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Challenges in Implementing Engineering Technology Education in Malaysia

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Abstract. As Malaysia races against time to achieve Vision 2020 to be a developed nation, there is an urgent need for highly-skilled human resources to fulfill the requirements of the industry. This calls for an expansion of the engineering technology program to increase the number of technical graduates. However, various challenges are faced by the institutions in the implementation of the Engineering Technology programs, which have significant negative impact on the nation in general and, in particular the graduates from the programs. Data was collected from a brainstorming session between six organizations involved in providing engineering technology education in Malaysia and the Universiti Teknologi Malaysia (UTM) and a convention on Engineering Technology Future in Malaysia. This paper describes and discusses the challenges faced in the efforts to expand engineering technology programs in Malaysia, and proposes ways to overcome them.

Keywords: Accreditation, Challenges, Engineering technology, Education, Technical graduates.

1. Introduction

Malaysia's aspiration to be a developed and high-income nation by 2020 requires an urgent supply of highly-skilled human resources to fulfill the needs of the industry. This calls for an expansion of the engineering technology program to increase the number of technical graduates. However, during the period of 1993-1998, only about 10% of the total number of graduates was technical graduates despite the implementation of the Science and Technology (S&T) policy (Reaz, 2005). The ratio of technologists to engineers in Malaysia is still very low compared to the target ratio of 2:1 for most developing countries. *(http://www.saice.org.za/downloads/other/eengineer_in_developing_country_r_du_toit.ppd).*

If this situation is not addressed within the next few years, it would be quite difficult for Malaysia to be globally competitive and resilient. This study explores the main challenges faced in the implementation of engineering technology programs in Malaysia. These challenges are then categorized to highlight the relevant educational aspect that needs to be focused on and addressed to ensure successful implementation of the programs. Recommendations of solutions are provided in the Conclusion section.

2. Literature Review

During the period of 1993-1998, only about 10% of the total number of graduates were technical graduates and the percentage of S&T graduates in technical fields and in other sciences such as medicine was about 27%. After 12 years of implementing the S&T policy, the output is still skewed to the arts and social sciences (Reaz, 2005). According to Sulaiman (2006), among the issues and challenges that have been identified in developing skilled workers which contribute towards making Malaysia a developed nation that is highly competitive and resilient globally, are as follows:

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1. Highly-skilled workforce to support k-Economy
2. Skills mismatch
3. Incompetent workers
4. Curriculum with an approach that is demand-driven and responsive to real needs
5. The need to recognize skills training as part of the mainstream education.

Conventional engineering programs often focus on theory and conceptual design, and the graduates are expected to be able to apply scientific concepts in designing new products and develop solutions to real world problems. These graduates from the engineering programs are called engineers. On the other hand, engineering technology programs draw upon the same body of knowledge as engineering, but focus primarily on the applied aspects of science and engineering and more heavily upon the applications and implementation related to manufacturing, testing, construction, maintenance, field service, and marketing. The graduates from the engineering technology program apply their knowledge to product improvement, product assurance, manufacturing, sales and engineering operational functions. These graduates are called engineering technologists (ABET, 1992).

For engineers and engineering technologists, it is very important to qualify for the international registration. Several international accords provide for recognition of graduates of accredited programs internationally. The Washington Accord (WA) provides for mutual recognition of accredited engineering programs while, the Sydney Accord (SA) establishes mutual recognition of accredited qualifications for engineering technology programs. These accords are based on the principle of substantial equivalence (Graduate Attributes and Professional Competencies, 2013). Both engineering and engineering technology programs are offered in Malaysia. However, only the engineering programs are being accredited. In Malaysia, the Engineering Accreditation Council (EAC) is delegated by the Board of Engineer Malaysia (BEM) and given the responsibilities for accreditation of the engineering degree programs offered. BEM is not providing the pathway for Engineering Technologist to be registered. On the other hand, the Malaysia Qualification Agency (MQA) is the responsible body for the accreditation of the Engineering Technology programs. There is no salary scheme for engineering technology graduates who wish to work in the Government sector. Malaysia is already a signatory of the Washington Accord and, therefore, the conventional engineering program can be placed under the Washington Accord.

In many developing countries, the responsibility of generating human capital has rested heavily on the government. These countries including Malaysia are eagerly adapting the German Dual System with varying success. The Ministry of Education is viewing both technical and vocational education as adding to the high-skill, high-income workforce in the country (Ismail, A. & Zainal Abiddin, N., 2014). Thus, the establishment of the Malaysian Technical Universities Network (MTUN) in early 2000s, comprising Universiti Teknikal Melaka (UTeM), Universiti Malaysia Pahang (UMP), Universiti Tun Hussein Onn (UTHM) and Universiti Malaysia Perlis (UniMAP) was timely. These universities offer a host of technical and vocational education at diploma and degree levels (Tan & Kim, 2014).

