Engineers	1995
South Africa	Engineering Council of South Africa	1999
Japan	Japan Accreditation Board for Engineering Education	2005
Singapore	Institution of Engineers Singapore	2006

There are two categories of Washington Accord membership, i.e. (1) Provisional Membership, and (2) Full Membership (Accord Signatory). Provisional membership requires that the accreditation system of the applicant nation is conceptually similar to those of the other signatories of the Washington Accord and has the potential capability to reach full signatory status. Full admission to the Accord will be granted should an applicant country proved that its accreditation system and criteria are of equivalent standard to those of the signatory nations. This equivalency will be established by several requirements (Adelman 1998), the most important of which are:

1 A set of accreditation documentation that satisfactorily addresses the fundamental criteria for accreditation (in particular, the required graduate attributes), procedures that evaluate in depth the outcomes of each program, and quality assurance.
2 An outcome standard that is consistent with those in existing signatory nations, as evaluated during live observation and interaction.

The Washington Accord agreement covers only professional engineering undergraduate degrees. Engineering technology (covered by the Sydney Accord), engineering technician (covered by the Dublin Accord) and postgraduate-level programmes (Masters and PhD) are not covered by the Washington Accord.

International agreements that cover the domain of professional practice include the FEANI Register of European Engineers (EUR ING), the Engineers Mobility Forum (EMF) and the Asia Pacific Economic Cooperation (APEC) Engineer.

7.2.2 ENAEE & the EUR-ACE Label

The engineering education domain in the European scene witnessed remarkable developments since 2004. Current and past practice in the continent is characterised by non-uniformity regarding nomenclature, systems and procedures relating to engineering education and the profession itself. This has created great confusion in the mutual recognition of academic and professional qualifications.

Notwithstanding the prestige of some engineering titles at national level, the lack of an accreditation system recognised on the European scale places the graduate in an objectively weak position when confronted with international recognition agreements in the context of a global job market. The remedial process to this serious weakness was the main motivating factor for the concerted efforts to ensure Europe-wide consistency in the accreditation of engineering programmes.

The European Network for the Accreditation of Engineering Education (ENAEE) was recently established in Brussels on February 8, 2006, by a consortium of 14 European accreditation bodies and other institutions in the field of engineering education. Among the key members are the European Society for Engineering Education (SEFI), the European Federation of National Engineering Associations (FEANI), and the engineering accreditations bodies for Germany (ASIIN), UK (ECUK), and France (CTI). The full list of founding ENAEE members are as in Table 9.

Table 9: Founding Members of the ENAEE

Category	**Organisation / Country**
National Institutions and Accreditation Bodies	Accreditation Agency for Study Programs in Engineering, Informatics, Natural Sciences & Mathematics (ASIIN), Germany
	Engineering Council, United Kingdom
	Commission des Titres d Íngenieurs (CTI), France
	Russian Association for Engineering Education (RAEE)
	Conference of Italian Engineering Deans
	Institution of Engineers Ireland
	University of Florence, Italy
	The Ordem dos Engenheiros (OE), Portugal
	Union of Associations of Civil Engineers of Romania (UAICR)
European level organisations and networks	European Federation of National Engineering Associations (FEANI)
	European Society for Engineering Education (SEFI)
	Conference of European Schools for Advanced Engineering Education and Research (CESAER)
	Council of European Professional and Managerial Staff (EUROCADRES)
	European Network for Quality of Higher Engineering Education for Industry (ENQHEEI)

The objectives of ENAEE are to build confidence in accreditation systems for engineering degree programmes and to promote the implementation of sound accreditation practices in Europe. In order to achieve this objective, ENAEE will establish a European system for engineering accreditation based on a framework of standards developed by the recently completed EUR-ACE project sponsored by the European Commission. This framework is known as the EUR-ACE Framework Standards for the Accreditation of Engineering Programmes, and accredited programmes will carry the EUR-ACE label. It is envisaged that this label will be a European Label indicating quality engineering programmes.

The list of 20 countries currently participating in the EUR-ACE project is given in Table 10.

These European efforts are also designed to achieve wider objectives as follows.

- Ensure engineering degree programmes maintain minimum defined educational standards based on educational outcomes.
- Improve the quality of engineering degree programmes.
- Facilitate trans-national recognition by means of the EUR-ACE Label.
- Facilitate mutual recognition agreements
- Facilitate recognition by competent authorities, in accordance with EU Directives.

The EUR-ACE Label and the EANEE were both launched in Brussels on March 31st 2006, and Malaysia, represented by a delegation from this study team, was honoured to be the only non-European nation invited to attend the ceremony.

7.2.3 ENAEE/EUR-ACE as an Alternative International Benchmark

The formation of the ENAEE to implement the EUR-ACE Label can effectively be viewed as a European Accord for engineering accreditation. The governance of the ENAEE has a well-defined structure, allowing for a wider European participation which involves differing education systems. There also appears to be an effort among the key European parties to understand and accommodate the aspirations of countries at various stages of development throughout Europe in enhancing engineering education.

