An evaluation of the impact of using authentic design and build industry projects in project-based learning

Clive Ferguson[a], and Stuart Palmer[b]
Chisholm Institute [a], Deakin University[b]
Corresponding Author Email: clive1@ncable.net.au

BACKGROUND
Chisholm's 'first year experience' is a significant feature of the new industry focused Bachelor of Engineering Technology program delivered in association with the South East Melbourne Manufacturers' Alliance (SEMMA). This conceive-design-implement-operate (CDIO Initiative) program commenced as a full time program in first semester 2012. Whereas it is common for CDIO Initiative programs to have a first year experience program containing a project typical of the type of industry project they would complete as a graduate engineer or engineering technologist, this goes further by using real industry projects provided by SEMMA members.

This design-and-build industry project runs across both semesters supporting project-based learning in three first year subjects. A concern is that the industry involvement of the projects adds substantially to an already heavy student workload. This has been further increased by the addition of two additional first year initiatives: writing workshops, and training in, and substantial use of, student oral presentations. It is recognised that an excessive workload could lead students to adopt surface learning approaches in other subjects.

PURPOSE
The goal of the project is to evaluate student perceptions of the value and work load impact of the industry project and the other new first year initiatives.

DESIGN/METHOD
Central to this project is a student survey-based evaluation of the industry project based learning that is the core of the 'first year experience'. The participants were limited to the small group of students who, in a single year, completed all three subjects that comprise the 'first year experience'. To avoid compromising the results the survey was administered by Chisholm Institute's Department of Strategy and Planning with no engineering technology degree program staff present. The survey included questions to enable responses to be linked with specific student demographics without identifying any of the respondents.

RESULTS
The study showed the industry project-based learning had worthwhile outcomes but placed considerable time pressures on most respondents. For some, this also impacted on their other subjects. A first year oral presentation program was also shown to have worthwhile outcomes. However no conclusions could be reliably drawn on the third initiative – writing workshops.

CONCLUSIONS
The results confirm that the authentic industry project is considered a worthwhile initiative but contributes significantly to student overload. This applies also – to a lesser extent – to the first year oral presentation program. Both also require new approaches to delivery as student numbers increase. Strategies to address these issues are discussed.

KEYWORDS
Project-based learning; Industry projects; Graduate attributes; Writing skills; Oral presentations; Student workloads.

Introduction

Chisholm Institute, based in South East Melbourne and surrounding regional areas, is one of the largest Victorian Technical and Further Education (TAFE) Institutes. TAFE Institutes are strongly industry focused and provide a wide range of predominantly vocational tertiary education courses in fields including engineering, business, finance, hospitality, tourism, construction, information technology and community work. TAFE institutes are owned, operated and financed by state and territory governments whereas the university sector – also owned by the state governments – is predominantly financed by the federal government. Until 2002 the TAFE sector delivered qualifications up to Advanced Diploma level, but has since been able to offer Bachelor degrees (and postgraduate diploma courses) to fill niche vocationally focused areas of study to meet local industry needs. However whilst their degree programs must be accredited by Australia's independent national higher education regulator, the programs as yet receive no funding from either the state or federal governments. Funding is entirely from full fee paying domestic and (increasingly) international students.

The Chisholm Institute Bachelor of Engineering Technology program commenced the full first year of the program in 2012. It is the first engineering technology degree program to be delivered outside of the Australian university sector. It has two streams, mechatronics and mechanical, and was developed in association with the South East Melbourne Manufacturers' Alliance (SEMMA) to meet the needs of high technology manufacturing. Almost half of Victoria's manufacturing output comes from the South East Melbourne region and SEMMA represents more than two hundred of the region's leading manufacturers.

Through the development of this program Chisholm became one of the first collaborating educational institutions in the Australia and New Zealand region of the worldwide CDIO Initiative. The CDIO Initiative – initially conceived within the Department of Aeronautics and Astronautics at MIT – was built on the realisation that engineering education and real professional practice had drifted apart since the 1950s. The focus of the Chisholm program on industry requirements led naturally to close alignment with the worldwide CDIO Initiative.