The establishment of technical universities MTUN mission is to educate and train highly skilled manpower to contribute to the world-class industrial nation. The objective of this MTUN is to complement the existing conventional systems which are industry driven. It is in fact, in line with the intention of the Malaysian government to assure the achievement of the ratio of engineering technology to conventional engineering graduates from 30:70 to 60:40 by 2015 (Hussin, 2011).

2.1. Engineering Education Technology across the Globe

As an academic field of study, engineering technology has evolved to become a well-recognized discipline in many developed countries. In Germany, Universities of Applied Sciences (Fachhochschulen) focus on teaching professional skills and are thus more application oriented. In the dual system of education, practical vocational training is given at work, while theoretical and general education are provided in vocational training schools which are generally attended on one or two days a week. This is one of the typical successful models of Engineering Technology education which delivers through a strong collaboration with industry. Starting 2010, apart from Diplom, these institutes also award degrees equivalent to European Bachelor's and Master's degree for courses with more theoretical orientation, in line with the Bologna Process *(http://www.bmbf.de/pub/fachhochschulen_in_germany.pdf*

The state-certified engineer is a European Union qualification for professional engineering technologist. It is granted to engineering technologists upon successful completion of a technical college. It can also be granted by an international organization with headquarters in Germany. Starting 2012, the state-certified engineer is a "level 6" on the European Qualification Framework (EQF), the equivalent of "bachelor" on EQF. Entry requirement for all Fachhochschulen programs is high school certificate, Fachhochschulreife or for those without this certificate can be admitted by passing an interview, aptitude test, and upon completion of evening courses by working adults or day school courses for those with work experience. The coursework comprises eight semesters (four years) of full-time study with various options for specialization. Students undergo one or two practical training semesters in an industrial environment.

During the final year, students sit for an exam and complete a thesis which usually is an extensive project of a practical or scientific aspect of the profession. Fachhochschulen is governed by the Federal Ministry of Education and Research, and its courses are accredited by the Accreditation Council(Akkreditierungsrat).

The Accreditation Council has representatives from higher education institutions, the ministries for education and research and from various fields of professional practice. An alternative to institutions of higher education is provided by Berufsakademien, which are professional academies implementing the dual system of vocational education and training to the tertiary sector. The qualifications they award are recognized as tertiary sector qualifications. In France, universities and polytechnics are characterized by a dual system of universities and polytechnics. The programs are generally geared towards research and its applications. Lycées offer non-university higher education courses leading to the Brevet de Technicien Supérieur (BTS). Most institutions come under the responsibility of the Ministry of Education and Research. The duration of the first level of a university is 3 years after the implementation of the Bologna Degree structure. The entry requirement for university courses is the Baccalauréat or passing the entrance examination to some Grandes Ecoles and other institutions following two years of preparatory courses.

The main accreditation authority in France is the Ministry of National Education. Diplomas are issued by institutions of higher education, whereas degrees are awarded by the ministry and public universities. For private institutions, accreditation is awarded by Ministry visa and recognition. In the United States of America, Engineering Technology programs combine theoretical coursework heavily reinforced with hands-on laboratory experiences and project work with a focus on the application of engineering principles. Training programs are also offered by employers or through contract by postsecondary institutions, professional associations, unions or consulting organizations. Education or training may be provided at the work site or elsewhere. Engineering Accreditation Commission (EAC) accredits an engineering program at the bachelor's or master's degree level, whereas the Engineering Technology Accreditation Commission (ETAC) accredits an engineering technology program at the associate's or bachelor's degree levels (http://www.bachelorstudies.com/Bachelor/Engineering-and-Technology/North-America/).

The Sydney Accord and the Engineering Technologist Mobility Forum (ETMF) are two international efforts to improve recognition for technologists. The Sydney Accord signed in 2001 is an agreement between the bodies responsible for accrediting engineering technologist qualification programs in each of the signatory countries which include Australia, Canada, Ireland, Hong Kong, New Zealand, South Africa, United Kingdom, the United States, and Sri Lanka. This agreement is an acknowledgment of the academic equivalence of accredited engineering technology programs in the signatory nations. The international engineering technologist (IntET) qualification was launched in late 2007 by the Engineering Technologists Mobility Forum (ETMF), which is part of the International Engineering Alliance (IEA).

