Competencies required of industry-based-learning students

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Structured abstract

BACKGROUND
The Industry-Based Learning Program (IBL) at our University is an optional program available to local undergraduate engineering students at the end of 5 or 6 semesters of study; where IBL placements are paid, full-time placements for 6 or 12 months. The placements are intended to provide engineering students with the opportunity to develop technical, professional engineering skills and non-technical skills. Feedback from companies and students at the end of IBL placements indicates that although the placements are of benefit to the host organisation and the students, the students do not always have the generic work-ready non-technical competencies required by graduate engineers. These include soft skills such as communication and leadership skills, and application of theory to industry. These lack of soft skills often results in a greater mentoring effort required by host company supervisors. It is then considered important to align appropriate undergraduate generic skills and attributes to ensure that they are work-ready at the student engineer level.

PURPOSE
The purpose of this work was to determine generic competencies required by industry of undergraduate students.

DESIGN/METHOD
A post-placement evaluation survey was conducted amongst 63 host IBL organisations to determine the undergraduate work-readiness and associated competencies of IBL students. Likert-type data were collected and analysed to establish a baseline of required company competencies for work-ready IBL students.

RESULTS
The fundamental outcomes of the company responses were that students were adequately trained in professional technical skills, but required additional soft skills development such as communication and leadership skills, and interpersonal relationships in the workplace. The results from the companies were similar to those required for EA Stage 1 generic competencies for graduate engineers in the workplace.

CONCLUSIONS
Outcomes of the study showed that there needs to be more focus in our undergraduate courses on developing industry required generic soft skills, especially for student engineers. This focus needs to start at the commencement of first-year and continue into each and every subsequent year to ensure that the students are work-ready at critical stages of their undergraduate learning.

KEYWORDS
Competencies, industry based learning, intern, work-ready, work-integrated learning, soft skills.

Introduction

Industry or workplace competencies describe the skills, knowledge and behaviors students will need to be successful as engineers. Work integrated learning (experiential education, co-operative, sandwich, and internships) is common in the UK, and Canada (E4E, 2011) and is vital to the development of engineering students as practicing competent professionals. The industrial workplace is one of the best places for students to develop and demonstrate workplace competencies (Brumm, Hanneman, & Mickelson, 2005; Clements, Hays, & Appleby, 2012; E4E, 2011).

An early study of competencies required of employees, Young (1986) found that interpersonal skills, work attitudes, communication skills, thinking, and problem solving were most important for new graduates, but highly specialized technical skills were not required for entry-level jobs. It was expected that graduates would develop these skills in their on-the-job involvement or from their own initiatives.

Nearly thirty years later, these skills have evolved into what is commonly termed "generic competencies" (ABET, 2013; Engineers Australia, 2012a). Consequently, recent initiatives in engineering education have developed learning outcomes based on sets of competencies required by graduates to work effectively within an industrial environment. The rationale for their formulation was the requirement by industry or accreditation bodies to define a competent engineer. An assortment of generic skills were identified by ABET (2013) as being appropriate for a competent engineer, and similar skills have been defined by Engineers Australia (2012b) as being required of graduate engineers and further enhancement of these skills for "mature" engineers (Engineers Australia, 2012a). Moreover, the UK (QAA, 2010) has developed a "subject benchmark statement" to produce generic statements describing expectations of the standards of a graduate engineer based on threshold levels they would attain. All three accrediting bodies determined the learning and working outcomes as a consequence of the educational framework. In each bodys' statements, the formulation of a competent engineer influenced the training program and facilitated the development of non-technical aspects of academic and professional competencies of the students (Woollacott, 2007). In addition, Spinks, Silburn, and Birchall (2006) undertook surveys of engineering employers which showed continued/ongoing gaps between employer expectations and graduate professional attributes.

While there has been significant focus on graduate work-readiness and graduate competencies over a period of time (Busse, 1992; Young, 1986), there has been limited research conducted on undergraduate work-readiness and undergraduate generic competencies for student engineers in the workplace. There is a gap in the competencies required of engineering undergraduates employed in industry. In particular, work-readiness of student engineers involved in an Industry Based Learning (IBL) program instigated by our university requires a set of competencies which may be different to those required of graduate engineers. IBL is an optional Work-Integrated Learning (WIL) program which is available only to domestic undergraduate engineering students, usually between semesters 6 and 7 of full time study for either single degrees (comprising 8 semesters) or double degrees (comprising 10 semesters). The IBL placements are paid, full-time placements for 6 or 12 months, and are intended to provide engineering students with the opportunity to develop technical skills, professional engineering skills, and non-technical skills. However, these skills do not necessarily form a set of threshold competencies at an undergraduate level.

