Outcomes for students working in industry

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CONTEXT

Engineering graduates without industrial experience may find that work is difficult to obtain immediately after completing their studies. Anecdotal evidence seems to suggest that work experience during an engineering course such as an industry-based learning (IBL) placement will assist in students' capstone projects, overall results in terms of grade point average (GPA), and employment prospects. As a result of their academic studies most engineering students have developed strong technical skills, and, as a consequence of their work experience, they may have developed 'soft' skills such as communication, teamwork, and interpersonal relations. In many tertiary institutes, 'soft' skills are often scaffolded all the way through the engineering program, but it is not until the IBL placement that students engage work in an industrial environment. The challenge within the tertiary environment is to determine if the students can translate their work experience to improve their academic performance.

PURPOSE OR GOAL

This study investigated the impact of two arrangements of work experiences; short term (over 12 weeks, STP) and long- term (over 52 weeks, IBL) on both final academic grades and capstone grades. The results from this work will inform future approaches of determining the benefits to students of the usefulness of industry based learning experiences (short or long term) as an indicator of academic performance, success in capstone project work, and employment.

APPROACH

This work involved a study of a sample of undergraduate mechanical engineering students. The data was collected over two years (four semesters). The first and third semester mechanical engineering capstone unit had enrolments of approximately 20 each and the second and fourth semesters having capstone unit enrolments of approximately100 students each. All the students had completed IBL (usually undertaken in their penultimate year), or a short term placement (STP), which can be undertaken at any stage of the engineering course. Analysis of student academic results in the capstone project, as well as the overall GPA, was performed and related to the student's involvement with either IBL or STP.

ACTUAL OR ANTICIPATED OUTCOMES

Analysis of data between IBL and capstone project performance and GPA yielded a small but positive relationship. However, STP placements and associated overall GPA was inconclusive.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This study found that students who spent time on work integrated learning or IBL in their penultimate year of their engineering course obtained better grades than those who did not undertake such a placement. One of the positive outcomes was that students' immediate employability was enhanced by the IBL experience, where a number were offered ongoing employment at the conclusion of their placement.

KEYWORDS

Industry-based learning, outcomes, capstone, GPA.

Introduction

A growing body of evidence is establishing that placement experience brings improved academic performance, in addition to the increased skills and employability that can be gained (Male, 2010, Male et al 2011). In a recent UK survey of industry and engineering students on “The Role of Work-integrated Learning in Academic Performance” it was found that there was a positive association between industry placements and improved academic performance. However, due to the limited sample size of 60 a somewhat greater sample size was required to validate their claims of correlation (Confederation of British Industry, 2009).

The positive effects of industrial placement schemes on academic achievement were noted as one of the major reasons for its implementation (Wangsa & Uden, 2007). Industry-Based-Learning (IBL) is used for a range of approaches and strategies which integrate academic studies with the work practice for at least a six month and often a 12-month term of employment. From a series of industry and work related employer interviews, (Patrick, Peach, & Pocknee, 2009) it was concluded that project work can be utilised to provide learning experiences that highlight the relevance of the degree to a particular industry. Project-based work contains an educational/academic emphasis, while exposing the students to workplace environments and interactions. The challenge in the tertiary environment is to determine if the students can translate their work experience to improve their performance academically. In particular can students improve their performance in the capstone project work, and so enhance their employment prospects (Jackson, 2014; Mendez & Rona, 2010).

The purpose of this study is to investigate the impact of two arrangements of work experiences; short term (over 12 weeks, called STP and long-term or over 52 weeks, termed IBL) on both final academic grades (GPA), and capstone grades. The results from this study will inform future approaches of determining the benefits to students of the usefulness of industry-based learning experiences (short or long term) as both an indicator of academic performance, or success in capstone project work.

