Practical Framework of Employability Skills for Engineering Graduate in Malaysia

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Abstract— **The purpose of this paper is to propose a practical and simple framework of engineering employability skills that will allow the concept to be explained easily and that can be used as a framework for working with engineering graduates to develop their employability before entering workforce. The framework was developed from existing researches on engineering employability skills issues and the requirement of the accreditation of engineering programme. The various skills of employability skills related to engineering included in the framework are discussed and their criteria justified bases on literature review of existing studies. The framework sets out exactly what is meant by engineering employability, in clear and simple terms, and the framework suggests directions for interaction between the various skills. The relationships between the skills within the framework remain theoretical. Further research to test the framework is planned and will be reported in future paper. The framework can be used to explain the concept of employability to those new to the subject, and particularly to engineering students and their future employer. It will be a useful tool for lecturers, careers advisors, trainers, employers and any other practitioners involved in employability skills. It will also be used to develop a model and a measurement tool for engineering employability skills. This paper contributes insights into the linking of graduate attributes, using national accreditation criteria and the framework of engineering employability skills from locally and globally expectation. It will be of value to anybody with an interest in employability issues.**

Keywords- Engineering; framework; employability; graduates; employers

I. INTRODUCTION

Today's engineering professions are continuously experienced major changes in knowledge, equipments, tools, systems and managements. Consequently, engineering firm continuously needs an engineer with a strong theoretical background, and require engineer equipped with employability skills. In order to face new challenges, new opportunities and on-going different circumstances, new engineers have to continually adapt and upgrade necessary skills such as self-learning [13], problem solving [10] and others personal skills [11] that can be applied in different situations. To overcome these phenomena, Higher learning institutions and employers need to have common understanding of which skills should be owned by engineering graduates. Therefore, a number of studies had been conducted to find this set of employability skills, and a few numbers of new frameworks of employability skills have been proposed. However, the aim of this paper is to focus on an acceptable and practical framework of engineering employability for Malaysian engineering graduates that are firmly based on requirement by accrediting bodies and professional bodies and existing research findings in employability skills.

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II. OVERSEAS ENGINEERING EMPLOYABILITY SKILLS

The popularity of the employability skills has increased around the world since the 1980s [2]. The concept of employability skills have common purpose which is to recognise an important set of skills that support the effectiveness of practising technical and nontechnical skills in the workplace [2; 5; 6]. DEST 2006 [5] asserts the important of employability skills as a tool to assist learners and candidates for assessment to demonstrate the technical competent and skills to achieve and maintain successful employment outcomes. Employability skills were accepted as being important in a competitive business environment, with greater emphasis now being placed on these skills [6]. The skills are also transferable [14] and applicable from one place to another [2].

The United State of America (USA), United Kingdom (UK), Australia (AUS), Japan and European Union (EU) define the criteria for the framework of engineering employability skills as identified by industry and employers [6]. Following are the criteria of engineering employability skills in these countries that becomes reference to Malaysia. These frameworks on engineering employability skills as shown in Table 1 are used as a guideline for their engineering employers and employee as well as for engineering graduates.

TABLE 1: INTERNATIONAL ENGINEERING SKILLS/ATTRIBUTES REQUIRED FOR ENGINEERING GRADUATES

USA	***UK***	*AUS*	***Japan***	***EU***
ABET Engineering Criteria 2000	***OSC Eng Occupational Standards***	*Engineers Attributes*	***Employable personal qualities***	***Generic Employability Skills***
Ability to apply knowledge of mathematics, science and engineering	Develop engineering products	Ability to communicate effectively, with the engineering team and with the community at large	**Personal skills** 1. Communication skills 2. Personal presentation skills 3. IT and computer skills 4. Problem-solving skills 5. Leadership skills 6. Visioning skills 7. Goal-setting skills 8. Self-assessment skills	**Mastery of one's native language** Including the basics of spelling and sentence structure
Ability to communicate effectively	Develop own engineering competence	Ability to function effectively as an individual and in multidisciplinary and multicultural teams, as a team leader or manager as well as an effective team member	**Attitudes** 1. Responsibility 2. Optimism 3. Curiosity 4. Ambition 5. Desire for challenge 6. Cooperation 7. Vitality	**Critical thinking** Ability to think through a problem or situation, distinguishing between facts and prejudices
Ability to design a system, component, or process to meet desired needs	Improve the quality and safety of engineering products and processes	Ability to manage information and documentation		**Understanding of the basics of maths and science** Particularly to cope with new technology
Ability to design and conduct experiments, as well as to analyse and interpret data	Install engineering products	Capacity for creativity and innovation	**Traits** 1. Initiative 2. Sensitivity 3. Flexibility 4. Individuality 5. Sincerity 6. Creativity 7. A balanced personality 8. An entrepreneurial mind	**Learning techniques** Ability to pick up new skills and adapting to new situations
Ability to function on multidisciplinary teams	Maintain engineering products	Capacity for life-long learning and professional development		**Team spirit** Ability to work in a group
Ability to identify, formulate, and solve engineering problems	Plan and manage engineering projects	Professional attitudes		**Personal discipline** Sense of responsibility
Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Produce engineering products	Understanding of professional and ethical responsibilities, and commitment to them		**Decision making** Sense of commitment and willingness to take risks;

