

Knowledge Expansion in Engineering Education: Engineering Technology as an Alternative

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Abstract. *The current and rising challenges in engineering education demand graduate engineers who are well-prepared to provide innovative solutions as technical specialists, system integrators and change agents. Realizing the importance of producing a highly competent manpower, the Malaysian Government has put considerable pressure to the universities to produce engineers who are competitive in the global market. Hence, this assignment of developing a highly competence engineering technologist workforce in support of the government policy highlights issues pertaining to the development and offering of practical-oriented programs as a knowledge expansion in engineering education at universities as envisioned by the Malaysian Government. This paper evaluates the current scenario and examines the application-oriented programs of engineering technology education as practice in local institutions in Malaysia in comparisons to some universities abroad. It also investigates the challenges faced by university management in dealing with issues concerning national quality assurance and accreditation pertaining to the engineering technology education programs. Specifically, it analyzes the faculty planning of pedagogies in term of hands-on skills in teaching and learning. A key conclusion of this research is that Malaysian universities need to evaluate its engineering technology education strategies if they aim for quality assurance and accreditation to be established and aspire for successful attempts towards the creation of the requisite knowledge workers that Malaysia needs.*

Keywords: *application-oriented, engineering education, engineering technology, hands-on skills, knowledge expansion*

1. Introduction

An engineering technology or practice-oriented engineering program at a higher level has been introduced in the Malaysian education system since early 2000. The program is believed to be able to provide competent and highly-skilled workforce and it has become crucial and more demanding from industries. With the current technological advancements in the engineering field, qualified workers become the standard market requirement (Kulacki & Krueger, 1998). Most importantly, graduates with skill-based orientation have a better probability of getting higher wages (Danielson, Hawks, & Hartin, 2006).

With engineering education knowledge expansion by introducing engineering technology that is to complement engineering program, institutions are able to adapt to the market relevance and current

needs. The changing role of engineers in the era of globalization of industry and the engineering practice as well as the increased use of technology in education has an immense impact on the economy of a nation (11th-Malaysian-Plan, 2015; Grip, 2004; Megat Johari, 1999). They play an important role to shape the significant and dynamic role of the engineering profession especially for the growth of human capital of a country.

Participation in engineering technology that applied engineering fundamentals and inclination towards addressing practical engineering problems can provide leadership in the globalization of engineering technology education. With its roots in application of theory, and the increasing inclusion of technology into all aspects of society, engineering technology education should be positioned to contribute to the knowledge expansion in Malaysia (K. Ismail & Puteh, 2008). This expansion in term of

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Received: May 13, 2015 ; Revised: June 29, 2015, Accepted: July 4, 2015

DOI: <http://dx.doi.org/10.12695/ajtm.2015.8.1.4>

Print ISSN: 1978-6956; Online ISSN: 2089-791X.

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School of Business and Management-Institut Teknologi Bandung

skills and abilities is a key source that can contribute to the growth of industry and research sectors and in turn affect the growth and productivity of the economy of the country.

The development of technology training is an important strategy to expose students to real working life and equip them with the necessary skills. Attempts have been made to develop the engineering technology path for a highly competent engineering workforce; however what is the scenario in Malaysia? Do the offerings of practical oriented engineering programs are on the right track, the right kind and quantity as envisioned by the Malaysian government? These issues are further discussed in the following sections.

2. Engineering Technology Programs Across the Global

The most well-known typical engineering technology program in Europe is in German universities. There are two kinds of engineering universities in Germany that are technical universities which emphasize more on theory and applied science universities (Fachhochschulen) which emphasis more on the applied technology. The Fachhochschulen educational concepts are more related to the Engineering Technology Education programs in Malaysia. Fachhochschulen is governed by the Federal Ministry of Education and Research, and its courses are accredited by Akkreditierungsrat, the foundation for the accreditation of study programs in Germany (Kehm, 2006). German engineers produced by the varied technical universities of applied science in Germany have a reputation for having more practical backgrounds and highly skills in application of theory.

