Global Accreditation for the Global Engineering Attributes: A Way Forward

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Abstract*: Engineering graduates today need to work within multicultural and multinational workplace environments with adequate professional attributes or competencies. In addition to the mandatory engineering (technical) capabilities, today's engineering graduates need to perform managerial, financial and other tasks in the workplace. The relevant literature on students' learning outcomes shows that graduates from university courses are not necessarily getting the skills and competencies that are required by industry or employers. The 'competency gap' between engineering graduate attributes and employers' expectations are elaborated in this paper using a case study of engineering graduates of Monash University. The paper also proposes a global engineering accreditation model to achieve global engineering competencies.*

Introduction

Institutions of higher education primarily aim to develop generalised measures of knowledge and skill outcomes for the student body. This being the premise, the expectation is that graduates of universities are ready at graduation for industry. The relevant literature on students' learning outcomes shows that graduates from university courses are not necessarily getting the skills that are required by industry. The literature suggests there is a lack of important skills such as communication, decision-making, problem solving, leadership, emotional intelligence and social ethics. The literature goes on further to elaborate that in a globalised work environment, graduates seem deficient in their ability to work with people from different backgrounds (Wellington et al., 2002). What seems to be evident from the research literature is that there is a mismatch between graduate students' skills during their studies and those needed in the workplace. This paper delves further into the alignment of graduate attributes to that needed in the engineering industry.

Graduate attributes

Graduate attributes are defined as:

> *'…the qualities, skills and understandings a university community expects its students to develop during their time at the institution and, consequently, shape the contribution they are able to make to their profession and as a citizen'*. (Australian Technology Network (ATN 2000))

> *'…the qualities, skills and understandings a university community agrees its students should develop during their time with the university'*. (Bowden et al. 2002)

It has been observed that universities are trying to produce graduates with the skills that are highly regarded by employers and are seen to add to the country's prosperity and social capital. In short, graduate attributes are examples of the expected attributes of graduates from an accredited programme (International Engineering Alliance, 2005). Several countries have already developed frameworks and/or guidelines for universities to clearly define, monitor and articulate graduate attributes in their curricula. In Australia, for instance, universities have nearly a decade of experience working with the concept of graduate attributes providing a framework of generic attributes for graduates (Commonwealth of Australia, 2007). Many universities have addressed or are addressing the importance of employability skills through their graduate attributes. Monash University, for example, is currently redefining its overall set of graduate attributes. Professional bodies such as the Accreditation Board of Engineering and Technology (ABET) and Engineers Australia (EA) are increasingly placing a high degree of emphasis on graduate attributes as outcome measures (Accreditation Board of Engineering and Technology,(ABET), 2007, Jolly, 2001, Engineers Australia, EA, 2008).

The recently published project report, initiated by the Business, Industry and Higher Education Collaboration Council (BIHECC) to review how universities teach, assess and report employability skills, presents recommendations based on an integrated approach that emphasises improved processes for identifying, developing, assessing and reporting on graduate employability skills (Commonwealth of Australia, 2007).

Engineering Graduate Attributes: Global Perspectives

It is generally accepted that engineering graduates need to be prepared for the increasing use of advanced and appropriate technology in their future workplaces. However as literature suggests there is a mismatch between engineering graduate students' skills during their studies and those needed in the workplace (Radcliffe, 2005, Wellington 2002, Patil, 2005). For example, the data collected in a report of the University of Manchester Institute of Science and Technology shows that careers of most engineers include managerial tasks although many remain in predominantly technological jobs. Furthermore the report summary states that most engineers' careers demand a variety of managerial skills and expertise, particularly in leadership and the management projects (Dudman & Wearne, 2003). Indeed, the workplace performances of engineering graduates have been a constant subject of criticism. A recent report on graduate skills and employability (inlcuding engineering graduates) published by the Business Council of Australia (BCA), for example, warns universities about falling behind in the ability to meet industrial needs. The report states that university engineering graduates were not skilled in essential engineering skills, such as, for example, simulation techniques (Maiden & Kerr, 2006).