In Australia, Engineering technology degree programs are 3-year full-time programs that provide training and experience in implementing engineering solutions. The names of the awards are Bachelor of Technology, Bachelor of Engineering Technology, or Bachelor of Engineering Science. Students have the option to be upgraded to Bachelor of Engineering degree programs with an additional 1 year. Accreditation of Engineering Technology programs are given by the Institution of Engineers, Australia (IEAust) *(http://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/140409_et_last_updated_9_april_2014.pdf)*

In the United Kingdom, engineering technologists, also known as incorporated engineers (IEng) are produced via the apprenticeship system of learning. Apprenticeship programs would normally lead to the EngTech professional qualification and with further studies at the higher apprenticeship level, an IEng. Since 2000, the normal route to an IEng is a Bachelor or Honours degree in engineering. Incorporated engineers are recognized internationally through the Sydney Accord academic agreement as engineering technologists. In the United Kingdom, incorporated engineers are comparable to chartered engineers, and is recognized as a professional engineer as declared by the Engineering Council of the United Kingdom *(http://www.engc.org.uk/)*.

The aforementioned countries have a clear and often flexible academic pathway for Engineering Technology. There are accreditation bodies which monitor and assess the quality of the programs to assure national and international recognition (*https://www1.oecd.org/education/skills-beyond-school/37474463.pdf*). In comparison, the engineering technology programs in Malaysia despite having attained the recognition from the Malaysian Qualification Agency have yet to be recognized by professional bodies.

2.2. *The Call for Changes*

Feedback from stakeholders is important in order to change to a new educational system or curriculum. The feedbacks and requirements can be obtained from the graduates who undergo the learning process and the industry who hire the engineering technology graduates. A study by Spinks, Silburn and Birchall (2006) found that the two broad areas of skills and attributes that the industry practitioners require are: i) skills in the engineering field which includes technical skills, a sound knowledge in engineering fundamentals, ability to apply theory into practice as well as creativity and innovation and ii) social and interpersonal skills and attributes that enable the engineer to operate in a commercial working environment such as communication skills, team-working skills, and business skills. In addition, the newly hired graduates should also have the awareness of the commercial implications of engineering decisions.

Royal Academy of Engineering (2007) reported that industry are looking for engineering graduates who have the following attributes: practical experience of real industrial environments, ability to apply theoretical knowledge to real industrial problems, theoretical understanding, creativity and innovation, team working, technical breadth and business skills. A group of researchers from Malaysia divided the graduates skills and attributes into two main categories: technical attributes and non-technical attributes (Zaharim, et. al., 2009). They found that the most important technical skills and attributes expected by the industries in Malaysia is competency in application and practice of the engineering tasks, followed by ability to apply knowledge of engineering fundamentals in the tasks given and technically competent in specific engineering discipline. Other attributes expected by the industries include knowledge of engineering systems approach, ability to design and conduct experiments as well as competent in theory and research. The most significant non-technical attribute is ability to communicate effectively, ability to identify problems and formulate a solution and the solution to engineering problem solving and ability to work in a team or the team.

Other non-technical attributes include understanding the professional, social and ethical responsibilities, lifelong learning and knowledge of contemporary issues (Zaharim, et. al., 2009). Alias, Mokhtar and Juri (2005) discussed more general skills and attributes expected from the engineering graduates. These include technical competencies, lifelong learning, interpersonal and social skills, entrepreneurship skills as well as innovative and creative skills. In addition, the graduates should also possess the positive work readiness and habits.

In addition to the industrial feedback, Spinks, Silburn and Birchall (2006) also conducted focus group interviews with the newly-recruited engineering graduates in the United Kingdom to investigate their job functions. They reported that newly-recruited engineering graduates are expected to be involved in research and development, design, production, and manufacturing. In addition, the job functions do not necessarily involve hands-on specialist engineering, but may involve the product lifecycle throughout the value chain.

In general there are two areas of skills and attributes of the engineering graduates required by the industry, the technical skills and the professional and social skills. The question is whether or not the engineering graduates are able to fulfill the industrial requirements. On the issue related to the industries' and employers' satisfaction on the skills and attributes possessed by engineering graduates, Spinks, Silburn and Birchal (2006) reported that firms in the UK are neither satisfied nor dissatisfied with their ability to recruit appropriately skilled engineering graduates. Zaharim, et. al (2009) reported that the employers' in Malaysia are satisfied with the following skills and attributes of the engineering graduates (the average score is around 55%): ability to acquire and apply knowledge of engineering fundamentals in the tasks given, competency in application and practice of the engineering tasks and ability to utilize a systems approach to design and evaluate operational performance.