The stated aim of the CDIO Initiative is to educate (engineering) students to understand how to Conceive-Design-Implement-Operate complex value-added engineering products, processes and systems in a modern, team-based environment (Crawley, Malmqvist, Lucas, & Brodeur, 2011). A requirement for CDIO Initiative programs is to have a first year 'introduction to engineering' module using structured design-build experiences to:

- illustrate the roles and responsibilities of professional engineers and technologists and the people with whom they interact;
- illustrate how disciplinary knowledge is applied in the solution of engineering problems; and
- target the development of knowledge, skills, and attitudes essential in professional engineering and technology. (Ferguson et al., 2008)

To support these aims a further requirement of a CDIO Initiative program is that it should have at least one design-build experience at a basic level. (Crawley, Malmqvist, Östlund, & Brodeur, 2007)

The Chisholm industry project-based learning concept

Chisholm's 'first year experience' meets these CDIO Initiative requirements employing project-based learning that uses real design and build industry projects that address manufacturing or product design issues. These are provided by SEMMA member companies. In practice there is an overlap between problem-based learning (PBL) and project-based learning. PBL began in the early 1970s at the medical school of McMaster University Canada, gaining growing attention in vocational disciplines, particularly medicine and dentistry. It is defined as a teaching strategy in which, "students confront contextualised, ill-structured problems and strive to find meaningful solutions" (Rhem, 1998, p. 1).

Project-based learning has its roots in experiential education and John Dewey, however it developed later than PBL (Rhem, 1998). Like PBL, project-based learning has a series of tasks designed to develop predetermined skills. However project-based learning more commonly has supporting lectures and the project is designed to draw on the background teaching program. Increasing use of project-based learning to address attribute development by Australian engineering schools was observed by Engineers Australia accreditation panels as long ago as 2005 (Bradley, 2005). In most cases projects are 'made-up' with the very notable exception of the international development projects offered by Engineers Without Borders. It is recognised however that 'made-up' projects have the advantage that they can be designed to be more closely targeted to subject content. In many cases several groups are given the same project challenge with groups often in competition with each other. However in the Chisholm degree program each group has a different real engineering project, usually provided by different companies and with inevitable variances in project complexity. The industry project is integrated into three first year subjects: 'Engineering Design and Practice' in first semester and 'CADII' and 'Engineering Practice II' in second semester. Engineering Practice II provides practical workshop skills in welding and fabrication but groups are also given access to the fitting and machining workshops as required to complete the build phase of their project. They will have completed their introduction to fitting and machining in the first semester.

Each sponsoring company is asked to present the details of their project on site to the student group who has selected their project. To develop student creativity the project must be presented as an issue to be solved by an engineering project rather than as a suggested solution. Each student group then develops at least three alternative proposals and uses a decision matrix to select their recommended design. At the end of 'Engineering Design and Practice' each group presents their various design concepts along with their recommended design (and approximate costs) to their sponsoring company as a group report and a group oral presentation in front of all of the sponsoring companies. Subsequent discussions (usually) lead to a design the company is willing to fund. The full working drawing package and subsequent build are then carried out across the two second semester subjects 'CADII' and 'Engineering Practice II'. A final group report to the industry sponsor is also a major part of the assessment for Engineering Practice II. However there are also two related elements added to the original accredited course structure of the first year of the program. These include a focus on using oral presentations as part of the assessment of several first semester subjects. Initial guidance and practice is provided in the subject 'The Professional Engineering Technologist'. To better support report writing skills, 'mind map'-based writing workshops were introduced in 2013 to complement the existing topic on report writing in 'The Professional Engineering Technologist' which focused on format and referencing. Both the writing workshops and oral presentation program contribute to the development of attributes assessed in the first year experience program.

The three initiatives do add to an already significant student workload. Although these initiatives encourage deep learning strategies it is critical that care be taken that they do not add unnecessarily to the student workload forcing some students to adopt a surface learning approach in other subjects. Beswick and Ramsden (1987) report a negative example of an additional activity-based unit developed specifically to deliver study skills to students over a number of Faculties that led to an increase in the use of rote learning (Beswick & Ramsden, 1987, p. 11). One reason given for the increase in surface learning was that the extra workload forced the students to adopt this approach to enable them to cope with the workload. Thus it is important to assess the educational and attribute value of these initiatives so as to deliver them as efficiently and effectively as possible.