Table 10: Participating nations in the EUR-ACE project

No.	Country	Signatory Organisation
1	Austria	Austrian Accreditation Council (ACC)
2	Czech Republic	The Accreditation Commission
3	France	Commission des Titres d Íngenieurs (CTI)
4	Germany	Accreditation Agency for Study Programs in Engineering, Informatics, Natural Sciences & Mathematics (ASIIN)
5	Greece	The Technical Chamber of Greece (TEE)
6	Hungary	The Hungarian Accreditation Committee (HAC)
7	Ireland	The Institution of Engineering of Ireland (IEI)
8	Italy	Conference of Italian Engineering Deans
9	Lithuania	The Center for Quality Assessment in Higher Education
10	Netherlands & Flanders	NVAO
11	Poland	Government-appointed institution
12	Portugal	The Ordem dos Engenheiros (OE)
13	Romania	The National Council for Academic Assessment & Accreditation (NCAAA)
14	Russia	Russian Association for Engineering Education (RAEE)
15	Slovenia	Government-appointed institution
16	Spain	The Spanish National Agency for Quality Assurance & Accreditation (ANECA)
17	Switzerland	Centre for Accreditation & Quality Assurance of the Swiss Universities (OAQ)
18	Turkey	The Engineering Evaluation Board (MUDEK)
19	UK	The Engineering Council (EC^{UK})

Some of the salient features of the ENAEE and the EUR-ACE Label project are:-

1. ENAEE declared objectives and the EUR-ACE Framework Standards appear to be well-structured and transparent.
2. The EUR-ACE Framework Standards cover both Bachelor (First Cycle) and Masters (Second Cycle) programmes (WA covers only the first cycle degree).
3. The EUR-ACE Framework Standards allow for a dual engineer profile based on outcomes, which is in line with Malaysia's engineering education strategy.
4. EUR-ACE/ENAEE has the official and financial support of the European Commission under the Directorate-General for Education and Culture.
5. ENAEE is a bigger grouping (20 participating nations) when compared to the WA.

7.3 A POSSIBLE ASIAN ACCORD?

The developments in Europe described above have sparked interest among several Asian countries of creating a similar regional framework, i.e. the possibility of an Asian Accord. Members of the Study Committee have deliberated with several engineering accreditation organisations in Asia, and the consensus appears to be for a recommendation for an Asian Accord, possibly comprising of four founding member countries, i.e. Japan, Korea, Malaysia and Singapore.

Such an Accord, possibly assuming the name of the Asian Network for Accreditation of Engineering Education (ANAEE), is an interesting proposition based on several premises:

1. There are many cultural similarities unique among Asian nations. These can be used as a catalyst for a more meaningful cooperation.
2. There is a wide disparity in the development of engineering education among Asian countries. This requires a unique approach that can accommodate as many nations as possible in the spirit of mutual cooperation.
3. A new regional accord can build on the invaluable experiences of the Washington Accord and ENAEE/EUR-ACE, and promote intra and inter-regional networking and cooperation.
4. There are still some discrepancies between engineering education approaches taken by WA and ENAEE and some major Asian countries.

The broad strategies that ANAEE could undertake may involve:-

1. Striking an inter-regional partnership with ENAEE that will mutually benefit Europe and Asia.
2. Working closely with the Washington Accord in efforts towards continuous quality improvement based on the outcomes approach.
3. Widening the membership base to incorporate other Asian countries.

7.4 MALAYSIA AND THE WASHINGTON ACCORD

In 2003, Malaysia through EAC/BEM, was admitted to the Washington Accord as a provisional signatory nation alongside Germany and Singapore. This was a significant development since it implied that Malaysia's accreditation system is conceptually similar to those of the full signatory members with respect to quality assurance of engineering education programmes. The Accord has subsequently appointed three countries as mentors, namely, Australia (acting as lead mentor), USA and Hong Kong. Currently the Malaysian accreditation system for engineering education is undergoing a major improvement programme with the assistance of its mentors through a series of visits, discussions and seminars.

In the first mentoring visit, representatives from Engineers Australia and ABET USA participated in accreditation visits to Universiti Kebangsaan Malaysia (UKM) and Universiti Multimedia (MMU), Cyberjaya Campus. The mentors noted a number of issues that must be addressed prior to a recommendation for admission to the Washington Accord. These included inconsistencies and ambiguities in the Engineering Programme Accreditation Manual and the panel evaluation exercises that were carried out. The mentors further noted that the philosophy and implementation of outcomes-based education and assessment, as advocated in their previous visit prior to provisional membership, is not clearly understood by members of the EAC, the accreditation panel members and large sections of engineering faculty members.

On a positive note, the mentors welcomed the paradigm shift towards the outcomes approach that is taking place in UKM's Faculty of Engineering, particularly in their educational design and review processes. These efforts were based on the recommendations of the 2nd International ABET Workshop on Continuous Program Improvement (December 2003) attended by members of the Faculty management.