USA	*UK*	*AUS*	*Japan*	*EU*
ABET Engineering Criteria 2000	***OSC Eng Occupational Standards***	*Engineers Attributes*	***Employable personal qualities***	***Generic Employability Skills***
Knowledge of contemporary issues				**Initiative** Sense of Curiosity and creativity
Recognition of the need for and an ability to engage in lifelong learning				**Professionalism** Sense of achieving excellence and gaining competitive edge
The broad education necessary to understand the impact of engineering solutions in a global/societal context				**Civic mindedness** Sense of service to the community
Understanding or professional and ethical responsibility				

The Accreditation Board for Engineering and Technology (ABET) of USA required graduates from an accredited programme to have and demonstrate the attributes (educational outcomes) as described in Criterion 3 Basic Level Accreditation Criteria, ABET Engineering Criteria 2000 [4], as listed in first column, Table 1. Meanwhile, UK's engineering graduates are required by engineering industry to accomplish the competencies in OSC Eng Occupational Standards as reported by Dodrige [2]. Second column, Table 1 lists the competencies in OSC Eng Occupational Standards. As an Australian professional body and an accrediting body, the Engineers Australia (EA) developed a suite of professional attributes in engineering competencies based on the findings of the review in the development of engineering employability skills for undergraduate students. The professional attributes included in the Engineers Australia competency standards are listed in third column, Table 1. In Japan, a practical industrialized curriculum in engineering had engaged to the Japan Accreditation Board for Engineering Education (JABEE) guideline to integrate employable personal qualities into the academic curriculum in order to generate skilled engineers [11]. Column 4, Table 1, presents the Employable personal qualities practiced in Japan. Lastly, in Column 5, Table 1, lists the generic employability skills proposed by The European Round Table of Industrialists (ERT) in European Union (EU).

Malaysian engineering education mainly guided by accrediting body, Engineering Accreditation Councils (EAC) of Malaysia and the Malaysian Quality Assurance (MQA) Department of the Ministry of Higher Education Malaysia. EAC is the body appointed by Board of Engineers Malaysia (BEM) for accreditation of engineering programme in Malaysia. Accreditation policy required engineering graduates to have the necessary attributes, skills and competencies reflected in the graduate outcomes specified in EAC Manual. According to study done by Basri [4] and Abdullah [1], Malaysian employers agreed that more than 70% of the attributes for engineers in EAC manual are important. Table 2 shows the attributes required by EAC.

TABLE 2: ENGINEERING ATTRIBUTES REQUIRED BY EAC (MALAYSIA)

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

Source: EAC Manual

Based on the EAC requirement and the employability frameworks discussed above, this paper try to propose the practical framework of employability skills for engineering graduate in Malaysia for this near future. However, innovations, developments and technologies keep on changing

in the world which requires the frameworks to be revised and to be updated as needed by industries.