The student demographic in this program differs considerably from that of a conventional university program. In 2012 the first year of operation of the degree program overall student numbers were very small, mainly domestic part time mature age students in full time employment. Most subjects were run in the evening as well as during the day. However the

subjects comprising the first year experience program were run only during the day. This resulted in only eight full time students taking part. In 2013 student numbers had grown substantially due mainly to international marketing and were now mainly young full time international students. The first year experience program was run during the evening to enable part time students to take part. However the fourteen students who studied all three subjects that comprised the first year experience were still predominantly full time students.

In 2012 a case of plagiarism involving two international students led to the recognition that some students do not have the basic essay writing skills we anticipated and would be severely disadvantaged in many assessment tasks throughout the program. This led in 2013 to the addition of creative mind mapping workshops to the report formatting and referencing skills delivered in 2012.

Based on experiences gained from the first year of program delivery a number of changes were incorporated into the program for 2013. The most significant was a substantial reduction in semester length from 15 weeks to 13 weeks (to bring it more in line with the Australian university sector). Changes that impact this study are:

1. The subject 'The Professional Engineering Practice' was extended from 10 weeks to 13 weeks and additional course credit points were allotted to this subject.
2. In 2012 the 6 week subject Engineering Practice II followed the 9 week subject CAD11. In 2013 the two subjects ran in parallel and the total scheduled contact hours were increased for each subject.

Method

The aim of this survey-based research was to determine the overall value of the industry-based first year project and the impact of the attribute developing features of adopting oral presentations as an assessment mechanism in a number of first year subjects, and the writing skills workshops introduced in 2013. The impact of the writing skills workshops would be through comparisons of the responses from those who studied 'The Professional Engineering Technologist' in 2012 and those who studied that subject after the writing skills workshops were introduced in 2013. The survey instrument began with a plain language statement indicating the research aims, method, confidentiality and estimated time commitment. It included a statement that the participant was free to withdraw from the study at any time and any information gathered up to that time would not be used.

The survey was in four parts:

1. Demographic information to provide deeper insights into the results and enable the comparison of responses between those who undertook the writing workshops and those who didn't.
2. Questions relating to the adoption of oral presentations as an assessment strategy in developing their presentation skills and confidence and in helping them learn.
3. The perceived value of the writing workshops in helping them to improve their written assignments throughout the program.
4. Questions relating to the industry project including the value in providing context for their study, team work issues and time pressure.

Questions for the sections on oral presentations, writing skill workshops, and industry project used Likert-type scales. Boxes were also provided at the end of each of these sections to encourage the respondents to provide comments and insights.

At the time of the study all twenty two first year experience participants were enrolled in one of two subjects. Classes in these two subjects were selected to implement the survey. To avoid any coercion of participants the administration of the survey was carried out entirely by Chisholm Institute's Department of Strategy and Planning. No staff member of the Bachelor of Engineering Technology program was present during the distribution and completion of the survey instrument. From the attendance list it was discovered that seven participants were not in attendance in those classes. These students were mailed the form to complete

and return by reply paid envelope to the Department of Strategy and Planning. Only one responded. From the survey demographic responses it was discovered that the response from the 2012 cohort comprised just four out of the eight participants, whilst twelve of the sixteen 2013 cohort responded. At 72.7% the overall survey response rate is particularly good. However with only a total of sixteen respondents the results of this study can be seen as indicative rather than definitive.

Results and Discussion

First year oral presentations

An engineering or engineering technology degree program that in the first year prepares students for oral presentations and reinforces these skills through a number of oral presentation-based assessments throughout the year is rare, particularly for programs with high enrolments. In many engineering degree programs this is left until the capstone year of the degree program. This part of the study assesses the students' perceptions of the value of this feature of the Chisholm program. The results given in Figure 1 show that all students agreed that the first year oral presentation guidance and practice helped develop their ability to prepare for an oral presentation with the majority indicating that the effect was notable or significant. Figure 2 shows that most students considered the first year oral presentation program did help them develop their ability to deliver a presentation. The results presented in Figure 3 show most considered the guidance and practice in oral presentations helped their level of confidence to deliver oral presentations.