Current Status of Industry Based learning

Patrick (2009) conducted a large-scale scoping study of work integrated learning in contemporary Australian higher education. His results showed that both universities and participants (students, staff, and industry based supervisors) consistently reported “the positive benefits” of working in industry. Further results provided evidence of commitment and innovative practice in relation to enhancing student learning experiences. Gomez, Lush, and Clements (2004) investigated the link between sandwich placement (a form of IBL) and academic performance of bioscience students. They found on average that sandwich placement students gain an advantage of nearly 4% in their overall final year performance over those who did not complete a sandwich program. In the business area, Duignan (2002) found that there was no significant difference in academic performance on return to studies between students who undertook work placement and those who did not undertake such a placement. When analysing the academic results from students who graduated from property management and development courses, Mansfield (2011) found that industrial placements were associated with overall higher academic performance in the last year of studies. Similar results from the disciplines of accounting, nursing, and music have all described the benefits of employment in industry during an academic program (Abeysekera, 2006; Draper & Hitchcock, 2006; Freudenberg, Brimble, & Cameron, 2011). These benefits included an increase in academic performance in some areas of their studies, an increase in work prospects after graduation, and enhanced attitudes towards their study. In a survey of economics students who had an optional placement year at the University of Surrey Mandilaras (2004), found evidence that industrial placement “significantly increases the chances of a student obtaining an upper second or higher degree class degree”. This positive influence was attributed to either the possible links between maturity and increased reliability, and focus by students on both their studies and work. In a further study of the

relationship between industrial experience of Business Administration students and their university work, Driffield, Foster, and Higson (2011) found that students, who complete a placement, perform “better” in “finals.” Students who spend time working in industry for either a short or long term period find that it assists their employment prospects (Jackson, 2013, 2014; Sahama, Yarlagadda, Oloyede, & Willet, 2008; Zegwaard & Hodges, 2003).

In many tertiary institutes, ‘soft’ skills are often scaffolded throughout the engineering program, Often it is not until the work placement experience that the students develop expertise in ‘soft’ skills. These skills include communication, teamwork and interpersonal relations, and enhanced project management and implementation skills (Male, Bush, & Chapman, 2011). In a comprehensive study conducted of Australian engineering students, Male (2010) found that they have developed strong technical skills in their undergraduate studies, but not necessarily the “soft” skills required for interaction amongst working colleagues. A number of workers have proposed that that although workplace experience may result in undergraduates with improved generic skills which are transferable (Jackson, 2014; Male, 2010; McLennan & Keating, 2008; Patrick et al, 2008); the effect of the work placement upon academic performance is not clear. Project work, often undertaken during work placement experiences can be utilised to provide learning experiences which highlight the relevance of the degree to a particular industry (Patrick et al., 2009).

At our institution, the Bachelor of Engineering program promotes IBL after completion of at least eight semesters of study and then the students return to complete their course. The IBL program gives undergraduates the opportunity to be placed in either a full year in industry or a six-month placement. Students are assessed on the basis of two IBL reports which are submitted on completion of the placement, as a pass or fail. In any one year, approximately half the local/domestic enrolled students undertake the IBL program, unless they are not eligible for the IBL program, or choose not to undertake IBL. International students are not eligible for IBL. The IBL program is not compulsory, but the STP of 12 weeks is a requirement by Engineers Australia as part of the accreditation of the Bachelor of Engineering (Engineers Australia, 2013).

Participants

This work involved a two-year study drawn from a sample of 240 undergraduate mechanical engineering students. The students were completing courses as a single four-year engineering degree and a five-year double degree (combining engineering with business).. In their last year of studies students completed a capstone subject either in the first semester or second semester. In each year, the capstone enrolment cohort in the first semester comprised approximately 20 students, whilst in the second semester, the capstone enrolment was approximately 100, resulting in almost 240 students overall, as given in Table 1.

Table 1. Student numbers for completion of capstone subjects.

Year	Semester 1	Semester 2
2011	17	98
2012	22	102

Later in their degree the mechanical engineering students completed either an optional IBL placement or a 12 week industrial placement; the latter being a requirement for graduation as an engineer. The Office of Industry Based Learning at our institution both located and engaged the majority of students in positions for both IBL and STP. These students were placed across a broad spread of industries, ranging from small to large private companies or government and semi-government organisations. In some instances, a few engineering students were responsible for negotiating their placements under the guidance of an academic advisor. For those students who had previously undertaken work in industry, an exemption for either STP or IBL or both was granted for “Recognition of Prior Learning”

(RPL). The distribution of final year students who had completed (or were exempt from) a work placement program is shown in Figure 1 for IBL, STP and RPL. Following their work placement all the students completed the “capstone” research project (Engineers Australia, 2013). Of the 240 capstone enrolled students, 141 had completed either an IBL or STP work placement. The remainder had worked in industry prior to enrolment in engineering. In about 30 percent of capstone projects, the sponsorship of projects came from the industrial placement companies.

