Data-Mining work experience reports

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SESSION

C1: Integration of theory and practice in the learning and teaching process

CONTEXT

As part of their work experience students are required to complete a 6000 word report. In addition to description of the work performed students are asked to describe three skill areas (from a list of seven) which have been most developed, to comment on the professional context of their work, to reflect on their studies and to make suggestions for changes to the degree program.

PURPOSE

The aims of this study were to mine the wealth of information which students record in their final year work experience reports, to collate the data and use it to make improvements to the educational experience of students, to make more effective integration of the practical experience into the degree, and provide the school with enhanced industry contacts.

APPROACH

407 student reports covering a period of 5 years were reviewed both qualitatively and using algorithmic text mining. Available pdf files were converted to text files and the text scanned to determine frequently used words and phrases. Statistics of the areas where students were engaged, the skills most exercised and differences between local and overseas experiences were obtained. Particular attention was given to identifying areas where students were poorly prepared.

RESULTS

The free form of the student reports presented challenges in extracting consistent and meaningful data. Nevertheless, statistics were developed showing which sectors of civil engineering were employing most students, and of the skills most required. It was noted that within Australia communication skills were seen as very important, whereas for students doing work experience overseas design was the main skill used and communication the least. For all students professional conduct and teamwork skills were significantly enhanced.

CONCLUSIONS

It is recommended that a revised web based report be developed to enable more thorough and reliable statistics to be obtained, that greater efforts be made to coordinate student and employer expectations and to enhance student workplace readiness. Skill areas where students reported the most challenges were in information seeking, teamwork skills and professional communication, and it is recommended that these be better addressed in the preparatory programs.

KEYWORDS

Work experience, Generic skills, Work readiness

Introduction

Work experience is integral to all engineering programs in Australia, and it is considered important and valuable by all stakeholders: students, industry and academics (King, 2008). Currently Engineers Australia requires industrial training as part of any accredited engineering degree, with this usually taking the form of 12 weeks' full-time work. Although the benefits are widely agreed upon there appears to have been little academic study of the benefits of work experience in engineering within Australasia apart from a report on a newly developed program in computer engineering (Pauling and Komisarczuk, 2006). There is anecdotal information that suggests students are finding it harder to acquire quality experiences, employers report being overwhelmed by applications, and increasingly work experience is being unpaid. As noted by King (2008) the challenges involved in finding work experience lead to a small, but growing number of students not completing their work experience until after their academic studies are finished, resulting in delays in graduation and also an undesirable lack of integration of the experience with their studies. At the same time the government is introducing more obligations on universities to ensure the quality of work experience, particularly where this experience is integrated with the degree. There is a general movement in higher education towards greater use of Work-Integrated Learning (WIL) as it is considered to have many benefits and a good theoretical base (Orrell, 2011).

There are a range of requirements for successful WIL recommended by Orrell (2011). At an institutional level these include a clear understanding of the purpose, value and expectations together with appropriate resourcing and integration with university support services. From an educational perspective students need to be prepared for the range of required tasks and expectations of employers, they need to be challenged and be given responsibilities and be provided with an opportunity for reflection on practice that is supported by the university. Finally strong relationships and effective communication between the university and the industry partners are required. In addition, it has been suggested that students need workplace experience during their studies to properly understand the importance of ethical practice and of going beyond simple compliance.

The wide range of companies and roles that graduates fulfil in those companies also presents difficulties for universities in providing the resources and support needed for really effective work experience and in providing clarity of expectations. For example over the summer break in 2015, approximately 150 students from the School of Civil Engineering at the University of Sydney were undertaking work experience and this was with about 80 different employers.

In response to some of the challenges mentioned above universities are adopting creative solutions to ensure students are able to benefit from greater knowledge and understanding of industry practices. These include formal industry based programs, cooperative education schemes, increasing use of industry projects, site visits (may be virtual) and the use of industry professionals as course lecturers. Currently these initiatives are adding to the 12 weeks full-time work. However pressures to graduate and ensure quality are leading to universities considering more formal instruction and a reduction in time spent in industry.

A further significant concern for the students and ultimately for the success of work experience is that increasingly students are accepting unpaid positions to enable graduation. While this may be acceptable for short periods of experience, 12 weeks without pay will create hardships for many students who often rely on casual jobs to support them through university studies. Work experience that is valuable and improves a student's job prospects would justify taking on an unpaid position, but the data on outcomes from unpaid work experience are mixed (Oliver et al, 2016).