Within the industrial workplace, employers need different measures to use when recruiting and training not only new engineering graduates but also undergraduate engineering (intern) students. Competencies fulfill this need by focusing on what the (student) engineers can do with their knowledge and training. Graduate generic competencies evolved over many years and are outcomes from numerous studies involving hundreds of representatives from industry and academia (Male, 2010; Male, Bush, & Chapman, 2011). In that review, gaps were identified between competencies developed during the undergraduate education experience and the competencies needed for working in engineering (Male & King, 2013). The outcomes of that work proposed the need for a review of education content to improve generic engineering competencies. Further studies by Male and King (2013), forming part of a project “Enhancing Industry Engagement in Engineering Degrees” initiated by the Australian Council of Engineering Deans, identified examples of “effective practice” including both an internship program in an Australian university and an internship program with industry. This format of internship or industry based work was also recently the subject of an Australian Technology Network of Universities (ATN) statement for “political action towards a national internship (IBL) program” (Thomson, 2013) and was in response to a recommendation “to increased use of work-integrated learning such as internships and cadetships” in the *Economic Action Plan for Enduring Prosperity* released by the Business Council of Australia (Business Council Australia, 2013).

Anwar et al (2012) developed a series of workshops for second year Civil engineering surveying students to develop learning outcomes and to map them to their graduate attributes. The results of that workshop showed that the content could be used as a learning platform for graduate attributes for the engineering cohort. However, there was little emphasis on work readiness competencies of undergraduate engineering students, e.g. in IBL (a form of “sandwich” study).

In a comprehensive study by Brumm et al. (2005) and WIL programs were considered to be an “excellent mode to observe and measure students developing and demonstrating specific competencies whilst being involved in the engineering profession.” The evaluations made by employers of student competencies (which are defined by the host educational institution) present an excellent opportunity for feedback and, if appropriate, curricular change which can address evolving employer needs or expectations. This was the approach taken in the current work. There is no such data available for Australia, where sandwich type courses e.g. IBL, cooperative, sandwich, work integrated learning, are not yet common (Business Council Australia, 2013). The benefits associated with such sandwich courses include improved work skills, enhanced employment prospects, and the opportunity to experience “work involvement”, and have been recognized as having a significant positive effect on students’ academic performance (E4E, 2011).

The study reported here is the first part of an investigation of generic undergraduate engineering attributes (GUEA). These GUEA are skills and competencies which are important to students in all engineering disciplines. It is vitally important that engineering students be given real (not simulated) industrial experience so as to be intimately involved with industrial experiences although not specifically industry-based.

Research Question

To explore the issues discussed previously concerning undergraduate engineering student competencies, the following research question was developed: what are the generic competencies required by industry of undergraduate engineering students?

The contribution of this work concerns an examination of industry requirements of student competencies and how they may relate to the undergraduate curriculum. The investigation of required competencies and skills is part of the student transition process from university to industry and the workplace, and how they relate to graduate skills and competencies. This work focuses on the perceived skills of students and their development as determined by employers.

Method

Participants

The goal of this initial study was to empirically determine employer required competencies and how students developed them during their time of employment. Skills and competencies which were important for IBL students to have on commencement of a placement were identified from company discussions and reflections, in an informal environment. A post-placement evaluation survey was conducted amongst 63 host IBL organisations to determine the undergraduate work-readiness and associated competencies of the IBL students. The survey was conducted through an online portal once the student placement had been completed and all IBL host companies participated. All respondents were experienced engineers to ensure the relevance of competence concepts for engineering, so as to bridge the gap between competencies developed in education and those required of the student engineers by industry. The host organizations of varying sizes included both private and government departments, and represented a variety of industries including manufacturing, consulting, design, and medical.

The IBL cohort comprised 61 male and two females from four engineering disciplines, viz. 38% Civil, 36% Mechanical 17% Robotics and Mechatronics, and 9% Product Design students.

The Survey Details

Listed in Table 1 are the 15 survey questions concerning employers' perceptions of student abilities and competencies (IBL students' skill growth), where the responses were Likert-type (Crowther & Lancaster, 2012), classified as 1=high growth; 2=some growth; 3=no growth and 4= not applicable. In addition, three open ended questions were asked, i.e. "…is further development required?" " …what are the strengths of the student?", and "… is additional employment offered?"