The German's applied science universities have a close collaboration with industries and engineering students' senior years are required to do a hands-on internship at companies. According to these companies the programs are effective at developing employees who are productive the day they

are hired as well as promoting loyalty to the employers (Grip, 2004). Furthermore, voluntary periods of work experience in industries during the universities holidays and project work for the degree thesis give good opportunities to students to establish contact with industries as well as enhancing their practical relevance (Mraz, 2015).

However, in the United Kingdom, engineering technologists also known as Incorporated Engineers (IEng) are produced via the apprenticeship system of learning. There are a number of universities in Australia offering 3-year full-time engineering technology programs. These programs are accredited by Engineers Australia Accreditation Board at the level of engineering technologist (IEA, 2014). At Central Queensland University, the program is the project-based focus where students undertake real-life engineering tasks in order to put theoretical knowledge into practice. The students also have six weeks of industry placement during the program to equip them with skills by applying and adapting engineering technology practices to meet engineering challenges as reported by the university.

Engineering Technology programs in the USA combined theoretical coursework heavily reinforced with hands-on laboratory experiences and project work with a focus on the application of engineering principles. Engineering Accreditation Commission (EAC) accredits an engineering program whilst the Engineering Technology Accreditation Commission (ETAC) accredits an engineering technology program at the associate's or bachelor's degree level (UCF, 2005).

The Sydney Accord and the Engineering Technologist Mobility Forum (ETMF) are two international efforts to improve recognition for engineering technologists. The Sydney Accord signed in 2001 is an agreement between the bodies responsible for accrediting engineering technologist qualification programs in countries such as Australia, Canada, Ireland, Hong Kong,

New Zealand, South Africa, United Kingdom, the United States, and Sri Lanka. On the other hand, the International Engineering Technologist (IntET) qualification was launched in late 2007 by the ETMF which is an international forum held by signatories of the Sydney Accord to explore mutual recognition for experienced engineering technologists and to remove artificial barriers to the free movement and practice of engineering technologists amongst their countries.

3. Engineering Technology Evolution in Malaysia: The Past, Current and Future

Engineering is an important area of knowledge for the nation and thus, engineering education is important to be a main sector in tertiary education. Malaysia took a bold step in the early 2000 by establishing four technical university colleges (TUCs) to-date known as Malaysian Technical University Network (MTUN); to produce applications and practice-oriented engineering graduates that are relevant and ready for industry in both local and overseas job markets. The graduates should be different from those graduating from other conventional Malaysian universities who are traditionally more theoretical and research-oriented. This is in tandem by the survey done by the Ministry of Higher Education (MOHE) in 2006 that the applications and practice-oriented profile, constitute a very significant component of the national demand for engineers.

There are two categories of engineers, the theoretical and research-orientated and the applications and practice-oriented engineers. These profiles of professional engineers are popular in several European countries such as Germany. Although the two categories are important, but a more balanced profile in terms of curricula and designated outcomes need to be enhanced. This third category is called balanced orientation, which is also needed by the nation. Employers require widely preferred balanced profile combining both theoretical and

research as well as applications and practice orientations (MOHE, 2006).

Institute of Engineers Malaysia (IEM) plays an advisory role to the professional associations in the country and works in tandem with the engineering technology profession. Debates concerning the professional registration of engineering technology graduates in Malaysia have been highlighted. These include (K. Ismail & Puteh, 2008):

- The incorrect term for engineering technology. 'Applied Engineering' would be a better description to differentiate it from the standard engineering practice (Cheshier, 1985).
- The four-year practice of standard engineering curriculum – less applied knowledge with fewer laboratories should be taught.
- The Institute of Engineers Malaysia (IEM) and Board of Engineers Malaysia (BEM) are stringent on the issues of licensure and professional registration. Denying these graduates to become professional engineers will place a barrier to realizing their full engineering potential and the advancement of their profession.
- The Washington Accord agreement covers only professional engineering graduates whereas engineering technology is embraced by the Sydney Accord.

