The role of work placement in engineering students' academic performance

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Engineering graduates without industrial experience may find that employment is difficult to obtain immediately after completing their studies. This study investigates the impact of two arrangements of work experiences; short term (over 12 weeks, STP) and long- term (over 52 weeks, IBL) on academic grades. This study involved 240 undergraduate mechanical engineering students. Results from the study indicated 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. The findings of this work have highlighted the relevance of work experience to improved academic grades for engineering students. An additional outcome was that some students were offered ongoing employment at the conclusion of their placement. Limitations of the study include factors external to the industry based work experience which may influence student grades. It is proposed that tertiary institutes embed a lengthy work experience program within the engineering academic syllabus. *(Asia-Pacific Journal of Cooperative Education, 2016, 17(1), 31-43)*

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Industrial work placement experience often results in improved academic performance. This work experience has also been shown to result in increased engineering generic skills and employability (Male, 2010, Male, Bush, & Chapman, 2011). A recent UK survey of industry and engineering students on "the role of work-integrated learning in academic performance" (Confederation of British Industry, 2009) found that there was a positive association between industry placements and improved academic performance after such a placement. However, due to the limited sample size of 60 in the UK study, a somewhat greater sample size was required to validate their claims of correlation.

The term industry-based-learning (IBL) is used for a range of approaches and strategies, which integrate academic studies with work practice for at least a six month and often a 12-month term of employment. IBL is known by many names, including co-operative education, sandwich year, and work integrated learning. It provides students with the opportunity to undertake a paid, relevant work placement as part of their university degree, for example, in an engineering discipline. The positive effects of industrial placement schemes on academic achievement were noted as one of the major reasons for its implementation (Wangsa & Uden, 2007). From a series of industry and work related employer interviews, (Patrick et al., 2009) it was concluded that "project work can be utilized to provide learning experiences which highlight the relevance of the degree to a particular industry." Project-based work contains an educational/academic emphasis while at the same exposing the students to experience workplace environments and personal interactions as part of their learning experience. The challenge in the engineering tertiary environment is to determine if the students can relate their work experience to their academic work, and so improve their academic grades as well as enhancing their employment prospects (Jackson, 2014; Mendez & Rona, 2010), in particular, improvement of student grades in completing their capstone project work. We define capstone projects as a final year subject where it "provides an experiential learning activity in which the analytical knowledge gained from

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previous courses is joined with the practice of engineering in a final, hands-on project" (Dutson et al., 1997).

This study investigated the impact of two arrangements of work experiences for engineering students; short term (over 12 weeks, called STP) and long-term (over 52 weeks, IBL), on academic grades at Swinburne University of Technology. All the Bachelor of Engineering (including honors) students are required to complete a minimum of 12 weeks of relevant industry experience as part of their studies and fulfilment of this requirement is compulsory prior to graduation. Where students complete Industry-Based Learning, an exemption is granted for relevant industry experience. The results from this work will inform future approaches of implementing industry-based learning experiences (short or long term) in the engineering curriculum.

In this study, there were a number of limitations. The 240 participants were from one tertiary institution and one faculty viz. engineering at Swinburne University of Technology (2014). The study involved only the academic results gathered from the students participating in either IBL or short term placement. The inclusion of data from students who did not participate in any form of work placement would have provided for a greater variety of perspectives. However, this was beyond the scope of this research, which sought the perspectives of the groups of people mentioned above. Finally, no claim is being made that this student group is representative of other engineering students or other disciplines in the tertiary sector.