Table 1: Company Survey Questions- IBL students' skill growth*

Professional skills	Problem solving skills, initiative & resourcefulness	Flexibility and adaptability to change
Technical Skills	Planning and organisational skills	Independent learning skills
Ability to apply academic studies to professional practice	Communication skills	Innovative and entrepreneurial approaches
Self –awareness and reflection	Teamwork skills	Openness to feedback
Professional values and ethics	Leadership skills	Awareness of different environments

*High growth means that the student experienced a significant and observable change in the attributes listed, and also indicates that the student came in with no or low competence in those particular areas. 'Some growth' indicates that the student improved to some extent in terms of observable behaviour and implies that the student already demonstrated competence in those particular skills. 'No growth' indicates that the student's base level of skills did not improve.

Company satisfaction with the IBL program was also surveyed, and the relevant questions are listed in Table 2. These questions were also based on Likert-type approaches, where the responses were; 1=totally satisfied; 2=satisfied; 3=neutral; 4=dissatisfied, and 5=not applicable. Additional free response questions reflected the industries' perceptions of: strength of the IBL program; aspects of the IBL program needing improvement; and willingness to participate in the IBL program again.

The resulting data was collected and analysed to establish a baseline of required company perceptions of student abilities and their satisfaction with the IBL program

Table 2: Company Satisfaction with IBL program

University's preparation of the students for the workplace	Supervisor visit to the workplace	Value of IBL program to the organisation
University's placement process	Support, advice and response from IBL staff	Overall satisfaction with the IBL program

Results and Discussion

The results of the Company Survey Questions- IBL students' skill growth are shown in Figure 1, indicating that areas of *high* growth required by students (i.e. those skills and competencies in which the IBL students were lacking when entering the workforce, as assessed by industry supervisors) were primarily professional skills. The skills which were considered to only require *some growth* were those already possessed by the students.

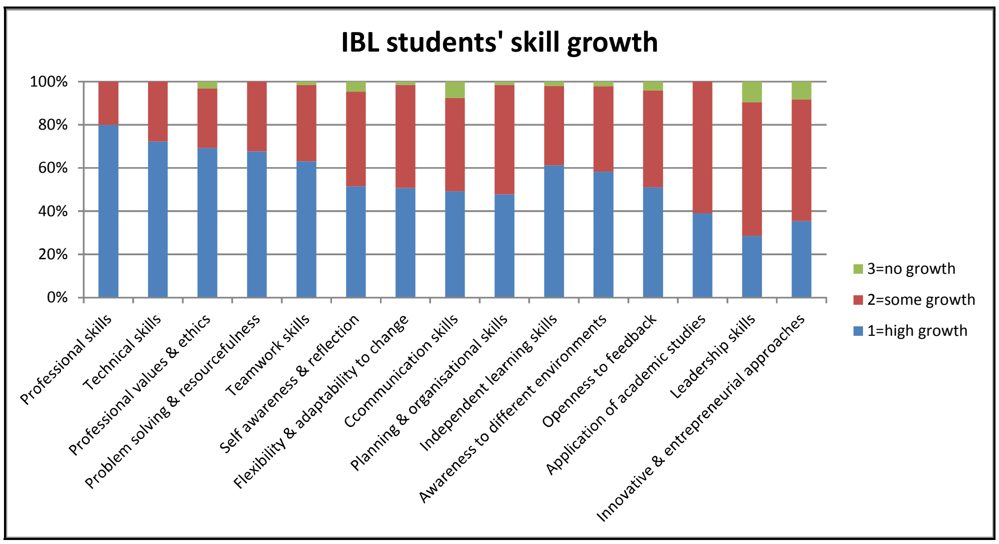

Figure 1: Company perceptions of IBL students' skill growth

Student competency areas which experienced *some* growth included leadership skills, the application of academic studies to professional practice, and planning and organisational skills. Whilst the organisations participating in the IBL program were aware that the students were still undergraduates with generally either one or two years of study remaining, their expectations of work-readiness were the same as that of graduates – undergraduates are expected to display competence in both the technical aspects of engineering but also in the non-technical or 'soft' skills (Brumm et al., 2005; Maddocks et al, 2002; Passow, 2007, 2012).

There were no significant differences in employer perceived skill growth across the engineering disciplines or industries covered, indicating that generic competencies were indeed generic across disciplines and amongst industries.