On the other hand, for the non-technical attributes, employers are only satisfied with the following attributes: team working skill, understanding professional, social and ethical responsibilities as well as communication skills. The average score for these three attributes is 52%. It can be concluded that the employers are not really satisfied with the skills and attributes of the current engineering graduates in Malaysia. Therefore, engineering curriculum needs to be improved and upgraded in order to improve satisfaction ratings by the employers.

3. Research Methodology

This research is conducted by a group of researchers working on the application-based education in engineering technology (ET), to explore the main challenges in implementing ET programs in Malaysia. The researchers are working with the higher education providers that have been granted to run ET programs in Malaysia. These education providers are: (i) four public universities that offer ET programs in Malaysia namely Universiti Teknikal Melaka (UTeM), Universiti Malaysia Pahang (UMP); Universiti Tun Hussein Onn (UTHM) and Universiti Malaysia Perlis (UniMAP). These universities are also known as Malaysian Technical Universities Network (MTUN); (ii) Universiti Kuala Lumpur (UniKL), a private university that offer ET programs; (iii) Polytechnic Department of the Ministry of Education, which represents the three Premier Polytechnics in Malaysia that offer ET programs.

The representatives from the top management of these higher education providers were invited for a focus group discussion (FGD) session. They are chosen because of their involvement and experienced in developing the ET programs as well as their current experience as administrators and faculty members at their university and department. In addition, they are also involved in teaching and recruiting the lecturers for the ET programs at their university. It was felt that the inclusion of these participants would add both to the richness of the data on ET graduate skills, as well as provide a potentially different understanding of the issues and possible solutions. It should be noted that the first cohort of students at MTUN are currently in their third year of a four-year program whereas the pioneer students at UniKL and Premier Polytechnics have already graduated.

Prior to FGD, the researchers prepared the questions as a guide during the discussion session. The questions covered the following area: i) understanding the direction of the ET programs; ii) how the programs are implemented; iii) the challenges faced in implementing the programs; iv) physical infrastructure provided by the institutions; and v) the participation and support received from the industries. The purpose of the questions was to stimulate discussion and to collect the required information.

The FGD was held in September 2014 at Universiti Teknologi Malaysia (UTM). The session involved all the nine researchers from UTM and 10 representatives from MTUN, UniKL and Polytechnic Department of the Ministry of Education. The FGD was moderated by the advisor of the research project who acted as the chairman for the session. All participants were given an opportunity to fully participate in the discussions. The FGD session was audio and video recorded, with the permission of the participants. The session lasted about 2 hours. In order to gather more information on the challenges encountered in implementing the ET programs, the researchers also attended the Engineering Technology National Convention, held on 22 September 2014.

The convention was organized by the Malaysian Society for Engineering & Technology (MySET) and UniKL. Among the objectives of the convention were (Engineering Technology National Convention, 2014):

1. To promote TVET and ET as the pathway to produce technologists as well as highly professional and skilled workforce for the nation.
2. To provide a platform where issues in ET can be discussed and resolved.
3. To improve or develop new ideas both at the highly-skilled (engineering technologists) and semi-skilled (engineering technician) level of human capital aspirations.
4. To enhance the relationship and collaboration between Government Agencies and Industrial Companies and MySET.

The data recorded during the FGD session was verbatimly transcribed by the authors.

To determine the themes of the FGD, the transcript was analyzed using constant comparison methods. The results of the analysis together with the information gathered from the convention will be discussed in the next session.

4. Findings and Discussions

Among the issues and challenges that have been identified in developing skilled workers to support K-economy include incompetent workers and skills mismatch between what is required and what is available in the job market. One of the root causes for these problems is the fact that in Malaysia, most higher educational institutions have always given priority to prepare students for the academic pathway rather than for work, whereas the industries require work–ready graduates (Jaafar, S., 2014). Building science, engineering and technology capacity in developing countries are crucial issues that face the world today, besides economic growth, poverty reduction, improved health and sustainable development. Capacity development is complex and multi-dimensional and occurs at the individual, organizational and institutional level.

Due to the challenges described above and the current engineering technology education scenario in Malaysia, several aspects need urgent attention. Data was gathered from the following five aspects during the FGD session between the six organizations involved in providing engineering technology (ET) education in Malaysia and the Universiti Teknologi Malaysia (UTM):

1. Direction of Engineering Technology Education
2. Implementation
3. Challenges
4. Infrastructure
5. Industry support

All the participants shared their views on ET programs and shared their experiences and practices in running them. The participants expressed their concerns and described the challenges they face in implementing the ET programs at their respective institutions.