IMPORTANCE OF INDUSTRY BASED LEARNING

During a course of study, the effect of an industrial work placement on final academic, results has been the subject of discussion by many workers over the past 10-15 years. In the business area, Duignan as early as 2002 found little or 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. 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 gained approximately an advantage of nearly 4% in their overall final year performance over those who did not complete a sandwich program. 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. The work placement students matured more rapidly, and workplace responsibilities may enhance student reliability. Patrick et al. (2009) conducted a large-scale scoping study of work integrated learning in contemporary Australian higher education. Their explicit aim was to identify issues, map a picture of "work integrated learning (WIL) across Australia, and to identify ways of improving the student learning experience about WIL. Their study identified a comprehensive range of participants involved in either providing or benefiting from WIL experiences. These included students, tertiary academic staff, employers, professional associations, and government. Their results showed that that both universities and participants consistently reported on the benefits of working in industry, and provided evidence of commitment and innovative practice to enhancing student learning experiences.

Mendez and Rona (2010) found a positive association between placements and improved academic performance for engineering students from the School of Engineering at the University of Leicester. They further suggested it was not self-evident that work experience translated into enhanced academic performance, and may be due to a number of reasons including the discipline of study, the type of employer, and the relation between the student and the employer. Their results were similar to those found from empirical evidence by Green (2011) for business students, which showed that "the completion of a placement year on average, improves the final classification award achieved by the students".

When analyzing 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 from students in their final year of study. 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 further study of the relationship between the industrial experience of business administration students and their university work, Driffield, Foster, and Higson (2011) found that students, who completed a placement, performed "better in finals". Students who spent time working in industry for either a short or long term period found that it assisted their employment prospects (Jackson, 2013, 2014; Sahama, Yarlagadda, Oloyede, & Willet, 2008; Zegwaard & Hodges, 2003). The overall results from these studies were that students returning from IBL gained an improvement in their academic results after completing an extended period working within industry, and in some cases enhanced their future employment. In a study conducted by Flynn (2013) for the Learning and Teaching Institute at the University of Hertfordshire, it was found that "whatever the length of the placement, that workplace experience is enormously valuable." Further, she reported that at the university of Manchester in 2004, "40% of the annual graduate intake from graduate employers who took work placement students, consisted of former placement students"; and at the Queen's University in Belfast "for engineering sandwich students those who were on placement in 2009/10, 100% gained graduate level employment within 6 months".

SKILLS FOR WORK

There is a lack of reliable approaches for defining and classifying skills required for employment. Employers distinguish between hard skills or job-specific skills which are closely connected with knowledge and observed and easily measured, and 'soft' skills which are non-job specific skills including ethics, communication, team based work, management, and entrepreneurial skills (ABET, 2015). Many of these skills are closely connected with attitudes, which are elusive and difficult to quantify and develop. Torres (2014) implies there is no generally accepted skills taxonomy. Firth (2011) has noted that "because of increases in the complexity of industry and businesses with an associated move to coordination of industrial engineering and communication; employers are putting more weight on soft skills with oral, written and electronic". Chikumba (2011) emphasized the importance of multi-faceted skills for engineers to "deal with solving of society's problems". The author also noted that "for engineers to achieve this they have to be equipped with the right technology and skills". He suggested that the development of "hard engineering skills, which include computation, analysis, and design, could be achieved through a combination of tuition and work integrated learning". However, students also require soft skills in addition to hard skills, which enable them to effectively communicate and interact easily with others when entering the work environment. WIL can contribute towards the imparting of these soft skills. He suggested that a mentoring program be developed by both the academic institution and the industrial supervisor during their period of WIL. In a survey of engineering students' perceptions of soft skills and engineering expectations, Itani and Srour (2015) concluded that engineering programs need to emphasize the importance of "gaining certain skills, especially soft skills in the workplace."