A working group based in UKM was subsequently appointed by EAC to address the main mentor recommendation of drafting a new manual. UKM was also entrusted to spearhead an intensive project aimed at driving a culture change towards the outcomes approach in Malaysian engineering faculties based on the sharing of their experience in the implementation of outcome-based educational practices as noted by the mentors.

In the second mentoring visit, the representatives from Engineers Australia, Institution of Engineers Hong Kong, and ABET USA participated in accreditation visits to Universiti Teknologi Malaysia (UTM) in Johor Bharu and Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM) in Melaka. The mentors noticed that there was a sharp contrast in performance between two sets of accreditation panel evaluators. The mentors recommended that panel evaluators should be trained to be role models, and as catalysts for a culture change towards the outcomes philosophy. The mentors also noted a significant variance between the performance of UTM and KUTKM. The programmes in UTM were found to be satisfactory, and singled-out the excellent documentation related to outcome-based practices by the Civil Engineering Faculty and suggesting that it could be a model for other universities.

7.5 RECOMMENDATIONS

A sound accreditation system ensures that a minimum standard is maintained in the delivery of engineering programmes. Benchmarking of Malaysia's accreditation system against appropriate international standards will go a long way in assuring quality graduates who are able to compete in the global job market, and in enhancing the nation's effort to be an education hub for the region.

There appears to be, however, resistance amongst some against the introduction of internationally-accepted best practices in Malaysia's accreditation system. Thus we recommend that

14. **BEM should seriously step up its effort towards gaining full signatory status in the Washington Accord by adopting internationally accepted best practices in accreditation.**

The ENAEE as a European accord represents a new, well-structured and transparent international quality framework. It is also noted that its proponents are very positive in extending their activities to involve non-European nations. Thus we recommend that

15. **EAC/BEM should forge closer links with ENAEE and initiate efforts towards securing the EUR-ACE Label, which is an European mark for quality engineering education.**

There is a clear interest and intent expressed by the accreditation bodies in Korea and Japan to strengthen Asian cooperation towards a possible Asian Accord. There was a similar move under the Federation of Engineering Institutions of South East Asia and the Pacific (FEISEAP) recently. It would be a strategic move for the nation's internationalisation objective if Malaysia could play a joint-founding role in the proposed Accord. Thus we recommend that

16. **LAN/MQA/EAC should offer to provide a secretariat for the possible establishment of an Asian Accord for the accreditation of engineering education.**

CHAPTER 8
FUTURE CHALLENGES
FOR ENGINEERING EDUCATION IN MALAYSIA

8.1 CONTINUOUS QUALITY IMPROVEMENT AND THE OUTCOMES APPROACH

8.1.1 A Culture Shift towards an Outcome-based Education

The engineering education community in Malaysia is currently engaged in intense efforts aimed towards full membership of the Washington Accord. The most significant requirement for this process is the need for a genuine shift from the conventional prescriptive-based system towards an outcome-based education (OBE) system. The outcomes approach for continuous programme improvement is a significant element in the contents of the Accreditation Manual of the Engineering Accreditation Council (EAC).

Prior to this, educational elements based on objectives and outcomes for continuous programme improvement are mentioned in at least two regulatory documents, i.e. the accreditation guidelines of the National Accreditation Board (NAB) and the Code of Practice for Quality Assurance (Ministry of Higher Education Malaysia). However, the emphasis and the clarity of those elements in these documents are not as explicit as the requirements spelt out as Criteria 2 and 3 in ABET Criteria (revised Nov. 2005). As is now widely recognised and anticipated, the outcomes-approach will feature more prominently in subsequent engineering accreditation exercises in Malaysia as well as internationally.

Apart from meeting the above regulatory requirements, it is clear that by initiating and sustaining a genuine shift towards OBE, the engineering programmes can anticipate real benefits and improvement that includes:

- A more directed and coherent curriculum,
- Graduates with attributes more relevant to industry stakeholders, and
- Continuous Quality Improvement (CQI) as an inevitable consequence.

An awareness of these significant benefits should provide a powerful motivating force for engineering faculties to be committed to the implementation of OBE. Thus in meeting the Washington Accord requirements, the engineering education system will necessarily be driven towards continually improving programme quality. This, regardless of the status of Washington Accord membership, is the more important consequence benefiting the engineering profession in Malaysia.

What is Outcome-Based Education (OBE)?

OBE focuses on outcomes in the preparation of graduates for professional practice. This requires documented evidences, which demonstrate that the graduates have achieved the required outcomes, rather than focusing on the process in achieving the outcomes, even though this may also be important.

Programme outcomes are those outcomes that are expected to be attained upon graduation, while programme objectives are the longer term outcomes following graduation. Both programme outcomes and objectives are identified, tracked, assessed and evaluated for use in continually improving the quality of the programme.