In order to enhance the mobility and licensing of engineers, it is important to assess engineering design skills and associated elements of the professional engineer who is capable of working in the global context (Vohra & Kasuba, 2004). As a result, there is a strong need to include so called *Global* Competencies along with the *Hard* and *Soft* Competencies in engineering programmes, especially since engineering graduates need to work within multicultural and multinational workplace environments (Patil & Codner, 2007). The elements of essential global competencies defined by Patil and Codner (2007) are as listed below:

- Awareness of global political and societal issues;
- Understanding of cross and multicultural issues;
- Understanding of the globalised nature of engineering education;
- Knowledge of the international labour market and workplace imperatives;
- Understanding of the international business, economy and world market;
- Competency in applying engineering solutions/applications in a global context.

Identifying Competency Gap: a Case Study

As a case study, the employers' survey results on engineering graduates of Monash University are presented in this section. In May 2002, the institutional self-review *Still Learning* observed that "the university's monitoring mechanisms lack systematic feedback from employers about their perceptions of Monash graduates … an Employer Survey should yield valuable institutional information about graduate attributes and their relevance to employers' needs" (Monash University, 2002, p.16) and recommended that such a survey be developed. In 2003, the Centre for Higher Education Quality (CHEQ) developed and administered the inaugural Monash Employer Survey with the University's endorsement that this would be a regular monitoring activity to be conducted approximately every five years. The planned 2008 survey was brought forward to 2007 to provide input to the Review of Coursework being undertaken by the Education Plan Implementation Corp.

Methodology

A list of 23 graduate attributes was used in the survey derived from statements of Monash graduate attributes, key university documents, feedback from faculties and other Australian sources such as the Graduate Careers Council. Employers were asked to rate each attribute in terms of importance and their satisfaction with the extent to which each was demonstrated by Monash graduates they employ. The survey was administered over a four month period by specially trained staff.

Only employers who had recruited at least one Monash graduate in the past 3 years were contacted to complete the questionnaire. One hundred employers from various engineering related professions participated in the survey.

Key Findings

Figure 1 show the importance-satisfaction ratings based on a 5 point Likert scale, where 1 means low importance-satisfaction and 5 means high importance-satisfaction. The result generally shows that there is a significant gap in many attributes between the expectations of industry to what graduates bring to the work force. These findings could be applicable to other universities.

A gap analysis of the attributes demonstrates differences between importance-satisfaction ratings ranging from 0.02 to 0.65. The top ten areas that have the greatest differences of employer's expectations are reported in Table 1. The three highest differences were observed for 'oral communication skills', 'interpersonal skills with colleagues and clients' and 'written communication skills'. On the other hand 'Broad background general knowledge' and 'general business knowledge' showed the smallest gap between importance and satisfaction.

Discussion

The results of the employer's survey match the findings of previous research in that there seems to be skills that are lacking with university graduates (eg, Patil, 2005; Jones, 2007). The results also show consistencies in that the shortfalls are primarily in communication (item #1 and #2), problem solving (item #7), leadership (item #13) and social ethics skills (item #17) [See Figure 1 and Table1]. These results further suggest that employers also want to have application skills where graduates can work to make systems more efficient and improve on what they were doing. Many of the skills listed in Table 1 are essential skills that an engineering graduate should be proficient in after his/her courses at a university while others are the soft skills that make a graduate ready and efficient as an employee. Backing this premise is the research work which reports that there are few examples of the development of assessing professional skills, such as students' ability to evaluate and resolve ethical dilemmas, assessment of team skill development and project effectiveness, etc (Shuman, et al, 2005; Coates, 2007).