In many tertiary institutions, soft skills are often scaffolded throughout the engineering program. These skills include those which are technical or administrative and impact on an organization's core business (Coates, 2004). 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 of Australian engineering students' skills, Male (2010) found that some of them have developed strong technical skills in their undergraduate studies, but not necessarily the soft skills required for interaction amongst working colleagues. It has been proposed that that although workplace experience may result in undergraduates with improved generic skills, which are transferable, the effect of the work placement upon academic performance is not clear (Jackson, 2014; Male, 2010; McLennan & Keating, 2008; Patrick et al. 2009). Project work, often undertaken during work placement experiences, "can be utilized to provide learning experiences that highlight the relevance of the degree to a particular industry" (Patrick et al. 2009)

A recent study by Freeman et al. (2014) of the effect of active learning on STEM (Science, Technology, Engineering and Mathematics) education found that "university instruction would be more effective if students spent some of their class time on active forms of learning like activities, discussions, or group work, instead of spending all of their class time listening". They found that students in an active learning environment are 1.5 times less likely to fail, that they outperform those (students) in traditional lectures on identical exams. Participation in WIL encompasses all forms of active learning albeit in an industrial environment and so may improve students' GPA.

INDUSTRY BASED LEARNING AT OUR INSTITUTION

At Swinburne University of Technology, the Bachelor of Engineering program, which is eight semesters long, promotes IBL to students to be taken at any time after five semesters of study. The IBL program gives undergraduates the opportunity to be placed in either a full year or a six-month industry 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. All engineering students must complete a minimum of 12 weeks relevant industry experience. Where students complete industry-based learning, an exemption is granted for STP. In addition, due to current government regulations international students holding a student visa are not able to undertake IBL. Overall, approximately 20% of our students do not qualify for IBL and of the remainder approximately 25% do not undertake IBL.

RESEARCH DESIGN

Study Participants

The present study involved the analysis of students'academic grades over a two-year period of a sample of 240 undergraduate mechanical engineering students. These grades are a combination of summative and formative assessment procedures. The students were completing courses as a single four-year engineering degree or a five-year double degree (e.g. combining engineering with business or arts). All students completed the first-year project subject. In their final year, students completed a capstone subject either in the first or second semester. The capstone project at our institute is a "final-year project which provides students with a professionally focused learning experience which allows them to put learned theory into practice" (Swinburne University of Technology, 2014). IBL students complete their placement after two and a half years of study, while STP students completed their 12-week placement at any stage of their degree. The grade data was collected over two years (four semesters).

The capstone enrollment over the two-year investigation comprised approximately 240 students. There were approximately 20 students in semester one of both years and approximately 100 students in semester two.

Later in their degree the mechanical engineering students completed either an optional IBL placement or a compulsory 12-week industrial placement; a requirement for graduation as an engineer in Australia (Engineers Australia, 2013). Our institute's Office of Industry Based Learning 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 organizations. In some instances, a few engineering students were responsible for negotiating their work placements under the guidance of an academic advisor. For those students who had previously undertaken work in industry, an exemption 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 final year "capstone" research project (Engineers Australia, 2013).

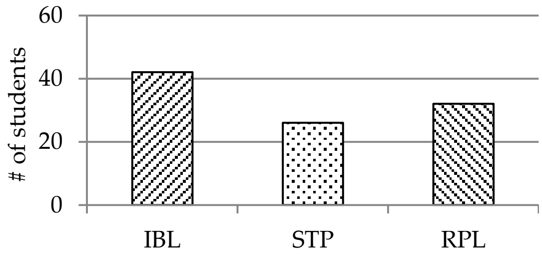

FIGURE 1: The distribution of final year students who had a work placement program, where IBL means Industry Based Learning, STP means Short Term Placement, and RPL means Recognition of Prior Learning.

METHODOLOGY

The analysis of data involved an *ex-post facto* design. It included the collation of student GPA, their overall academic results in the capstone project, as well as the students' involvement in either IBL or STP. The data collection sample was of the 159 mechanical engineering students who completed either IBL or STP from the original cohort of 240.

The data was statistically analyzed according to the four criteria contained in the questions given to the students. In the student questionnaire, question one (Q1) explored whether the process of IBL could affect the average grade of mechanical engineering students in subjects taken after completing IBL.