OBE has been described as *'an educational process which is based on trying to achieve certain specified outcomes in terms of individual student learning. Thus, having decided what are the key things students should understand and be able to do or the qualities they should develop, both structures and curricula are designed to achieve those capabilities or qualities. Educational structures and curriculum are regarded as means not ends. If they do not do the job they are rethought*'. (Willis and Kissane 1995)

An important and integral component of the OBE approach is Continuous Quality Improvement (CQI). Opinions of stakeholders must be taken into consideration at all stages of quality improvement; from the time of curriculum design until the execution and implementation of the programme.

Some of the immediate effects and advantages of an outcome-based approach are:

- Universities are always alert and concerned about the quality of the graduates produced;
- More systematic, innovative and flexible teaching methods, for example, project based learning within an integrated learning environment, will be encouraged, and;
- Student's increased exposure to professional practice through industrial training, site visits and industry-linked projects or assignments.

8.1.3 Driving a Culture Change in Malaysian Engineering Faculties

The Ministry of Higher Education, EAC, and the Engineering Faculty of Universiti Kebangsaan Malaysia, have embarked on an intensive project aimed at driving the required culture change towards OBE in Malaysian engineering faculties. The project was based on the sharing of the UKM experience in the implementation of OBE practices, and was implemented in an 18 month period throughout 2005 until May 2006.

The desired culture change in the universities was initially driven by and centered on a conscious effort in changing the existing curriculum in line with OBE. This strategy has been found to be effective for the case of UKM.

The first main objective was for all engineering faculties in Malaysia to design and adopt an outcome-based curriculum and implement it in the academic session of 2006. This exercise will create the necessary initial awareness, understanding and motivation for faculty staff to continuously improve the programme by focusing on outcomes.

Workshops on OBE awareness, setting objectives & outcomes, and the implementation of OBE in curriculum design, were offered to participants from among management in all engineering faculties. It was expected that the participants would immediately conduct similar workshops on selected groups in their own faculties. These groups will then form the core team to spearhead OBE curriculum design and delivery. The workshop modules are continually revised and improved, and are currently appropriate for wider implementation covering panel evaluators and EAC members.

Conferences on engineering education, led by UTM and the Malaysian Council of Engineering Deans, have been held annually since 2004 where all engineering faculties in Malaysia were requested to present and share their experiences in their efforts to implement outcome-based educational policies and practices.

8.1.4 Recommendations

To meet the requirements for Washington Accord and other quality assurance frameworks, universities as well as the engineering education fraternity must prepare themselves for a major culture change in the educational practices; from a system which currently focus on facilities, resources and processes, towards one that focus on outcomes of courses and programmes. This culture change will inevitably contribute significantly towards strengthening quality assurance for graduate outcomes, and consequently such effort is highly desirable regardless of Malaysia's membership status in the Washington Accord.

It is essential that the new educational practices necessary for this endeavour be solidly founded on rigorous research findings. Changes for continuous quality improvement based on the outcomes philosophy must be reinforced by a strong and reliable research activity. Thus we recommend that

17. **Universities should endorse research in engineering education as a valued and rewarded activity that is categorically linked to promotional exercises among academics.**

And that

18. **MOHE should allocate grants for research in engineering education from the fundamental research fund.**

In this context, the enhancement of institutional support for engineering education research is a necessary pre-requisite. Thus we recommend that

19. **MOHE should set up a Centre for Engineering Education Research within the framework of the existing National Institute for Higher Education Research (IPPTN).**

8.2 ENHANCING CAPABILITIES OF ACADEMIC STAFF

A clear consequence of the proliferation of new engineering faculties and programmes in Malaysia within the last decade is that the limited number of well-qualified, experienced lecturers in the country have been spread too thinly, to the extent of significantly affecting teaching quality. While the number of engineering graduates produced by Malaysian IHEs increase each year, the quality of these graduates needs to be ensured. Weaknesses that are prevalent need to be identified and rectified. This study has identified three areas for improvement in Malaysian engineering faculties, i.e.

1) Quality of academic staff,

2) Industrial exposure,
3) Facilities and infrastructure.

Key findings made by the Washington Accord team on a mentoring visit to Malaysia in 2006 found significant variance between the newer technical universities and the more established ones. While the technical universities have superior laboratories and equipment, their academic staff were deemed to be much inferior compared to the traditional universities. Problems associated with the technical universities include:-

- The appointment of many recent graduates with little or no industry experience and no doctoral qualifications.
- High student to staff ratio.
- Lack of adequate engagement with industry and student stakeholders in a cycle of continuous quality improvement.

In Malaysia, BEM has imposed industrial training as a requirement for engineering degrees in order to provide students with some industrial experience. However, responses from the qualitative study interviews indicate that graduate engineers are still not adequately trained to meet industry needs. Many lecturers at public IHEs enter the academic profession without any significant working experience in industry. While these academics are well versed in engineering theories, the lack of industrial experience prevents them from presenting to students an accurate representation of engineering practices in industry.