Another issue is the increasing number of international students, all of whom are required to obtain work experience. At present this is largely occurring in their country of origin as Australian employers are reluctant to take on international students as there is little benefit in

it for them. Perceived issues include language difficulties, lack of cultural understanding and visa limitations that prevent subsequent employment. British studies (Milburn, 2009) have also reported the exclusion of minorities and poor treatment of international students during work experience. It has been suggested that there is a significant national benefit to be obtained by giving international students Australian work experience.

In addition to these specific concerns, work experience has the potential to facilitate communication between employers and universities and to provide input into curricula. Traditionally engineering employers valued graduates for their technical knowledge and intellectual capabilities. However, there is now increasing emphasis on good interpersonal skills, practical work experience and commercial understanding. For universities the requirements for the latter has led to a reduction in the engineering science content of the courses, but the question of where and how the skills that make graduates work-ready are best developed is not resolved.

For all these reasons a better understanding of the nature and value of work experience of engineering students is required.

Context

At the University of Sydney both undergraduate and professional masters course engineering students are required to complete a zero credit point subject practical experience. Currently the subject has prerequisites which results in the practical experience generally occurring when the students have one year of study remaining. Students are expected to find an opportunity through their own efforts, and after 12 weeks or 420 hours of the experience to write a 6000 word report summarising their experience. The intention of the report is to get the students to reflect on the experience, its connection to the course, and the skills required of graduate engineers. They also have an opportunity to comment on their studies. At present the reports are only reviewed by the student's final year thesis supervisor and receive a simple pass/fail mark. Provided that the students have followed the prescribed headings and written in reasonable English, the reports are passed and no further action, such as providing feedback, is taken.

For several years the reports have been submitted electronically, stored and forgotten. This data resource contains information on the students' experience in terms of the skills and types of work. The majority of students report that the most important skills are related to communication, effective teamwork, information-seeking and use of IT. While academic staff feed this information back to the students, the value of building skills in these areas does not appear to be fully appreciated by the students until work experience. The data resource of past reports provides an opportunity to feed-forward this information using the student feedback. Also, the resource contains data from the whole cohort of how they value the course and has suggestions for possible improvements and innovations. There are obvious benefits to capturing and aggregating this data.

This paper provides the outcomes of a preliminary project which aimed to tap into this resource of information. The procedure used to mine the wealth of information which students record in their final year work experience reports is described and the data collated and discussed. From the results some suggestions are made to improve the educational and practical work experiences of students.

Review of Work Experience Reports

Process

407 work experience reports (WERs) submitted by prospective Civil Engineering graduates were surveyed from the periods 2010-2012 and 2014-2015. The reports were analysed by an algorithmic text-mining method to quantitatively gauge the type and extent of the skills

exercised by the students and the type of work undertaken. The methodology was based on an assessment of the frequency of occurrence of selected indicative words and phrases. This was achieved by extracting text files from the stored pdf files and processing these in a Matlab environment to identify the relative frequencies of targeted terms within the reports and the distribution of these frequencies overall. The quantitative algorithmic analysis was supported by the manual examination of individual reports to provide further understanding of the issues identified and a deeper insight into student experiences. In particular, the identification of the key skills most exercised and developed was extracted from students' answers in the 'Graduate Outcomes Table, Assessment of Learning Progression' forms, attached to individual reports.

The skills that were searched for were in the seven areas specified in the list of graduate attributes provided to assist students in writing their reports, namely:

- Design
- Engineering/IT specialisation
- Maths/Science Methods and tools
- Information Seeking
- Communication
- Professional conduct and teamwork
- Project management.

Data Summary

A majority of the work experience was undertaken by graduating students within Australia (76%) with 19% undertaking work experience in mainland China and the remainder across various other countries, all in the region of far-eastern Asia.

Most Exercised skills

With relation to the graduate outcomes, the skills students reported *most exercised,* shown in Figure 1, were: communication (42% of students), design (33%), and professional conduct and teamwork (28%). A notable discrepancy was observed in the trends of skill usage between students having conducted their experience overseas (predominantly China) and those having undertaken work experience in Australia. In particular, students having undertaken work overseas were more likely to report the Design, Maths/Science Methods and Tools and Engineering/IT specialisations as being more exercised and/or developed. In contrast the key skill of communication, which emerged as the most exercised skill overall was not significantly exercised in international work experience.