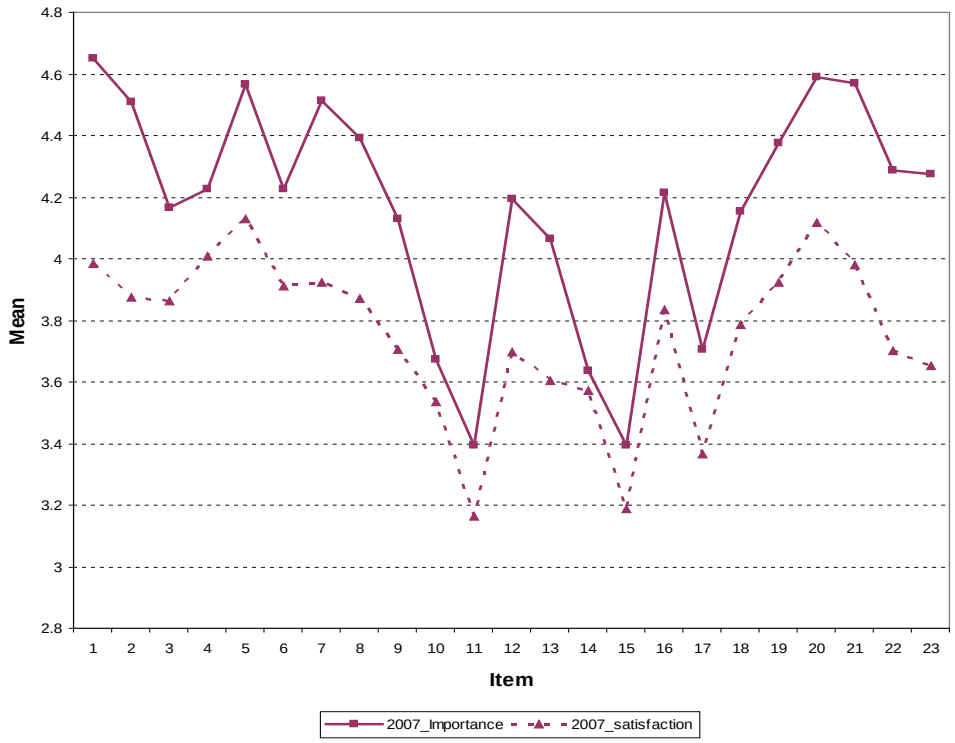

Figure 1: 'Importance' and 'Satisfaction' Means for 2007 Engineering Graduate Attributes.

The global employment has placed a new attribute found to be essential for engineering graduates, this being the ability to work in a multicultural work environment. Rojetier (2005) reports that cultural awareness and diversity are required attributes for effective engineering practice. The results of this survey also highlight this as an issue though not listed by Australian employers in the top 10 attributes that most need attention.

Table 1: Gap Analysis of Engineering Employers Perception of Attributes.

Rank	Item No	Attributes	Mean		Gap (I - S)
			Importance (I)	Satisfaction (S)	
1	1	Oral communication skills	4.57	3.92	0.65
2	21	Interpersonal skills with colleagues and clients	4.56	3.99	0.57
3	2	Written communication skills	4.38	3.83	0.55
4	7	Capacity to analyse and solve problems	4.58	4.04	0.54
5	13	Ability to develop new or innovative ideas, directions, opportunities or improvements	4.17	3.72	0.45
6	22	Time management skills	4.07	3.62	0.45
7	20	Capacity for co-operation and teamwork	4.60	4.16	0.44
8	8	Ability to apply knowledge in the workplace	4.33	3.91	0.42
9	23	Ability to cope with work pressure and stress	4.03	3.63	0.40
10	5	Capacity to learn new skills	4.60	4.22	0.38

The results of the employer survey suggest:

A. there is a need to have a clearer understanding of essential generic and professional attributes of graduates to ensure quality in higher education, and,
B. that universities in general have to work hand in hand with industry so that graduates are better equipped for the work force.