III. DEFINITION OF ENGINEERING EMPLOYABILITY SKILLS

Skill is an ability to perform a specific task [5] and employability is about having the capability to gain initial employment, maintain employment and obtain new employment if required [8]. Employability skills was defined as 'those basic skills necessary for getting, keeping, and doing well on a job' by Robinson [12] and as 'skills required not only to gain employment, but also to progress within an enterprise so as to achieve one's potential and contribute successfully to enterprise strategic directions' by DEST 2002 [5]. Based on above definitions and other researches result [1; 2; 4; 5; 6; 7], hence, *engineering employability skills* can be defined as:

> *'Ability to perform engineering related skills, knowledge and personal attributes to gain employment, maintain employment and succeed in the engineering field.'*

Engineering employability skills are highly related to technical and non-technical skills or abilities. This definition and the overseas frameworks have been used as a starting point to develop a new theoretical framework for Malaysian engineering employability skills. This proposed Malaysian Engineering Employability Skills Framework (MEES) can be used as a guideline in training package and qualification in Malaysia. Every qualification is suggested to have an Employability Skills Report to describe how each of the employability skills is addressed in that qualification and embedded in the outcomes of the individual units of competence.

IV. PROPOSED ENGINEERING EMPLOYABILITY SKILLS FRAMEWORK FOR MALAYSIA

Employers and leading engineers in Malaysia agreed that engineering graduates are lacking of oral and written communication skills [3], generic skills and nontechnical skills [9; 10; 3; 2]. They required new engineers to perform engineering related skills and knowledge effectively. The fact that an engineering labour market becoming more knowledge-based and global, the importance of developing recognised employability skills globally become more critical [6; 9; 3; 2]. Therefore, this study proposes a **Malaysian Engineering Employability Skills** (**MEES**), a framework of engineering employability skills that intended to provide a framework for engineering related programmes. It can be used as a guide to generate skilled engineers that ready for industry practice locally and internationally, and as a benchmark for engineering graduates to be skilled and competent engineer. This framework was derived from existing researches on engineering employability skills issues, developments in other national frameworks [2; 6], literature on the views of Malaysian employers [1; 2; 4; 5] and the requirement from accrediting bodies of engineering programme. MEES satisfies the criteria and inline with the requirements of the Accreditation Board for Engineering and Technology (ABET), the Engineering Accreditation Councils of Malaysia, the Board of Engineers Malaysia and the Malaysian Quality Assurance Department of the Ministry of Higher Education Malaysia, Washington Accord and also satisfies qualification criteria of other professional bodies. Yet, the proposed framework of MEES is still open for consultation, discussion and debate in Malaysia. Following (Figure 1) is the Framework of MEES and the components made up for the framework.

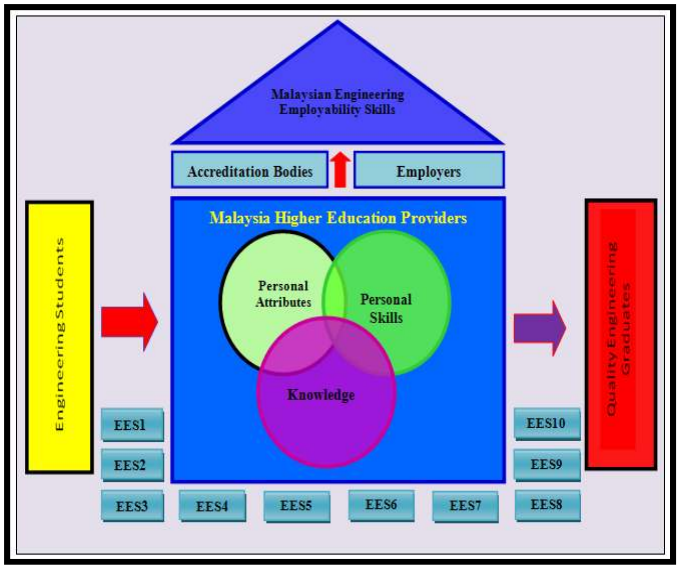

Figure 1: Framework of MEES

MEES comprises three main components: personal attributes, personal skills and knowledge. These three main components are integrated of communication skills (EES1), teamwork (EES2), lifelong learning (EES3), professionalism (EES4), problem solving and decision making skills (EES5), competent in application and practice (EES6), knowledge of science and engineering principles (EES7), knowledge of contemporary issues (EES8), engineering system approach (EES9) and competent in specific engineering discipline (EES10). Key components of the MEES framework is comprised of:

I. Personal attributes: - These attributes have been identified [2 − 11] as an ability needed to enable the engineer work well and effectively with others on a job and society.

EES1- Communication skills
EES2- Teamwork
EES3- Lifelong learning
EES4- Professionalism
EES5- Problem solving and decision making skills

II. **Personal Skills: -** These skills considered in an applied context which provide the foundations to gain employment maintain employment and succeed in the engineering field.