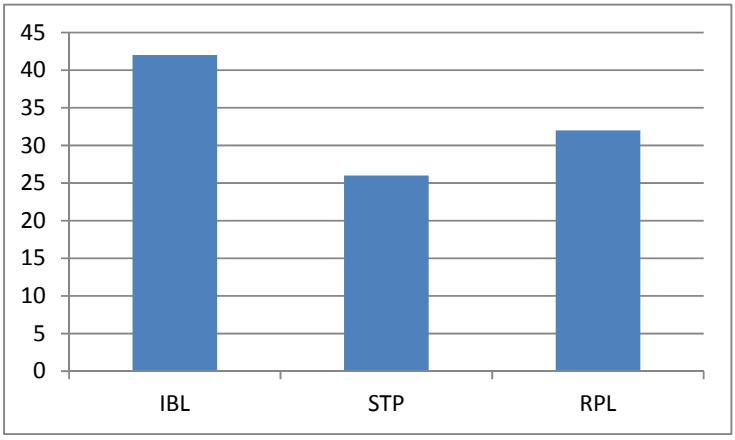

Figure 1. Percentage of final year students (2011-2012) who had completed a work placement program (including those exempt).

Procedures

The data collection sample was of 141 students from the original cohort of 240, viz. as a result of 81 students being granted RPL and the remainder not continuing with their course. Data analysis involved an *ex post facto* design from the remaining students. This process involved the collation of student first year project work grades, GPAs, and their academic results in the capstone project. In addition, data of the students’ involvement in either IBL or STP was collected and correlated with their various academic grades. The data was collected over two years (four semesters).

Methodology

Both qualitative and quantitative data was collected. The qualitative data was concerned with ongoing employment after IBL and was obtained from an employer exit survey (Blicblau & Nelson, 2013).

Statistical analysis approach

In this paper, three different statistical methods (two T-tests and one ANOVA) were employed to test hypotheses described in four questions. The statistical analysis utilised IBM SPSS (version 22) software (IBM, 2014). The following descriptions will explain the individual analysis (test) which was conducted.

T-tests

The T-test is used when the researcher has two groups or two sets of data and wants to compare the mean score on some continuous variable. In our case students who completed IBL and completed a short term work placement, STP and the grades obtained for one subject. There are two common T-test methods, *Paired sample tests,* and *Independent sample tests.*

Paired sample tests are used when the comparisons are needed to evaluate among one group in two different timeframes (before and after). Analysis of questions one and three are related to *Paired sample tests*.

Independent sample tests are used when the researcher has two different (independent) groups and wants to compare their mean scores. Analysis of question four is related to Independent sample tests.

One-way analysis of variance (ANOVA)

One-way analysis of variance is similar to T-tests but is used when the researcher has more than two groups and wishes to compare their mean scores on a continuous variable. Then the researcher can do further analysis by using Post-hoc comparisons to find out which groups are significantly different from one another.

Statistical analysis of Questions

Ex post facto quantitative data of student grades was analysed according to criteria which answered the following questions. The first question (Q1) explored was "whether the process of IBL can affect the average grade of mechanical engineering students in subjects taken after completing IBL." A *Paired sample T-test was* conducted to evaluate the impact of IBL on their average grades.

The second question (Q2) examined the difference between final year (capstone) grades for those students who completed IBL and those who decided to undertake only a 12 weeks placement in industry (STP). A *one-way analysis of variance (ANOVA)* between groups was conducted to establish any significant difference between grades of those capstone subjects among students who completed IBL and those who completed the STP program. The total data was divided into three groups. The first group was for those who completed IBL, the second group related to those who completed the STP program, and a third group is referred to those who did not complete any of those programs. It was noted that some students had not yet completed any of those options and so that data was not incorporated into the analysis.

The third question (Q3) studied the relation between first-year project subject grades and the final year project (capstone) grades, irrespective of completing time in industry during the course. A *Paired sample T-tests* was conducted among student grades in order to compare the grades in the capstone subject and the first-year project subject.

The fourth question (Q4) was concerned with the impact of students' with prior learning and/or other qualifications on the grades obtained in their final year subject. An *Independent sample T-test* was conducted among student who either undertook the first-year project subject and those who did not undertake the project subject i.e. RPL students. These RPL students may have had a TAFE preliminary program called *pathway*, a trade qualification, or a technical or science qualification) which gave them advanced standing in the engineering degree course. (who)

Results and Discussion

Approximately 10 percent of the students from IBL or STP were offered ongoing employment at the conclusion of the placement. This offer required the students to work and study part-time. Only four students took up the immediate work offer as the remainder wished to complete their studies full-time. In a follow-up survey of graduate student employment, a small number were employed by their IBL of STP employer. The main reasons for a decrease in employment was that students wished to either travel or work in a different field or take up further studies.