This problem is not unique to Malaysia. In a survey of US college graduates, 74% felt that the most important factor in gaining employment was work experience and 52% of employers concurred with this finding (MonsterTRAK 2004). Industry believes that graduating students are not adequately prepared to enter the workforce because a large number of academic staff has little or no industrial experience (National Academy of Engineering 2005).

8.2.1 Recommendations

It is imperative that the serious shortage of capable academic staff in the newer faculties, categorically noted by the Washington Accord mentors, be effectively overcome through resource consolidation to maintain standards across all IHEs. Such resource consolidation will necessarily involve cross-university movement of staff, particularly between the newer and more-established universities. Recognising that there is some degree of competition between IHEs, it would not be realistic to expect universities to collaborate and consolidate human resource among themselves. It is more effective that such actions be coordinated and undertaken at the MOHE level. Thus we recommend that

20. **MOHE should set up a task force comprising of senior academics to advise on the necessary actions to upgrade and ensure the quality of academic staff in existing engineering faculties, in particular to facilitate inter-university staff mobility and collaboration.**

Each university must have a clear plan and a serious, concerted effort to ensure the provision of adequate numbers of qualified and capable academic staff. While it is acknowledged that the government is already undertaking measures to train and upgrade Malaysian academic staff, they are mostly young, inexperienced, limited in number and still fall short in fully addressing the problem. The other alternative is to tap the international market which demands matching compensation schemes and reasonably fast hiring procedures. However, past experience indicate very serious problems in bureaucracy involving multiple government departments. Thus we recommend that

21. **The national "brain-gain" project should be facilitated by quickly ensuring the removal of bureaucratic obstacles and provision of salary schemes that are internationally competitive.**

A more comprehensive solution to rectify the deficiency in practical experience among university teaching staff is urgently required. Thus we recommend that

22. **Universities should facilitate the promotion of lecturers who do not have postgraduate degrees but possess a wealth of professional experience.**

In order to encourage and enable academics to gain industry experience, incentives must be made available to academic staff. Thus we recommend that

23. **Universities should incorporate industry experience gained by academic staff as an important criterion in their appointment and promotion.**

It is widely acknowledged that closer ties need to be forged between industry and academia in order to facilitate a more effective integration of industry input in curriculum design and delivery. Thus we recommend that

24. **The Malaysian Council of Engineering Deans, in conjunction with the Ministry of Higher Education, should establish council/s of university-industry leaders to foster closer collaboration between the two sectors.**

8.3 PROVISION OF ADEQUATE FACILITIES AND INFRASTRUCTURE

The engineering profession is undergoing a transformative evolution where technology advancement is taking place at breakneck speed. While fundamental engineering processes such as design and development have remained the same, the domains of application are rapidly expanding (Williams 2003). It is important that universities are equipped with up-to-date and advanced facilities, equipment and infrastructure so as to ensure that engineering students receive sufficient exposure to the current technology.

The view solicited from the qualitative study interviews was that the requirement for upgrading and expansion of facilities and infrastructure has not kept pace with the rapid increase in engineering student intake. Laboratory sessions have to be conducted in groups that are too large, where a number of these students simply become passengers during the laboratory experiment sessions. Inadequate facilities and infrastructure at universities make for an engineering education environment that is not conducive to the satisfactory attainment of designated graduate outcomes.

8.3.1 Recommendations

Engineering faculties at local IHEs must keep pace with technology advancement and the expanding enrolment. In view of this, it is vital that there is adequate funding for purchasing and upgrading of library and laboratory facilities, equipment and infrastructure. Thus we recommend that

25. **The government should provide adequate funds to upgrade existing library and laboratory facilities for teaching and research, as well as to procure new ones.**

8.4 EMPLOYER PREFERENCE ON CATEGORY OF UNIVERSITIES

In the recruitment exercises, employers were asked to give their preference of graduates from the public universities compared to the graduates from private universities and overseas universities. Figure 17 shows a summary of the findings, indicating 64% of the respondents prefering public IHE graduates, followed by overseas graduates at 30% and private IHEs at 6%. Among the reasons cited by respondents for prefering graduates from public IHEs are their good reputation and that their graduates have a good theoretical and practical knowledge.