These results strongly support the evidence found for graduate engineers that the so-called 'soft skills' such as teamwork, communication, professional approach were as important as technical skills and problem solving, and these skills were also significant to IBL student engineers (DeClou, Sattler, & Peters, 2013; Male et al., 2011; Passow, 2012). These undergraduate student engineers (interns) have not had significant exposure, either academically or in practice, to the range of interpersonal, communication and management skills which were deemed to be important by employers for graduates. It appears that employers were willing to provide on-the-job- training to assist the IBL students in their overall development as an engineer. This situation is further evidenced by the number of employers offering positions to the students either whilst they are continuing studies or post-graduation employment. Of the 63 IBL students, over 50% were offered ongoing employment on a part-time basis whilst completing their studies, and a further 15% were offered employment to commence after graduation. These offers were made whilst the students were on placement.

The overall outcomes from industry supervisors' perceptions of the IBL students' skill growth indicated that students required further development in both technical competence and professional expertise during the industry placement, which is a reflection on the undergraduate status of the students, and the situation where they may not yet have been exposed to the appropriate professional expertise required by industry. The major strengths which most students had on entering the work placement were their willingness to learn and take on new challenges.

Satisfaction results with the IBL program are shown in Figure 2. Of the 63 companies, 38 were totally satisfied, and 25 were satisfied, no companies rated the program negatively. Moreover, 45 respondents indicated that the IBL program was considered of value to the organisation (with a rating of 'totally satisfied') and 17 indicated that they were satisfied with the contribution of the IBL program to their organisation, even though the undergraduates did not have the technical skills expected of graduate engineers.

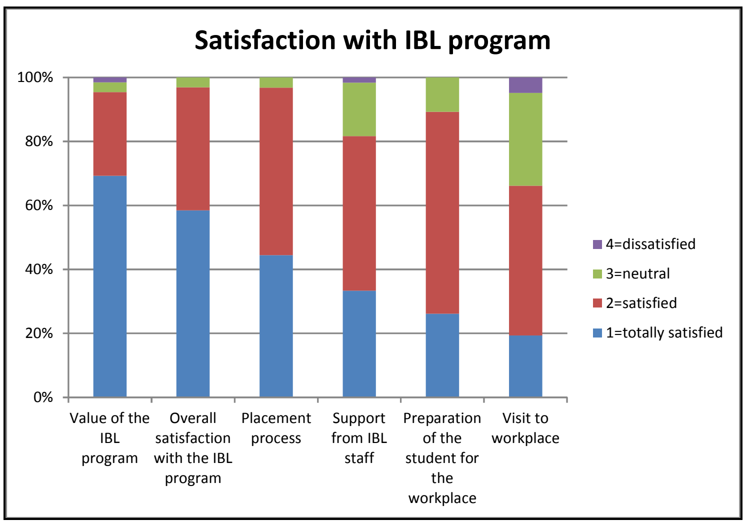

Figure 2: Company Satisfaction with the IBL program

Comments from employers about the strengths of the IBL program included:

"provision of workplace experience for the student and the opportunity to groom participants for potential full time roles within the company"

"win-win situation for both the student and the employer. There is not a better opportunity for the student to gain inside industry knowledge and professional experience of a real workplace."

Whilst remarks from employers about IBL program areas requiring improvements included:

"student preparation by both the University and the host"

"humanities subject to get (sic) the student candidates more confidence"

"giving students exposure to real world experiences and design problems"

Over 90% of companies were willing to participate in the IBL program again with a selection of observations, including:

“yes-immediately. Past several years have been very successful; several have returned after completing their studies”

“yes- long term; the quality of the students is a credit to the university”

“yes- our organisation has participated in the IBL program for a number of years and will continue to do so”

Students’ high growth in key competencies indicates that a high level of mentoring, guidance, and supervision is required by supervisors. This situation may continue far longer than originally anticipated, and is of benefit to the student, and which may add to the cost of employing IBL students.

The IBL program is seen by employers as an area where they were prepared to put in the effort to contribute to the technical and professional development of future graduates; and as a way of ‘test driving’ future employment prospects.

Conclusions

Students entering the workforce as IBL interns do not have all the competencies of graduate engineers. Companies recognise these shortcomings and are willing to mentor the students to achieve their full range of skills and competencies to be able to function as graduates. Students are lacking in both some technical skills and soft skills. Although technical skills and problem solving is integrated into the undergraduate engineering course, there needs to be more focus in our undergraduate courses on developing the soft skills especially for student engineers. This focus needs to start at the beginning, in first-year and continue into each and every subsequent year to ensure that the students are work-ready at all stages of their undergraduate learning to enable them to graduate with a full set of skills and competencies.

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