Engineering technology needs to distinguish themselves from engineering programs by addressing areas that will develop engineering technology programs into stand-alone programs, working in association with engineering and technical programs. One approach is to create separate registration path between the engineering and engineering technology workforce with different scope functions. Figure 1 shows the spectrum of jobs and jobs function stipulated by the University of Florida (UCF, 2005).

The scope of practice can be tallied with the existing definition of engineering technology by (ABET, 2002):

“Engineering technology is that part of the technological field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational spectrum between the craftsman and the engineer at the end of the closest to the engineer. The term ‘Engineering Technicians’ applies to the graduates of Associate Degree programs. Graduates of baccalaureate programs are called Engineering Technologists.”

Further definition on the scope is offered by (ABET, 2002):

“Engineering problems require solutions of varying degrees of complexity and non-technical considerations. As the technical leader, the engineer determines the policy basic to technical solutions and exercises responsibility to society in the non-technical dimensions. The technician and the technologist work in many functional and responsive ways to execute the applications designed by the engineer.”

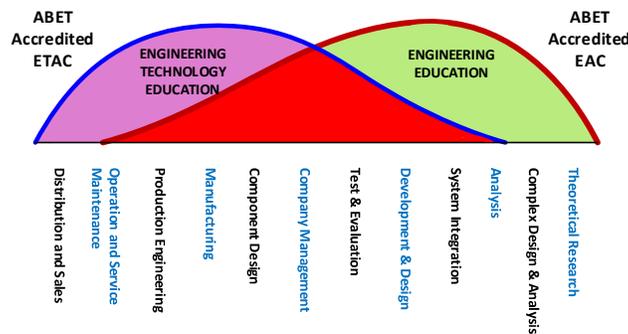


Figure 1. The Spectrum of Jobs and Jobs Function in Industry Adapted (UCF, 2005)

In Figure 1, the engineering technology entails the application of scientific and engineering knowledge and methods, combined with technical skills, for the implementation and extension of existing technologies. It is the profession in which knowledge of mathematics and natural sciences gained by higher education, the experience, and the practice are devoted primarily to the implementation and extension of existing technology for the benefit of humanity (ABET, 2002). The focal point of engineering technology education is preparing graduates for positions that involve product development and improvement, system development, management, manufacturing, and engineering operational functions. It focuses primarily on the applied aspects of science and engineering principles aimed at preparing graduates for practice in that portion of the technological spectrum closest to product improvement,

manufacturing, construction, and engineering operational functions. To be a developed nation, Malaysia needs to have more engineering technology graduates to fulfill the requirement of skilled workers.

4. Development of Undergraduate Engineering Technology Programs

Realizing the importance of highly skilled engineering labor force in the era of knowledge age and globalization, in 2003 the Board of Engineers Malaysia (BEM), Institution of Engineers, Malaysia (IEM), and the Federation of Engineering Institution of Islamic Countries (FEIIC) conducted a study on the Malaysian Engineering Technologist and Engineering Technician (MEET) profession. As a result, a model curricula development route and career path for these engineering workforces were proposed as illustrated in Figure 2.