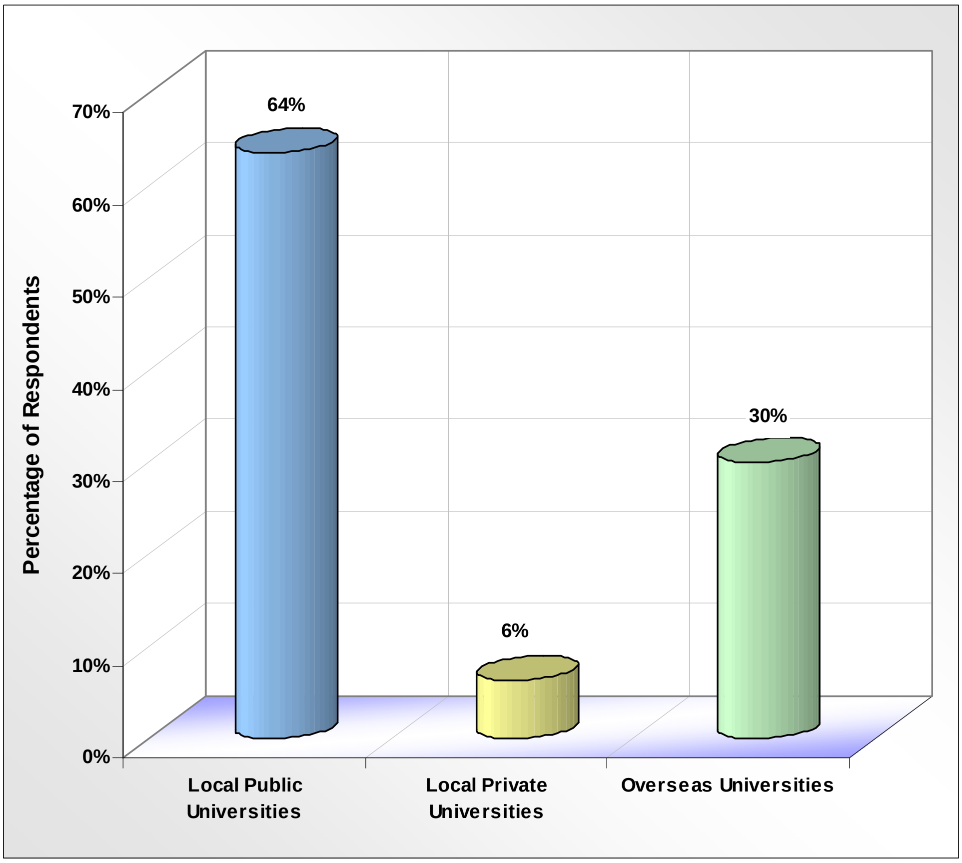

Figure 17: Preference of Employers on Graduate Category

8.4.1 Recommendations

Given the overwhelming preference of employers for local public university graduates compared to foreign and local private universities, and given the widespread misperception that the opposite is true, there is a danger that public confidence of public universities in Malaysia be unduly eroded. This is especially pertinent in the light of recent criticisms in the media regarding alleged non-marketability of graduates from public universities. Thus in the interest of maintaining and enhancing the image of public universities, particularly for its engineering programmes, we recommend that

26. **MOHE should use this evidence to enhance the image of public universities by highlighting the overwhelming preference given by employers to graduates from their engineering programmes.**

CHAPTER 9
RECOMMENDATIONS

The following is a collection of the recommendations that have been presented in the preceding chapters.

9.1 ENGINEER PROFILES OF MALAYSIA

It is clear that Malaysian employers require engineers with mainly two types of competency profiles. While the first and more widely preferred is a balanced profile combining both theoretical/research and applications/practice orientations, the second, i.e. the applications and practice oriented profile, still constitute a very significant component of the national demand for engineers. The government's decision to set up TUCs in previous years was a correct strategic move to meet this demand. Thus we recommend that

1. **The TUCs should continue to consolidate and strengthen the existing programmes to produce applications and practice oriented engineers.**

Another implication of the study findings is that conventional universities should re-orient their engineering programmes to produce engineers with a balanced competency profile. The bigger preference towards a competency profile with a significant theoretical and research component is in line with the requirements of the national strategic shift from a purely manufacturing-based economy to one that is more knowledge-based in nature. Thus we recommend that

2. **The conventional universities ensure that their existing programmes are sufficiently provided with applications-oriented content to ensure their graduates achieve an outcome profile which is balanced, i.e. where the applications component is at least as significant as the theory part,**

Purely theoretical and research engineers are required in relatively smaller numbers, i.e. less than 5%, and are presumably required for academia and R&D departments of giant multinationals. Recognising that the established universities are already capable of offering programmes at the post-graduate level, we recommend that

3. **The demand for theoretical/research-oriented engineers should be met by research-based Masters and PhD programmes currently offered by local universities.**

9.2 COMPETENCIES FOR MALAYSIAN ENGINEERS

The views of employers on graduate competencies clearly imply that there is an urgent need for engineering programmes to improve in all areas, particularly in several non-technical aspects of engineering education. Engineers must be educated to think broadly in fundamental and integrative ways about engineering. Apart from the application of mathematics and the sciences as core engineering subjects, engineering curriculla must stress more on the humanistic, as apposed to scientific and mechanistic, aspects of problem solving or project implementation. There is also agreement among employers and leading engineers that local IHE graduates lack effective both oral and written communication skills. In preparing the student for his professional career, the importance of mastering these soft skills must be further emphasised.