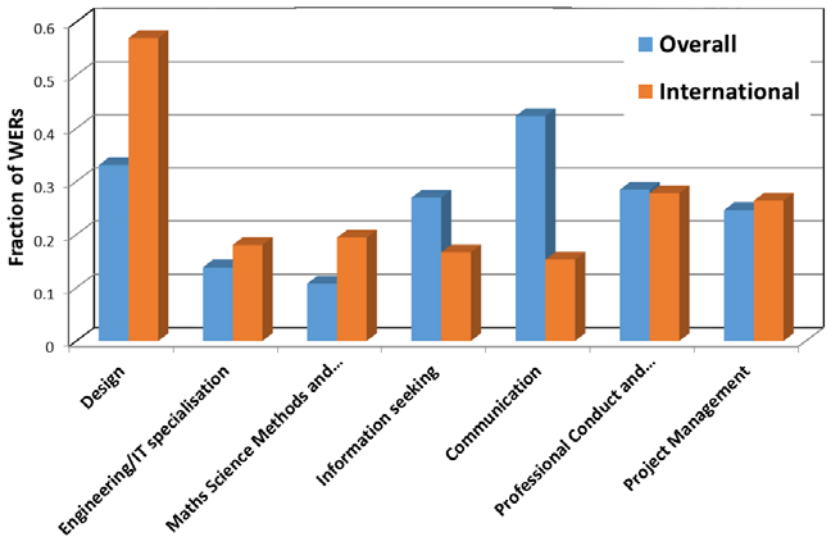

Figure 1: Most exercised skills

Most developed skills
A similar breakdown of data has been obtained for students' reports of skills *most developed*. It should be noted that not all student reports specified *skills developed* as separate to *skills exercised*. From an analysis of these data, communication and information seeking are most developed, with respectively 57% and 37% of students identifying these skills as having been among the most developed during their work experience. From a comprehensive review of student reports a notable observation is the lack of preparedness of students with regards to communicating with staff and managers across the various levels of hierarchy in the host organisation. However, the student experience is generally portrayed in a positive aspect with respect to these deficiencies and it is more common to encounter sentiments of achievement and professional development rather than conflict and friction arising from deficiencies in these attributes.

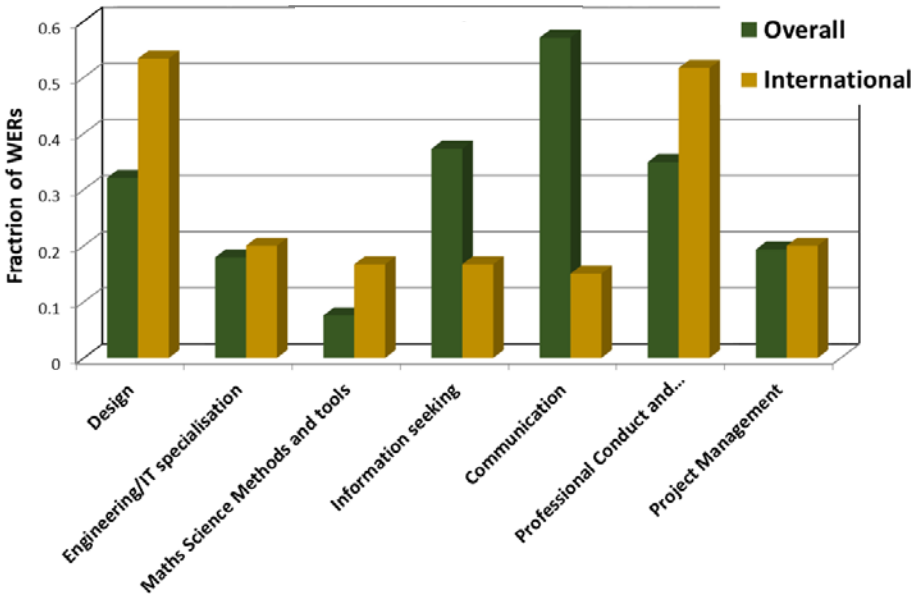

Figure 2: Most developed skills

Unexpected Outcomes
One interesting outcome of the work experience relates to the acquisition of practical experience in their chosen sector and the development of new insights into the various aspects of the field (*i.e.* "tricks of the trade"). In particular this relates commonly to "soft skills" not developed in their degree program. This finding highlights the importance of work experience and suggests that there would be benefit in including industry professionals in teaching and curriculum design within the earlier years of the degree, particularly in specialist civil streams.

Another finding was that work experience often led directly to the commencement of a career. Approximately 15% of students reported the possibility of ongoing employment arising from their work experience. These career opportunities involve either continuing part-time employment during their final year of study and/or opportunities for employment subsequent to graduation. It should be noted that self-employment was not reported by students, suggesting that the work experience is insufficient for students to consider entrepreneurism or independent career paths.

Analysis of the key skills

Communication
A high number of students identified *communication* as being the most important skill exercised and developed during practical experience. This was expressed as being most

important to develop as well as being the most common source of difficulties. For example, many students reported that asking for help and clarification regarding workplace duties was likely to cause disharmony.