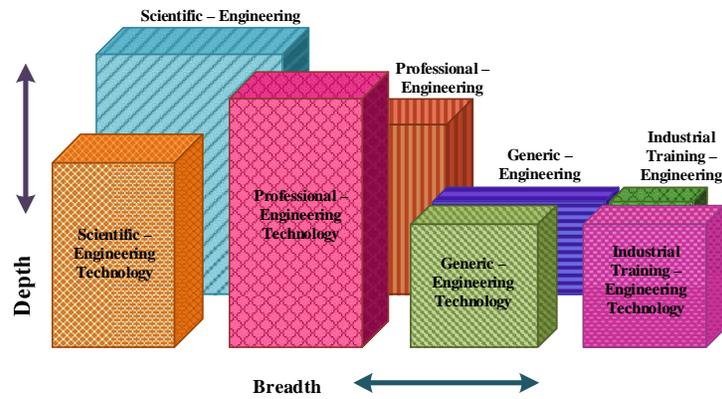


Figure 2. Breadth and Depth Relationships between Engineering (Eng) and Engineering Technology (Eng. Tech) for Undergraduate Programs (BEM, 2003)

Figure 2 illustrates the proposed engineering technology education model as reported by the Board of Engineers Malaysia (BEM, 2003) and Malaysian Qualification Agency (MQA, 2011). It can be seen that the curriculum contents of engineering technology is significantly differed in

practical skills compared with the traditional engineering education. The two programs differ on the mode of deliveries and the breadth and depth of the subjects as shown in Table 1 according to percentage distribution and the number of credit hours allocated.

Table 1. Malaysian Engineering Education and the Proposed Engineering Model (BEM, 2003; MQA, 2011)

	Malaysian Engineering Technology Model (140 credits)**	Malaysian Engineering Model (120 credits)***	Summary Percentage Distribution from Selected Countries
Qualification	B. Eng. Tech	B. Eng	-
Professional Skills } Practical Skills }	65-75% (78-90 credits)	50-35% (65-45 credits)	40-90%
Basic Science and Math Skills } Scientific Skills }	15-20% (18-24 credits)	20-35% (25-45 credits)	
Global and Strategic Skills } Industrial Skills } Humanistic Skills }	15-20% (18-24 credits)	30% (40 credits)	5-25%
Delivery/Assessment (Theory : Practical)	60 : 40*	80 : 20*	-

Note: Entry Requirements into this program varies
 * Ratio of contact times
 ** Programs Standards for Engineering & Technology, MQA, 2011.
 *** EAC Manual, BEM, 2012

From Table 1, the proposed ratio for engineering technology model for delivery/assessment is 60:40 that is 60% theory and 40% practical; where students are exposed to practical-based training throughout the 4-year program with a weight age of 60% practical and 40% theory (ratio of 60:40, practical to theory) covers a total number of 140 credits (MQF, 2010). Practical are conducted in the form of laboratory works, workshops, and industrial training. In addition, students are nurtured to be dynamic, creative and ethical by instilling soft skills throughout the teaching and learning process. Students are guided by qualified and experienced academicians that are experts and professional in their respective fields. At the end of the program, students are expected to be dynamically competent to fulfill the ever growing needs and requirements from community and industries.

In Malaysia, the main players offering engineering technology at the undergraduate level are four public technical universities also known as Malaysian Technical University Network (MTUN) and UniKL (University Kuala Lumpur) which aims to educate and train highly skilled manpower to contribute to the advancement of world-class industrial nation, and act as a catalyst for the national strategies in achieving national higher income. This is to counterbalance the vacancies of a professional team called the Engineering Technologists which are required by the industry. The Engineering Technology Program offered by MTUN and UniKL is a four-year bachelor degree options mainly in Civil, Electrical and Electronics, Mechanical, and Chemical engineering. All are accredited by MQA as the curriculum fulfilled the standard (MQF, 2010).

5. Challenges Faced by the Engineering Technology Program

The challenge for engineering technology education in Malaysia is to improve the current engineering education systems so

that the Malaysian engineering graduates are recognized internationally. Nevertheless, engineering technology education in Malaysia is constantly reviewed together with professional members from the industries and the education department.