Thus, in the interest of promoting competitive engineering graduates, we recommend that

4. **The learning experience in engineering programmes should be strengthened in all areas, but with greater emphasis on communication skills, teamwork, problem solving, creativity and innovative thinking.**

While recognising the need for wider and new content to be incorporated into engineering curricula, the normal study period of engineering programmes is a limiting constraint. Leading engineers and employers agree with the view that today's engineering curriculum are too packed with technical courses, and therefore needs a fresh look. The current trend for undergraduate degrees that are too specialised has led to graduates weak in engineering fundamentals. There are suggestions that such specialised technical courses might be more appropriately covered in more advanced postgraduate programs. This will also be in line with encouraging continuing professional development as expected of professional engineers. In line with this approach, we recommend that

5. **Engineering undergraduate courses should emphasise more on the fundamental aspect of engineering while the specialised courses be appropriately taught at postgraduate level.**

Engineering fields have evolved into specialty areas such as biomedical engineering, micro-electro-mechanical systems, and many others, which involve interaction between several fields. Knowledge in multidisciplinary engineering is vital since many of the current industrial practices require working in teams of engineers of differing disciplines, and even with non-engineers. Multidisciplinary skills have been identified by the employer survey and leading engineers as a necessary attribute of current and future engineers in Malaysia. Thus we recommend that

6. **A multidisciplinary engineering approach should be incorporated as an important component of engineering curricula, not necessarily restricted to the final year of study.**

In facing the numerous challenges of the future, the graduate engineer is expected to master new and innovative areas of engineering in order to be able to solve new engineering problems. Recognising that Masters programmes are very flexible in responding quickly to market demands, we recommend that

7. **Engineering faculties should offer programmes addressing new emerging engineering fields at the postgraduate level.**

Current and future engineering problems and projects require knowledge of all the fundamental sciences of physics, chemistry and biology. It is observed that current practice restricts matriculation students to take only two basic science courses. In order to be adequately prepared as engineering students, we recommend that

8. **The Ministry of Education should allow matriculation and STPM students to take all the three basic science courses, i.e. physics, chemistry and biology.**

9.3 INDUSTRIAL TRAINING IN THE ENGINEERING CURRICULA

There is a wide consensus among stakeholders on the necessity of incorporating industrial training in engineering curricula. This is consistent with the current mandatory status of industrial training for the accreditation of engineering programmes.

Overall, most employers are willing to participate in industrial training programme. The study also indicates most employers prefer the duration for the training should be at least six months. This will provide sufficient exposure for the trainees with real working experience in order to better achieve the desired programme outcomes. Thus we recommend that

9. **Engineering programmes should extend the industrial training period to six months.**

Industrial training could be mutually beneficial. Recognising that there is a significant component of industry who are still hesitant or unwilling to provide industry placements for students, it is imperative that the government play a more influential role in enhancing university-industry collaboration towards this purpose. Thus we recommend that

10. **The government should introduce legislation and set up an agency to facilitate industrial training placement at the national level.**

9.4 DEMAND AND SUPPLY TRENDS AND THE ENGINEERING JOB MARKET

The demand for Malaysian engineers is expected to continue to rise and the supply of graduates from local universities must continue to be increased significantly in accordance with government projections. In order to meet this demand, the universities must significantly increase student enrolment. However, as an essential pre-requisite, their resources and capabilities must also be correspondingly improved, particularly with respect to human resource development. Thus we recommend that

11. **Conventional universities, including new ones, should upgrade and enhance their capabilities in order to introduce new engineering programmes and expand student intakes for existing ones.**

However, the engineering profession must brace itself for an impending scenario where Malaysian industry have to internationalise their activities and more engineers need to be self-employed. Engineering programmes and curricula must be reviewed to take account of the overseas employment market and self employment/entrepreneurship as alternative career options for graduates. Thus we recommend that

12. **Engineering programmes should incorporate entrepreneurial skills and global competitive traits as essential components of graduate outcomes**

Recognising the benefits of study and work experience in foreign environment, we recommend that

13. **Universities should encourage and facilitate cross-border mobility of students and overseas placements for industrial training and subsequent employment.**

9.5 ACCREDITATION AND INTERNATIONAL BENCHMARKING FOR QUALITY ASSURANCE

A sound accreditation system ensures that a minimum standard is maintained in the delivery of engineering programmes. Malaysia is currently the only developing nation that has secured Provisional Membership of the Washington Accord. Benchmarking of Malaysia's accreditation system against appropriate international standards will go a long way in assuring quality graduates who are able to compete in the global job market, and in enhancing the nation's effort to be an education hub for the region.