EES1- Communication skills
EES2- Teamwork
EES5- Problem solving and decision making skills
EES6- Competent in application and practice
EES10- Competent in specific engineering discipline

III. **Knowledge: -** knowledge which provides the necessary understanding of scientific and technologies principles to gain employment maintain employment and succeed in the engineering field.

EES3- Lifelong learning
EES5- Problem solving and decision making skills
ESS7- Knowledge of science and engineering principles
EES8- Knowledge of contemporary issues
EES9- Engineering system approach

The specific skills of MEES related to engineering included in the framework are justified based on literature review of existing studies, attributes required by accrediting bodies and graduate profile of professional bodies. The framework sets out exactly what is meant by engineering employability skills, in clear and simple terms as presented in Table 2, and the framework suggests directions for interaction between the various skills that being identified. It is obvious that in engineering students are recommended to develop their employability skills in conjunction with their subject knowledge while they are still in undergraduate studies. The higher education providers shall furnish their graduates with attributes that satisfy local requirement and global criteria. These skills are very important for new engineers as well as for engineers to succeed in their profession and being promoted [5; 6].

TABLE 2: MALAYSIAN ENGINEERING EMPLOYABILITY SKILLS (MEES) FRAMEWORK

Code	Skills
EES1	**Communication skills** Ability to present ideas with confident and effective through aural, oral and written modes, not only with engineers but also with the community at large. Engineering graduates should have the skills sufficient to: *1. Speak in clear sentences,* *2. Give clear direction ,* *3. Listen and ask question,* *4. Ideas presented with confident and effective,* *5. Speak and understand more than one language.*
EES2	**Teamwork** 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. Engineering graduates should have the skills sufficient to: *1. The ability to function effectively as an individual,* *2. Understand the role in a group,* *3. Work in a group as an effective team member,* *4. Accept and provide feedback in constructive and considerate manner,* *5. Work in a group with the capacity to be a leader*
EES3	**Lifelong Learning** Ability to recognize the need to undertake lifelong learning, and possessing / acquiring the capacity to do so. Engineering graduates should have the skills sufficient to: *1. Recognize the need to undertake lifelong learning,* *2. Possessing and acquiring the capacity to undertake lifelong learning,* *3. Able to engage in lifelong learning,* *4. Set their personal learning targets,* *5. Plan to achieve their learning goal(s)*
EES4	**Professionalism** Ability to understand the social, cultural, global and environmental responsibilities of a professional engineer, and commitment to professional and ethical responsibilities. Engineering graduates should have the skills sufficient to: *1. Understand the social responsibilities,* *2. Understand the cultural and global responsibilities,* *3. Understand the environmental responsibilities,* *4. Commitment to professional responsibilities,* *5. Commitment to ethical responsibilities.*
EES5	**Problem solving and decision making skills** Ability to undertake problem identification, apply problem solving, formulation and solutions. Engineering graduates should have the skills sufficient to: *1. Undertake problem identification,* *2. Implement problem solving,* *3. Apply formulation and solution ,* *4. Be creative, innovative and see different points of view in solving problems,* *5. Analyse and identify the root cause of the problems.*
EES6	**Competent in application and practice** Ability to use the techniques, skills, and modern engineering tools. Engineering graduates should have the skills sufficient to: *1. Use the necessary techniques for engineering practice.* *2. Use the necessary skills for engineering practice.* *3. Use the modern engineering tools and software.* *4. Work toward quality standards and specifications.* *5. Assemble equipment following written directions.*
EES7	**Knowledge of science and engineering principles** Ability to acquire and apply knowledge of engineering fundamentals. Engineering graduates should have the skills sufficient to: *1. Acquire knowledge of engineering fundamentals such as Mathematics and Science.* *2. Apply the knowledge of engineering fundamentals,* *3. Select and use proper tools and equipments for specific job / task,* *4. Access, analyse and apply skills and knowledge of sciences and engineering,* *5. Understand of principles of sustainable design and*