Ensuring the quality of engineering technology education is vital in today's globalised world. The globalization and mobility have created unique opportunities for the flow of technology, knowledge, people, skills, money, labor force, goods and services, and ideas across the borders. International mobility of engineering technology graduates has forced universities to enhance the quality and standard by introducing various quality assurance and professional accreditation processes (Chowdhury, Alama, Biswasb, Islamb, & Islamc, 2013). Hence, it is imperative for the educational institutions, employers, industries and professional organizations to work together to ascertain the quality of education received by engineering technology graduates achieved the desired attributes of future technologist or technicians, as internationally mobile in today's globalised economy.

Accreditation is a proof that a university or college program has met certain standards necessary to produce graduates who are ready to enter their professions (ABET, 2002). Students who graduate from accredited programs have access to enhanced opportunities in employment, licensure, registration and certification, graduate education and global mobility. The accreditation of traditional engineering programs in Malaysia is under the jurisdiction of the Engineering Accreditation Council (EAC). The EAC is formed by the Board of Engineers Malaysia (BEM), the government body which has the legal responsibility of registering and regulating the engineering profession in the country. The EAC derives its membership from the Institution of Engineers Malaysia (IEM), Accreditation Board of Malaysia, the Public Services Department of Malaysia (PSD), the Malaysian Council of

Engineering Deans, and several members appointed by the President of the BEM from among industry practitioners (EAC, 1999).

Furthermore to acknowledge the importance of a highly skilled engineering workforce particularly in this knowledge age and globalization, Malaysia needs to propose the following to further develop its engineering technology programs as stated in the Engineering Technology Path, 2002:

- the emphasis on practical and hands-on skills in advanced technology
- enhances participation of industry in education and training
- adopts new approaches to learning
- nurtures entrepreneurship
- a thinking culture amongst engineering students and the workforce.

Another challenge faced by the engineering education in Malaysia is a clear direction of the engineering technology program and incorrect perception of the Malaysian society in general. Often the perception is that the graduate of the engineering technology is rated as “second class engineers”. This causes MTUN universities that are set up and run engineering technology programs to produce engineering technologist in Malaysia faced with the dilemma in running the program. They passively migrated to produce engineers instead as any other established universities (Mogat Johari, 2009).

Moreover, there is lack of incentives for the graduates. Even though BEM provides the pathway for the engineering technologist, but the PSD does not provide a proper employment scheme. To resolve this issue, all parties such as the Economic Planning Unit (EPU), BEM, Ministry of Human Resource (MoHR) and related parties must convene to get a clear direction and Ministry of Education (MoE) must also be in line to ensure that universities produced the desired professionals (engineers and engineering technologists) (11th-Malaysian-Plan, 2015; EPU, 2012).

Formulating a good engineering and engineering technology programs requires the interaction of engineers in industry and the universities (Nor, Rajab, & Ismail, 2008). This interaction promotes inter and cross-disciplinary research. However, this is the challenge we faced as there is a limited partnership between industries and universities, and therefore resulted in the difficulty recruiting quality faculty members, specifically experienced engineers. In addition, many research findings have not been commercialized, resulting in structural inefficiencies that impair a university's ability to adapt and change. These two parties must be considered so that the change made will result in an effective system such as providing better educational needs of the students. This understanding enables the students to succeed in the current and future global multi-disciplinary world.

In view of broadening and shifting the scope of the engineering profession, the undergraduate education programs should be a broad-based engineering technology program (Nor et al., 2008). It is imperative to shift the focus of curricula from transmission of content to the development of skills that support engineering thinking and professional judgment (Adams & Felder, 2008). However, adapting programs to the current industrial needs is not an easy task. Academia does not change easily, particularly when addressing interdisciplinary requirements and in understanding what and how to change. Hence, it is a challenge for both the academics and the industry to find a common platform in order to converge on their diverse understandings.