The second question (Q2) asked whether there was a significant difference between final year project grades for those students who completed IBL and those who decided to undertake only a 12 weeks placement in industry (STP). This STP is a requirement of Engineers Australia (Professional Experience in Engineering) as part of their accredited degree program (Engineers Australia, 2013). 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) queried the relation between first-year project subject grades and the final year project (capstone) grades, irrespective of completing time in industry during the course. The statistical analysis was conducted to find a relationship between the average grade of students in the final year capstone project subject and their first-year project subject grade. The fourth question (Q4) was concerned with the impact of students with prior learning and/or other qualifications (who did not undertake the first-year project subject) on the grades obtained in their final year subject.

In this paper, three different statistical methods were used to test hypotheses described in the four questions. The statistical analysis utilized IBM SPSS (version 22) software (IBM, 2014). The following descriptions will explain the individual analysis (test) which was conducted.

TABLE 1: Summary of statistical tests used in this research/study to analyze collected data

Concept behind research questions	Variables	Statistical Test
Q1. The effect of IBL on the overall grades of the students	Overall Grades before IBL GPA after IBL	Paired sample T-tests
Q2. the differences of grades between IBL completion and STD students	Grades for final year project (IBL)* Grades for final year project (STP)**	One way analysis of variance (ANOVA)
Q3 The relationship between first year project and final year project	Grades for first year project Grades for final year project	Paired sample T-tests
Q4. The impact of previous certification on final year project	Completing first year project(IBL or STP) Not completing first year project (IBL or STP)	Independent sample T-tests

* - Those students who completed Industrial Based Learning

** - Those students who completed Short Term Placement (12 weeks)

The paired sample T-test was used because we had two groups or two sets of data, and we wished to compare the mean grades of overall completed subjects before IBL and the GPA after IBL (Q1). Using the T-test, we then compared the mean grades obtained by first year and final year students in their project work (Q3). *The independent sample tests* were used to compare the mean grades for those students who completed first year projects with those who did not complete the first year project (Q4).

We used a one-way analysis of variance test (ANOVA) to compare the mean grades of those students who completed a first year project (and went on to undertake IBL or STP) and those students who were exempt from completing a first year project and went on to complete either IBL or STP. We performed further analysis by using posthoc comparisons of grades for those students who completed IBL and STP and those who had recognition of prior learning. Analysis of question two is related to a one-way analysis of variance (Q2).

RESULTS AND DISCUSSION

Statistical analysis of final student grades (examination, test, oral presentations, and capstone project work) together with their involvement in an industrial work placement was performed. Table 2 summarizes the results of the statistical tests.

When considering the first question, Q1, the impact of IBL on their average overall grades (GPA); the analysis indicated that there was a statistically significant increase in average grades from before IBL to after IBL. The increase of the mean was 4.12 with a 95% confidence interval of the difference ranging from 1.7 to 6.4. The results indicate 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 show 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 an honors degree (Confederation of British Industry, 2009) after completing a work placement program.

When considering the second question, Q2, the outcomes showed that there was astatistically significant difference in scores for capstone subjects. Post-hoc comparisons, using the Tukey test, indicated that the mean score for the IBL group was significantly different from the STP group. 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 who completed 12 weeks in industry (STP). These results seem to suggest that the IBL program helped students to perform better in their final research project and with accompanying better grades.

When considering the third question, Q3, the outcomes of the analysis showed that there was no significant difference between the grades for the first year project subject and the grades for the capstone subject. These results indicate 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 for those who undertook the first-year project subject and those who did not have that subject showed that there was no significant difference in scores for those who had undertaken the first year project subject and who did not have this subject. The evidence from this last analysis explains that students' grades for capstone research projects have not been affected by a students' prior learning i.e. had an alternate qualification or completion of some tertiary studies prior to attempting the capstone project. Those students who came into the capstone project with a pre-qualification, on average, achieved grades similar to those who had no pre-qualification.