Scope of Work
From numerous WERs, a varying degree of misalignment is evident between student and employer expectations in areas including the scope of the students' role, skill level, work activities and outcomes. This may derive in part from a lack of preparation on behalf of both students and the industry hosts prior to the commencement of work experience. This can be ameliorated by better preparation of the students by the University and by providing better information to the employers.

Task Related Skills
As a significant subset of the mismatch in expectations, it was in approximately 10 % of cases, reported that students were unprepared to carry out the technical tasks expected of them at the commencement of work (for example: modelling, management and site inspection duties). However, in a clear majority of cases, these initial difficulties were resolved, leading to positive learning outcomes rather than ongoing difficulties. In a few isolated cases skill deficiencies resulted in negative student experiences, in particular when accompanied by poor communication.

Teamwork and Interpersonal Conflict
Teamwork and dealing with the wide range of construction industry personnel was a concern for many students who reported friction in dealing with colleagues. This can be considered a distinct subset of the required professional communications skills. In particular conflict with construction labourers appeared to occur with not insignificant frequency. The teamwork experiences of students in their undergraduate degree had not prepared them for the full range of possible work-colleague situations that they might find themselves in. It is difficult to replicate this range in the course-work subjects, but some exposure to the full range of work-colleagues (and not just professional engineers) might help students adjust their expectations.

Sourcing Information
Students identified information seeking as a key attribute exercised (27%) and developed (37%) during their work experience. Across all civil engineering sub-disciplines and sectors, students reported encountering difficulties in acquiring and processing large volumes of information from sources such as work reports, standards and various technical documents. These are skills which can easily be included in the undergraduate curriculum. Information-seeking skills, such as internet finding and filtering, should be part of any undergraduate's toolkit and resources are usually easily available through the university librarians and archivists.

Student observations

Student growth
The work experience, by and large, caused the students to readjust their understanding of the multitude of aspects in the engineering profession, with most appreciation coming in the areas of risk management, client liaison, teamwork, communication, protocol development, documentation and reporting.

Student Career Intentions
Most students reported satisfaction with their current path and career intentions, though a sizeable minority expressed some re-assessment of their career plans. A similar scenario is encountered with respect to academic direction, with varying degrees of self-evaluation by students.

Degree reflections
Students reported the following recommendations/criticisms of their degree:

- Many (~8%) report a view that a greater emphasis should be placed on design education rather than mathematical calculations.

- The need for some teaching of AutoCAD software is frequently mentioned.

- More emphasis should be placed on acquiring job-relevant skills in the framework of their academic studies. The reports frequently mention the need for a greater emphasis on practical work and workplace-focused situations. Conversely a significant number of students reported that they would like to make changes to syllabi to emphasise the more academic aspects of the degree, as these theoretical aspects are less accessible through workplace based development.

While these results are insightful, more quantitative data would be required before any remedial action should be suggested or implemented.

Recommendations

The results of the data-mining available to this current research do not lead to incontrovertible findings, however they can be said to be indicative of what may be expected by further and better designed methods. With this in mind the following recommendations are presented:

1. Presentation of the final (6000 word) report should include a significant amount of form-based and on-line information. If well-designed, this could lead to an easily analysed database which could lead to the implementation of better preparation and experience for the students' work placement.

2. Coursework-based modules should be introduced in the UG program to better prepare students for their work placement experience. These could include the following breakdowns:

    a. Module: Communication skills, which would include:

        i. Professional workplace communication.

        ii. Effective and valuable communication with non-engineers.

        iii. Technical writing and reporting, including exposure to actual engineering reports to both technical and non-technical audiences.

        iv. Conflict avoidance and dealing with people of varied backgrounds.

    b. Module: Job skills, which could include:

        i. Career planning

        ii. Resume writing

        iii. Job seeking tools

        iv. Self-development awareness.

Conclusion

Industrial placement is a crucial component of the BE degree however the student experience can be improved through better preparation and support of students. The Work Experience report is a potential wealth of information about what can be done to make these improvements and thus create better prepared graduate engineers.

Preliminary analysis of historical reports presents strong evidence for continued development of student feedback mechanisms with a view to feed-forward important information on expectations to students. The reports also point to the need for better communication with industry representatives to clarify student skills and provide clearer expectations. In particular, there is evidence that greater integration of the Work Placement with the rest of the degree would lead to better outcomes for the students.

Based on these preliminary findings, there is justification for designing a better system for the submission of work reports whereby the data can be more easily analysed and provide more reliable feedback into the preparatory programs. Future development of this research is planned using form-based work report submissions which can inform the Practical Experience Placement program.

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