Graduate Attributes through Quality Assurance

A literature search shows evidences of surveys of industry perceptions of engineering graduates for both technical and non-technical skills and attributes. Most of these studies (including the study presented in this paper) have consistently identified communication, interpersonal and teamwork attributes are important competency gaps (Lang et al. 1999, Meier et al. 2000, Scott and Yates, 2002). Research study has been also carried out at the University of Cape Town in South Africa to investigate engineering graduates' perception about their readiness at work (Martin et al. 2005). This study reveals that engineering graduates are well prepared for industry with adequate expertise in technical skills however they identified their weaknesses in other important skills such as; working in multi-disciplinary teams, leadership, practical preparation and management skill.

In engineering education, it is important to investigate essential graduate attributes and also to identify competency gaps. The next important step is to integrate these attributes in the whole of educational process cycle and to monitor the results at the output part of the cycle. The important steps towards producing engineering graduates with adequate skills and attributes for the needs of industry are as below:

A. Identify and integrate the desired attributes in the programme
B. Check whether graduates have achieved the desired attributes?
C. Cross check the achieved outcomes meet the needs of industry/employers?

Integration and Evaluation of Graduate Attributes

Professional accreditation bodies along with industry and educational institutions can identify, define and set the desired graduate attributes for educational programmes. For example, Engineers Australia has defined and set the following graduate attributes for accrediting undergraduate engineering programmes.

- *ability to apply knowledge of basic science and engineering fundamentals;*
- *ability to communicate effectively, not only with engineers but also with the community at large;*
- *in-depth technical competence in at least one engineering discipline;*
- *ability to undertake problem identification, formulation and solution;*
- *ability to utilise a systems approach to design and operational performance;*
- *ability to function effectively as an individual and in multi-disciplinary and*
- *multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member;*
- *understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development;*
- *understanding of the principles of sustainable design and development;*
- *understanding of professional and ethical responsibilities and commitment to them; and*
- *expectation of the need to undertake lifelong learning, and capacity to do so.*

(Engineers Australia, 2006)

Global Accreditation Model

The desired engineering graduate attributes from the educational programme outcomes without doubt must be 'global' therefore, it is pertinent to design and apply 'global accreditation criteria' in the sense, the accreditation process will evaluate engineering programmes with the graduates acquiring adequate 'global engineering attributes'. There is an increasing need for designing global engineering professional criteria for accrediting engineering programmes which will foster enhancement of the global mobility and licensing of engineers. Several international consortia or signatories in engineering education are consistently emphasising common or comparable accreditation outcomes to facilitate professional mobility at the global level. The Engineers Mobility Forum, for instance, along with the Washington Accord signatories, developing an alternate route to the International Register using competency assessment (International Engineering Alliance, 2008).

At an institutional level, universities are working strategically with research findings and collaboratively with industry to make changes in attributes needed at the workplace. For example, Monash University in Australia has recently started a new Leadership program to equip engineering students with the desired technical and non-technical skills required to be the next generation of engineering leaders (Monash University, 2008). This program also broadens the traditional skills base of engineers. In another example, the University of Queensland has implemented a Project Centred Curriculum in Chemical Engineering (PCC), to engage students with realistic and relevant experiences that demand the integration and practice of desired engineering attributes in contexts that the students find meaningful (Crosthwaite, 2006). However, all these approaches and initiatives are very limited and slow and need a broader approach across the engineering education area.

Conclusion

The 'competency gap' between engineering graduate attributes and employers' expectations are outlined and described using a case study of engineering graduates of Monash University. Most of the research studies (including the Monash University case study) have consistently identified communication, interpersonal and teamwork attributes are important competency gaps. Due to the multi-dimensional (global, multicultural, multilingual, etc) workplace nature of engineering profession, engineering graduates need to acquire adequate 'global' competencies from the educational programme outcomes. As a result, there is a need for a Global Accreditation Model for ensuring consistent standards in engineering education. The implementation of such a model will assure uniformity in the engineering accreditation process with a systematic and scientific application of accreditation criteria and assessment for undergraduate engineering programmes. Most importantly the Model should result in better graduate outcomes by fostering adequate learning processes since it comprises all essential parts of the educational cycle (Patil and Codner, 2007). This model will provide a common framework of standards for engineering accreditation in the global context.

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