Statistical analysis of grades concerning capstone and first year project work, and industrial placement was performed using the techniques outlined previously. These analyses involved data mining for examination grades which provided the data to answer the four questions as discussed below.

For the first question, Q1; the outcomes showed that: there was a statistically significant increase in average grades from before IBL (M = 68.54, SD = 8.98) to after IBL (M = 72.66,

SD = 6.52), $t(40) = 3.557$, $p < 0.001$. The increase of the mean was 4.12 with a 95% confidence interval of the difference ranging from 1.7 to 6.4.

The statistic indicates that when students completed an IBL program, the average grades of those subjects that they completed after IBL was higher than those subjects before completing IBL. These results indicate that the IBL program can help students to achieve better marks. A similar phenomenon was found in the UK where the students also achieved a higher form of honours degree (Confederation of British Industry, 2009) after completing a work placement program.

When considering the second question, Q2; the outcomes showed that there was statistically significant difference at $p < 0.05$ in scores for capstone subjects as $F(2,145) = 5.51$, $p = 0.005$. Post-hoc comparisons, using the Tukey test, indicated that the mean score for the IBL group ($M = 78.67$, $SD = 6.46$) was significantly different from the STP group ($M = 73.74$, $SD = 9.2$).

These results indicate that among students sampled in this research, those who completed IBL, achieved better results in their capstone subject when compared with those students who completed 12 weeks in industry (STP). These results suggest that the IBL program helped students to perform better in their capstone project as shown by their accompanying better grades.

When analysing outcomes from the third question, Q3, the results showed that; there was NO significant difference between those scores as $p = 0.093$, and it is larger than 0.05. For first year project subject, the mean score was $M = 77.95$, $SD = 7.04$ and for HES5103 the mean score was $M = 76.15$, $SD = 7.84$, $t(97) = 1.695$ and $p = 0.093$ (2-tailed). This result shows that the grade in the first-year project subject had no effect on the grade of the capstone subject, and had no impact on students' academic grade achievement overall.

For the fourth question, Q4, the statistical analysis evaluated the impact of grades for those students who undertook the first year project subject and for those students who did not undertake the first year project on the grades they achieved in the capstone subject. The outcomes showed that; there was NO significant difference in scores for those who had undertook the first year project subject ($M = 76.15$, $SD = 7.84$) and who did not have this subject ($M = 73.78$, $SD = 9.99$); $t(80) = 1.46$, $p = 0.147$ (2-tailed).

The evidence from this last analysis indicates that students' grades for capstone research project have not been affected by a students' qualification prior to attempting the capstone project. Those students who came into the capstone project with a pre-qualification, on average, achieved capstone grades similar to those who had no pre-qualification. There was an improvement on the quality of the project work compared with those students who had not undertaken a period of IBL or STP.

The overall outcomes of the analyses indicate the positive benefits of industrial experience, academic performance, post-BL, in the form of the GPA, as well as capstone grades. These results for engineering students were similar to results for other professions mentioned previously, (Abeysekera, 2006; Draper & Hitchcock, 2006; Freudenberg, Brimble, & Cameron, 2011, Mandilaras 2004, Jackson, 2014; Mendez & Rona, 2010). However, an investigation of a broader range of engineering students, disciplines, industries, and educational institutions would be required to provide further demonstration of positive outcomes of working in industry, ie better grades overall and in capstone subjects, and enhanced employment prospects. Due to the limited sample size and students selected form only one engineering discipline. A somewhat greater sample size and discipline distribution was required to validate ther claims of correlation

Conclusions

As a result of the IBL or STP a number of students were offered ongoing employment before they completed their course, and some were offered employment after completing their course.

There is a positive association between completing an industrial placement (IBL or STP) and achieving a higher capstone project result in the final year of an engineering degree. This evidence may be valuable to both students who are uncertain of the potential benefits of industry placements and tertiary institutes which are deciding whether to incorporate or retain industrial placement programs.

Students' grades for the capstone research project have not been affected by the students' qualification prior to attempting the capstone project. Student grades in the first-year project subject had no effect on the grade of the capstone subject and had no impact on students' achievement overall

For those students who completed the industrial placement, in particular an IBL engagement, they achieved better results in their capstone subject when compared with those students who completed an STP in industry. It is suggested that identifying and optimising length of work placements are likely to be highly advantageous to students, employers, and higher academic institutions. In some cases the work placement experience may lead to immediate offers of employment with the host employer.

Further research

Future work will involve identifying IBL employment and placement factors which encourage academic development in both soft skills and academic grades.