It was discussed in the session that the concepts of ET have yet to be clearly defined. The differences between ETE (engineering technology education) and EE (engineering education) are often compared, and the latter is often considered superior to the other, instead of complementing one another in fulfilling the needs of the nation. Perceptions of the public regarding the lower level of ET compared to EE programs, and the equal expectations of industry on the job scope between the two fields of engineering are challenges to overcome. It was suggested that the gap between ET and EE should be identified for a successful implementation. Initial implementation of ET programs in the country in early 2000 was a top-down instruction, and ET was converted to EE during its infancy due to accreditation matters. The accreditation issue was also highlighted during the Engineering Technology National Convention.

It was highlighted that the pioneer group of ET graduates from UniKL are unable to register with BEM following the recognition issue. Additionally there is no employment scheme under the Public Services Department and no clear career path for ET graduates. Only recently MTUN were instructed again to offer the ET programs; for UTeM, the first cohort (intake 2011) will be graduating soon. The employment, professional qualification and opportunities for further education are issues to graduates and parents. These issues are related to matters of the governance that must be resolved in order to fulfill the nation's requirement of ET workforce.

The implementation and recognition of profession, in particular, has often raised arguments among the stakeholders. Implementation challenges include the program requirements and curriculum, which comprise the teaching and learning (T&L) approaches, assessment, and teaching staff competency. As highlighted by a respondent, not all MQA standards, such as the credit hours for industrial training and workshop, and the entry requirements are suitable for ET. It was also highlighted that ET standards are often underrated.

The most common mode of T&L is the work-based (or application-based) learning, which involves interactions between institutions and the industry, where learning takes place in industry, whilst engaging practicing engineers as teachers. However, assessment is still an issue. Meanwhile, the T&L in the campus has issues regarding the lack of industry experience among the teaching staff. This issue is an important aspect to be addressed since ET main objective is to produce manpower with skills that fulfill the industry needs. The institutions' representatives raised the challenges about budget and infrastructure for teaching facilities. However, fortunately for UTHM, it will move to a new campus in Pagoh with new facilities which include a teaching factory.

Analysis of the discussions from personal notes by members of the researchers, video and voice recorders were transcribed and categorized, leading to at least four main categories of challenges. These four categories of challenges faced by the institutions in implementing ET are shown in Fig.1:

1. Definitions, Concepts: Engineering Technology versus Engineering Education
2. Pathway, Mapping, Governance and Salary Scheme
3. Infrastructure, Budget and Teaching Staff Competency
4. Teaching & Learning Approaches and Assessment

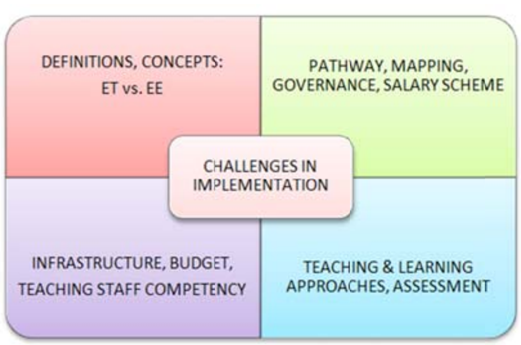

Figure1. Four Categories of Challenges

5. Conclusions

It can be concluded that ET is an important agenda in Malaysia. It is a field to complement EE in fulfilling the demand of the country. ET should be recognized as an equivalent level with EE, but providing a different scope of work. Lack of awareness regarding the different scope of 'expertise' between ET and EE among industry people and the society needs to be addressed. Therefore, recognition of the profession and accreditation of the programs need urgent solutions. The proposed Malaysian Board of Technologist (MBOT) and the realignment of MQA for ET are among the means to solve the first big hurdle in positioning the profession and qualification. Continuous support from the industry, professional bodies, and government initiatives are crucial means to resolve the rest of the challenges pertaining to the successful implementation of ET programs.

The key solution to overcome current issues would be to strengthen the engineering technology education. The curriculum should be demand-driven and responsive to real needs. Skills training should be recognized as part of the mainstream education (Idrus, Dahan and Abdullah, 2013). The implementation of the National Dual Training System (NDTS) in Malaysia which has been introduced in the early 2000s should be expanded to produce more and better-qualified knowledge workers (Sulaiman, 2006). In addition, engineering technology students should also be given the opportunity to engage in the latest and relevant knowledge and skills as they advance (Jaafar, M., 2014).

This study is only preliminary with a limited number of respondents comprising students, lecturers, and university administrators. Thus, to enhance the credibility of the findings on the challenges faced by various stakeholders of Engineering Technology education in Malaysia, a further study should include a bigger sample of the respective strata of the population.

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