TABLE 2: The results of statistical tests

	Grades before IBL		Grades after IBL		Statistical data		
Q1. The effect of IBL on the overall grades of the students	M	SD	M	SD	n	t(n)	p
	68.54	8.98	72.66	6.52	40	3.557	< 0.001
	IBL groups		STP groups		Statistical data		
Q2. the differences of grades between IBL completion and STD students	M	SD	M	SD	n	F(2,n)	p
	78.67	6.46	73.74	9.2	145	5.51	0.005
	First year projects		Final year projects		Statistical data		
Q3. The relationship between first year project and final year project	M	SD	M	SD	n	t(n)	p
	77.95	7.04	76.15	7.84	97	1.695	0.093 (2-tailed)
	First year projects		No first year projects		Statistical data		
Q4. The impact of previous certification on final year project	M	SD	M	SD	n	t(n)	p
	76.15	7.84	73.78	9.99	80	1.46	0.147 (2-tailed)

The overall outcomes of the statistical analyses indicate the positive benefits of industrial experience academic performance, post-BL, in the form of the GPA, as well as capstone grades. 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. In about 30% of capstone projects, the sponsorship came from the industrial placement.

With regard to employment, approximately 10 percent of the students from IBL, or STP were offered ongoing employment at the conclusion of the placement. However, this would involve part-time work and part-time study. Only two students took up the immediate work offer as the remainder wished to complete their studies full-time. In a follow-up survey of student employment, a number were employed by their IBL of STP employer.

Tanaka and Carlson (2012) developed regression models to determine the effects of final year GPA of WIL. Their results indicated that while WIL affected GPA to some extent, the statistical significance varied between institutions and years of data analysis. Specifically, first year GPA was a substantial predictor of third year results. They suggested that the general academic standard of students varied or the grading/assessment standard varied between faculties and that WIL is associated with increased final year GPA.

Implications of findings for this work highlighted the relevance of work experience to improve academic grades. It is proposed that in a tertiary engineering program, an extended work experience (six or twelve months) be embedded within the academic curriculum.

FACTORS THAT COULD IMPACT ON STUDENTS GRADES

Like other studies, this research has some limitations that readers should consider when interpreting these findings. It is not possible within the confines of this paper to explore the many factors that could impact on students grades apart from time spent working in industry. The data collection and analysis for the current work was largely based on a single institutional survey, a small sample size, and lack of gender student representation. The main limitation of this work is that IBL cannot be isolated as the only variable affecting grades.

Given less than 1% of the engineering student population in this study were female, the effect of gender was not explored. In a study conducted by Smith (2004) with a geography course at Brunel University, it highlighted that women consistently outperformed men even though they had started their courses with almost identical A-level results. There was no indication of industrial experience and gender effects on grades.

The effect of students maturing as they progress through their degree (both before and after WIL) was found by Smith and Worsfold (2015) to be a noteworthy factor influencing their behavior in the workplace as they "see more clearly the links between workplace task and consequential outcomes", where the influence on GPA was difficult to quantify.

Guillaume & Khachikian (2011) examined engineering students' attitudes on time devoted to a course (i.e. time-on-task), and the subsequent effects of this time-on-task on their performance in the course and their overall grade point average (GPA). Their results showed that 'A' students know they will earn an 'A' as long as they do the work, 'C' students are resigned to the fact that they will earn a 'C' and 'B' students wanted better grades and will devote the most effort towards achieving these grades. However, the influence of any time spent working in industry was not examined.

Furthermore, it has been noticed that when medical students manage their time (Abdulghani et al., 2014) they appear to obtain significantly higher academics grades. Time-management of homework at the secondary school level was also considered important in a study by Xu, Yuan, Xu, and Xu (2014). They found that "grades increased as time management was enforced". This management of time may be allied to student maturity and understanding of how the academic system works, and not necessarily related to the WIL experience. In a study of biology students, Jensen and Barron (2014) found that in their work "alerting students to the strong relationship between their first and final grades in the course might be beneficial either by (a) improving students' behavior and performance or (b) encouraging students who are badly failing to withdraw". They further suggested that their data was "consistent across wide ranges of disciplines, student interests, student maturity levels, and institution types". Results from a study of Irish engineering students (McCool, Kelly, Maguire, Clarke, & Loughran, 2015) showed that "mature students appear to achieve an improved GPA". The identification of more relevant predictors might enable even more academics to advise their students of the strong relationship between early academic performances, academic behavior, and final grades. The effect of WIL or IBL on overall student development is considered an integral part of the academic training and maturity.