References

Abeysekera, I. (2006). Issues relating to designing a Work-Integrated Learning (WIL) program in an undergraduate accounting degree program and its implications for the curriculum. *Faculty of Commerce-Papers*, 539.

Blicblau, A.S. and Nelson, T.L. (2013), Competencies Required of Industry-Based-Learning Students, paper presented at the ASEE conference, Gold Coast, 8-11 Dec. ASEE.

Confederation of British Industry. (2009). Future Fit: Preparing Graduates for the World of Work. London: CFA Higher Education Task Force.

Draper, P., & Hitchcock, M. (2006). Work-integrated learning in music technology: Lessons learned in the creative industries. *Asia-Pacific Journal of Cooperative Education, 7*(2), 24-31.

Driffield, N. L., Foster, C. S., & Higson, H. E. (2011). *Placements and degree performance: Do placements lead to better marks, or do better students choose placements?* Paper presented at the ASET Annual Conference, Leeds Metropolitan University, Headingley Campus,.

Duignan, J. (2002). *Undergraduate Work Placement and Academic Performance: failing by doing,*. Paper presented at the HERDSA Quality Conversations International Conference, Edith Cowan University, Perth, Western Australia.. http://www.ecu.edu.au/conferences/herdsa/main/papers/ref/pdf/Duignan.pdf

Engineers Australia. (2013). Program Accreditation. from http://www.engineersaustralia.org.au/about-us/program-accreditation

Freudenberg, B., Brimble, M., & Cameron, C. (2011). WIL and generic skill development: The development of business students' generic skills through work-integrated learning. *Asia-Pacific Journal of Cooperative Education, 12*(2), 79-93.

Gomez, S., Lush, D., & Clements, M. (2004). Work Placements Enhance the Academic Performance of Bioscience Undergraduates. *Journal of Vocational Education and Training, 56*(3), 373-385.

IBM. (2014). IBM SPSS Statistics (Version 22). Retrieved from http://www-01.ibm.com/software/au/analytics/spss/products/statistics/

Jackson, D. (2013). Employability skill development in work-integrated learning: Barriers and best

practice. *Studies in Higher Education*(ahead-of-print), 1-18.

Jackson, D. (2014). Modelling graduate skill transfer from university to the workplace. *Journal of Education and Work*(ahead-of-print), 1-33.

Male, S. A. (2010). Generic Engineering Competencies: A Review and Modelling Approach. *Education Research & Perspectives, 37*(1).

Male, S. A., Bush, M. B., & Chapman, E. S. (2011). Understanding generic engineering competencies. *Australasian Journal of Engineering Education, 17*(3).

Mandilaras, A. (2004). Industrial Placement and Degree Performance: Evidence for a British Higher Institution. .*International Review of Economics Education, 3*(1), 39-51.

Mansfield, R. (2011). The effect of placement experience upon final-year results for surveying degree programmes. *Studies in Higher Education, 36*(8), 939-952.

McLennan, B., & Keating, S. (2008). *Work-integrated learning (WIL) in Australian universities: The challenges of mainstreaming WIL.* Paper presented at the ALTC NAGCAS National Symposium.

Mendez, R., & Rona, A. (2010). The Relationship between Industrial Placements and Final Degree Results: a study of engineering placement students. *Learning and teaching in higher education, 4*(2), 46-61.

Patrick, C.-J., Peach, D., & Pocknee, C. (2009). The WIL [Work Integrated Learning] report: A national scoping study. In A. L. a. T. C. A. f. report (Ed.). Brisbane: Queensland University of Technology.

Patrick, C.-J., Peach, D., Pocknee, C., Webb, F., Fletcher, M., & Pretto, G. (2008). *The WIL (Work Integrated Learning) report: a national scoping study [Final Report]*. Brisbane: Queensland University of Technology.

Sahama, T. R., Yarlagadda, P. K., Oloyede, A., & Willet, G. (2008). Impact of Work Integrated Learning (WIL) on graduate preparation for the manufacturing industry.

Wangsa, I. T., & Uden, L. (2007). *Towards the development of industrial placement in Higher Education.* Paper presented at the European Models and Best Practice on Practical Placements of Students. Proceedings of the 3rd. EUI-Net International Workshop, Rome.

Zegwaard, K. E., & Hodges, D. (2003). Science and Technology Stakeholders' Ranking of Graduate Competencies Part 3: Graduate Perspective. *Asia-Pacific Journal of Cooperative Education, 4*(2), 23-35.

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