There is, however, a significant resistance among some members of BEM against the introduction of internationally-accepted best practices in Malaysia's accreditation system. Thus we recommend that

14. **BEM should seriously step up its effort towards full signatory status in the Washington Accord by adopting internationally accepted practices of accreditation.**

The ENAEE as a European accord represents a new, well-structured and transparent international quality framework. It is also noted that its proponents are very positive in extending their activities to involve non-European nations. Thus we recommend that

15. **EAC/BEM should forge closer links with ENAEE and initiate efforts towards securing the EUR-ACE Label, which is an accepted European mark for quality engineering education.**

There is a clear interest and intent expressed by the accreditation bodies in Korea and Japan to strengthen Asian cooperation towards a possible Asian Accord. It would be a strategic move for the nation's internationalisation objective if Malaysia could play a joint-founding role in the proposed Accord. Thus we recommend that

16. **LAN/MQA/EAC should offer to provide a secretariat for the possible establishment of an Asian Accord for the accreditation of engineering education.**

9.6 CONTINUOUS QUALITY IMPROVEMENT & THE OUTCOMES APPROACH

In meeting the requirements for Washington Accord and other quality assurance frameworks, universities as well as the engineering education fraternity must prepare themselves for a major culture change in the educational practices; from a system which currently focus on facilities, resources and processes, towards one which focus on outcomes of courses and programmes. This culture change will inevitably contribute significantly towards strengthening quality assurance for graduate outcomes, and consequently such effort is highly desirable regardless of Malaysia's membership status in the Washington Accord.

However, it is essential that the new educational practices necessary for this endeavour be solidly founded on rigorous surveys, studies and investigations. Changes for continual quality improvement based on the outcomes philosophy must be reinforced by a strong and reliable research activity. Thus we recommend that

17. **Universities should endorse research in engineering education as a valued and rewarded activity that is categorically linked to promotional exercises among academics.**

And that

18. **MOHE should allocate grants for research in engineering education from the fundamental research fund.**

In this context, the enhancement of institutional support for engineering education research is a necessary pre-requisite. Thus we recommend that

19. **MOHE should set up a Centre for Engineering Education Research within the framework of the existing National Institute for Higher Education Research (IPPTN).**

9.7 ENHANCING CAPABILITIES OF ACADEMIC STAFF

It is imperative that the serious shortage of capable academic staff in the newer faculties, categorically noted by the Washington Accord mentors, be effectively overcome through resource consolidation to maintain standards across all IHEs. Such resource consolidation will necessarily involve cross-university movement of staff, particularly between the newer and more-established universities. Recognising that there is some degree of competition between IHEs, it would not be realistic to expect universities to collaborate and consolidate human resource among themselves. It is more effective that such actions be coordinated and undertaken at the MOHE level. Thus we recommend that

20. **MOHE should set up a task force comprising of senior academics to advise on the necessary actions to upgrade and ensure the quality of academic staff in existing engineering faculties, in particular to facilitate inter-university staff mobility and collaboration.**

Each university must have a clear plan and a serious, concerted effort to ensure the provision of adequate numbers of qualified and capable academic staff. While it is acknowledged that the government is already undertaking measures to train and upgrade Malaysian academic staff, they are mostly young, inexperienced, limited in number and still fall short in fully addressing the problem. The other alternative is to tap the international market which demands matching compensation schemes and reasonably fast hiring procedures. However, past experience indicate very serious problems in bureaucracy involving multiple government departments. Thus we recommend that

21. **The national "brain-gain" project should be facilitated by quickly ensuring the removal of bureaucratic obstacles and provision of salary schemes that are internationally competitive.**

A more comprehensive solution to rectify the deficiency in practical experience among university teaching staff is urgently required. Thus we recommend that

22. **Universities should facilitate the promotion of lecturers who do not have postgraduate degrees but possess a wealth of professional experience.**

In order to encourage and enable academics to gain industry experience, incentives must be made available to academic staff. Thus we recommend that

23. **Universities should incorporate industry experience gained by academic staff as an important criterion in their appointment and promotion.**

It is widely acknowledged that closer ties need to be forged between industry and academia in order to facilitate a more effective integration of industry input in curriculum design and delivery. Thus we recommend that

24. **The Malaysian Council of Engineering Deans, in conjunction with the Ministry of Higher Education, should establish council/s of university-industry leaders to foster closer collaboration between the two sectors.**

9.8 PROVISION OF ADEQUATE LABORATORY FACILITIES

Engineering faculties at local IHEs must keep pace with technology advancement and the expanding enrolment. In view of this, it is vital that there is adequate funding for purchasing and upgrading of library and laboratory facilities, equipment and infrastructure. Thus we recommend that

25. **The government should provide adequate funds to upgrade existing library and laboratory facilities for teaching and research, as well as to procure new ones.**

9.9 EMPLOYER PREFERENCE ON UNIVERSITY CATEGORIES

Given the overwhelming preference of employers for local public university graduates compared to foreign and local private universities, and given the widely spread misperception that the opposite is true, there is a danger that public confidence of public universities in Malaysia be unduly eroded. This is especially pertinent in the light of recent criticisms in the media regarding alleged non-marketability of graduates from public universities. Thus in the interest of maintaining and enhancing the image of public universities, particularly for its engineering programmes, we recommend that

26. **MOHE should use this evidence to enhance the image of public universities by highlighting the overwhelming preference given by employers to graduates from their engineering programmes.**

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