Code	Skills
	development.
EES8	**Knowledge of contemporary issues** Ability to continue learning independently in the acquisition of new knowledge, skills and technologies. Nowadays, the use of information, communication and computing technologies are very essential in the knowledge-based era. Engineering graduates should have the skills sufficient to: 1. *Continue learning independently in the acquisition of new knowledge, skills and technologies.* 2. *Use of information technologies,* 3. *Use of communication technologies in the knowledge-based era,* 4. *Use of computing technologies,* 5. *Read news paper.*
EES9	**Engineering system approach** Ability to utilize a systems approach to design and evaluate operational performance. Engineering graduates should have the skills sufficient to: 1. *Utilize a systems approach to design,* 2. *Evaluate operational performance,* 3. *Design systematically* 4. *Analyse engineering design* 5. *Demonstrate a knowledge and understanding of engineering system for management and business practices.*
EES10	**Competent in specific engineering discipline** Ability to acquire in-depth technical competence in a specific engineering discipline, competent in theoretical and research engineering and perform basic entrepreneurial skills. Engineering graduates should have the skills sufficient to: 1. *Acquire in-depth technical competence in a specific engineering discipline.,* 2. *Apply technical skills in a specific engineering discipline effectively,* 3. *Design and conduct experiments,* 4. *Analyse and interpret data,* 5. *Knowledge in multidisciplinary engineering.*

Sources: ABET, EAC Manual, MQA, DEST 2006, Engineers Australia competency standards, OSC Eng Occupational Standards, JABEE, Washington Accord 1989 and The Future of Engineering Education in Malaysia, 2007.

National and international engineering accreditation criteria have a set of graduates' attributes that require the engineering graduates to be able to demonstrate these attributes after completing the study. The development of attributes and skills for engineering graduates will definitely link to the national and international engineering accreditation requirements. The local and global framework of engineering employability skills have to be parallel to local accreditation criteria. The local accreditation criteria satisfy the international accreditation criteria. Table 3 shows how the accreditation criteria and the framework of engineering employability skills from local and international can link graduates to a employable and marketable graduates, locally and globally.

TABLE 3: INTERNATIONAL, NATIONAL AND FRAMEWORK

International Accreditation Criteria	National Accreditation Requirement	Framework	Result
ABET Engineering Criteria 2000 (USA) ***OSC Eng Occupational Standards (UK)*** ***Engineers Attributes (AUS)*** ***Employable personal qualities (Japan)*** ***Generic Employability Skills (UE)***	MQA EAC	MEES	Employable And Marketable Engineering Graduates

V. CONCLUSION

The overview of overseas literature on framework for engineering related skills in this study has identified a renewed interest in engineering-related employability skills. In the study, this framework has been referred to as *Malaysian engineering employability skills* (MEES). The proposed framework inline with the work that has been undertaken overseas, particularly in Australia, the United Kingdom, the United States of America, Japan and European United. MEES comprises the personal attributes, personal skills, and knowledge that are required by stakeholders/employers [1; 2; 7] to enable engineering graduates to enter workforce, and progress in career path. The term e*mployability* "signals a connection to the world of work that is dynamic and long-term in nature" [6]. The identified technical and nontechnical skills included in the framework are accepted as commonly applicable in the all area of engineering. Adoption of this framework can create future opportunities for new engineer to become professional engineer. This framework can be a guideline to new engineers and "come-back" engineers to become employable and allowing them to remain as a valuable employee all time. The framework can also help engineers to develop their career and move up within the organisation.

The framework can be used to explain the concept of employability to those new to the subject, and particularly to engineering students and their future employer. It will be a useful tool for lecturers, careers advisors, trainers, employers and any other practitioners involved in employability skills. It would be useful for further research in developing a model and a measurement tool for engineering employability skills. This paper contributes insights into the linking of graduate attributes, using national accreditation criteria and the framework of engineering employability skills from local and international expectation.

Data collection and data analysis is still ongoing but it is expected that in-depth analyses of the framework will yield more insight to the implications of these findings for practice and policy making. Of interest would be comparisons of employer expectation ratings on the important of employability skills attributes should be own by graduates with employer perception ratings on the satisfactory of employability skills attributes own by graduates they hired. Some of these implications include a better understanding of how employers' expectations compare with that of employers' perceptions, and the implications such understanding might have on education and training.

However, as knowledge, technologies and workplace processes keep on changed and improved, there will be a need for ongoing skills development in employees for emerging new occupations and changing skills requirements [4; 6; 7; 13]. Continuously studies and researches need to be done to suit in the changes locally and globally.

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