The effect of classroom composition and classroom management based on a representative sample of 31,038 eighth-grade students was analyzed by Hochweber, Hosenfeld, and Klieme (2014). Their findings suggested that classroom composition (high achieving and low achieving students), parental educational background and classroom management influenced student grades.

Drysdale, Ward, Johansson, Zaitseva, and Sheri (2012) conducted an international project (involving four countries) to examine the relationship between WIL and the psychological variables believed to play a role for success in the transition to the labor market. Their results indicated that "there were many attitudes and behaviors shared by WIL and non-WIL students in the four countries – however there were also significant differences that shed light on WIL outcomes and/or the type of students who select WIL, regardless of where they reside". In all cases there "appeared to be no influence on the GPA, but as a sign of maturity non WIL students perceived themselves as better critical thinkers in their courses than WIL students, but, WIL students are more concerned with high grades and gaining the approval of others".

The participation of students in STP or IBL/WIL is self-selecting. IBL is not compulsory for engineering students. International students are not permitted to undertake IBL in Australia due to conditions attached to their visa. A number of students have "recognition of prior learning" deemed to be equivalent to IBL and a number of students decide not to complete IBL, as they wish to complete their course in the shortest time possible. Economic and financial conditions within the engineering industry often influence the number of positions available for IBL. Overall, approximately 40%-50% of our engineering students undertake a period of IBL. There is little or no evidence that students in this study who do not participate in IBL during their engineering degree, or before their capstone project, tend to be weaker academically (due to various factors mentioned earlier). It is recognized that at the time this study was undertaken all engineering students were required complete a period of STP (12 weeks employment) to qualify for graduation. This STP may have been completed previously as part of their recognition of prior learning, or may be the first 12 weeks of fulltime employment.

An important area for future research lies in the exploration of these and a number of as yet unknown external influences which affect student grades. In the present work, only students' academic results from engineering disciplines were analyzed, suggesting that a larger population be examined for the effect of different periods of WIL or STP on GPA as part of future work.

CONCLUSIONS

The outcomes of the analysis offer evidence which suggests that there is a positive association between completing an industrial placement and achieving a higher final year project result in the final year of an engineering degree. This evidence may be valuable to both students and tertiary institutes. The benefits of IBL in engineering may be an influence on university departments that are deciding whether to incorporate or retain industrial placement programs. Similarly, the positive benefits of IBL may influence students in their career choices in engineering.

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, that is, 12 weeks' short-term placement in industry. Students' grades for the capstone research project have not been affected by students' qualifications 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. It is important that tertiary institutes and universities develop curricula that enhance student employability by incorporating opportunities for work experience.

It should be recognized that this study is limited by the sample size and student employment demographic being only mechanical engineering students. The data in the present study did not distinguish between male and female academic performance (Gomez et al., 2004). Whilst the analytical methods are rigorous, both a larger sample size and spread of engineering disciplines is required in the future to strengthen the claims of the strong relationship between work placement and academic results.

Future work will involve identifying IBL employment and placement factors which encourage academic development in both soft skills and academic grades. Outcomes of such a study may help universities identify IBL placements to maximize these skills and grades. It is suggested that identifying and optimizing the 'placement effect' is likely to be highly advantageous to both employers and higher academic institutions including work placements in their engineering program.

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The Asia-Pacific Journal of Cooperative Education publishes peer-reviewed original research, topical issues, and best practice articles from throughout the world dealing with Cooperative Education (Co-op) and Work-Integrated Learning/Education (WIL).

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