There is a need to address the issues of curriculum structure and course innovation in order to meet the expectations of industry, research, students and the professions with regard to engineering graduates of the coming decade (Nor et al., 2008). The curricula must be dynamic and flexible in order to adapt to new changes of technologies. The course content must provide more industrial-related problems in applying the understanding of the changing

requirements of industry in order to attract and maintain the motivation of engineering students. Practical application, theoretical understanding, creativity, and innovation are seen as the top priorities for these graduates to master in. The curriculum should be in line with the aspiration of The Engineering Technology Path to ensure that the foundation for the engineering technology program remains solid in the years to come. It should also depict engineering education that develops the motivation, capability and the knowledge-based for lifelong learning.

Inadequate financial support is another demanding matter. A significant amount of financial allocations is needed to materialize the engineering technology programs. Existing infrastructure such as classrooms, laboratories, computer laboratories including Internet and information infrastructure need to be improved and upgraded in order to accomplish the program educational objectives in an atmosphere conducive to learning. The economic transformation in Malaysia propelled by the introduction of the National Key Economic Areas (NKEAs) will expect the demand for labors in Malaysia to exceed supply (A. Ismail & Abidin, 2014).

By 2020, up to an additional 3.3 million jobs will be created, of which 1.3 million will be TVET (Technical & Vocational Education and Training) related which also include the B. Eng. Tech (EPU, 2012). The current capacity of TVET institutes reveals that it is insufficient to meet the needs of economic transformation (A. Ismail & Abidin, 2014). One way to overcome this problem, the B. Eng. Tech. should be given a priority in the Malaysian Education system. However, referring to the many challenges faced by the B. Eng. Tech programs mentioned in Section 5, as well as the slowdown of the Malaysian Economy at the moment, the future change in Malaysian education system brought about by the B. Eng. Tech is expected to be slow.

6. Conclusions

Malaysia aspires to become a developed and high-income nation by 2020. To attain this, Malaysia will require human capital with the knowledge and skills, as well as ethics and morality, to drive inclusive and sustainable economic growth (11th-Malaysian-Plan, 2015). The initiatives under the Eleventh Plan are projected to generate approximately 1.5 million new jobs by 2020, of which 60% require TVET-related skills. To meet this demand will require Malaysia to increase its students' intake in TVET-related skills. The industry feedback constantly reveals a discrepancy between the knowledge, skills and attitudes the graduates have and what is required in the workplace. Thus, engineering technology (B. Eng. Tech.) is an alternative in the knowledge expansion of engineering education.

To resolve the quality and the quantity of the graduates, industry and TVET providers need to collaborate from students' recruitment, through curriculum design, delivery, and job placement. In the Malaysian Engineering Technology program, students are exposed to practical-based training throughout the 4-year program with a weighted of 60% practical and 40% theory (ratio of 60:40, practical to theory). Students also have access to a variety of innovative, industry-like programs that better prepares them for the workplace which requires graduates to be technically competence and possess professional skill, as well as to be exposed to the global scenarios, current trend and future requirements.

The Malaysian Engineering Technology model includes 65-75% professional skills, 15-20% basic science and maths skills, and 15-20% global and strategic skills. This prepares the technologists for the positions that involve production, development, management, manufacturing, and engineering operational functions. Incorporating humanity skill into their knowledge-based and professional practice, the technologists must also cope with continual technological and organizational changes in the workplace.

The bottom line is that both the conventional and the practice-oriented graduates must be given the equal status from the employment point of view. Articulation from engineering technology to the professional engineer status would require BEM to amend the Registration of Engineers Act. The challenge for engineering technology education is to improve the current system so that Malaysia's engineering technology's graduates are recognized internationally. Then recently the introduction of Malaysian Board of Technologists (MBOT) by the government of Malaysia is timely. MBOT needs to determine and govern the ethics and conduct of the profession as well as provide guidance and professional development programs for career advancement. Through these activities, MBOT will elevate the role and recognition of engineering technologists.

Acknowledgments

We would like to acknowledge the Ministry of Education of Malaysia for funding the project under FRGS R.K 130000.7840.4F493 and to Universiti Teknologi Malaysia for providing the research facilities and support.

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