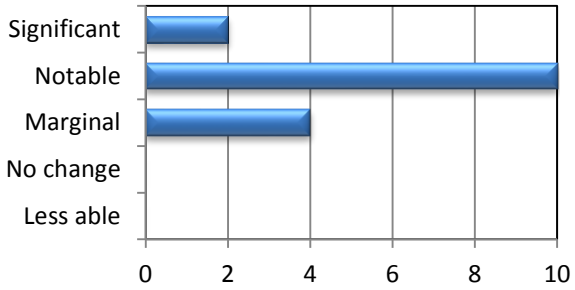

Figure 1: Ability to prepare for presentations

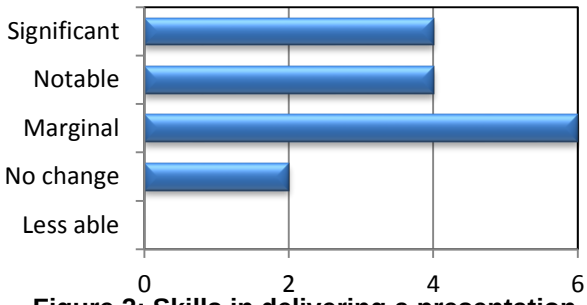

Figure 2: Skills in delivering a presentation

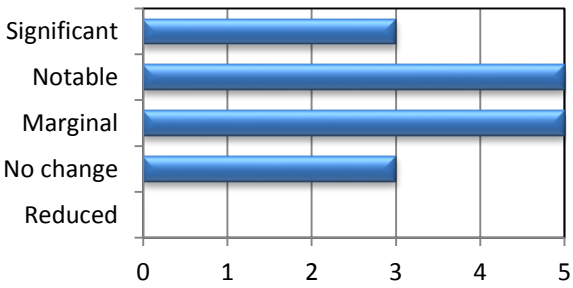

Figure 3: Confidence in presenting in front of an audience

The question posed in Figure 4 'is based on the old adage that 'the best way to learn is to teach'. Figure 4 shows that whilst 25% felt it an equivalent study method, the majority considered it marginally better and a few found it notably or significantly better. The critical final question for this section was whether they felt that the time spent on oral presentations was worthwhile. The results presented in Figure 5 show that no student felt that it was not worth the time. Whilst 25% said the time spent was just balanced by value of the skills and knowledge gained, 75% considered the skills and knowledge gained more than justified the time spent.

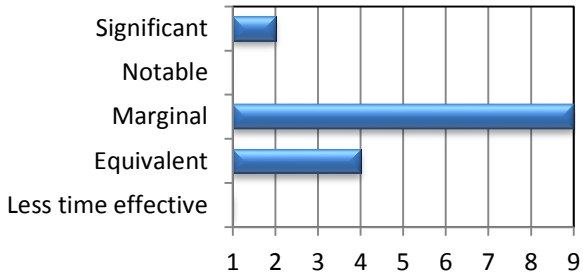

Figure 4: Did preparation for orals help your studies?

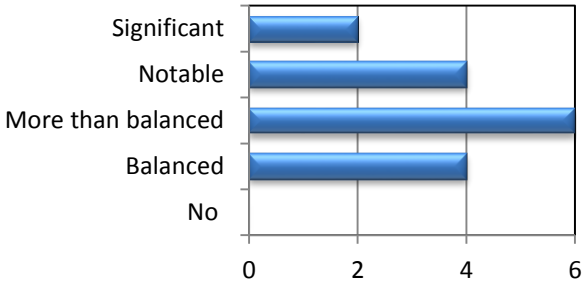

Figure 5: Time spent on oral presentation worthwhile?

Overall the results show most students found the significant use of oral presentations was beneficial. In the comments boxes there were six positive comments and two negative comments. Of the positive comments most considered the oral presentations improved their research skills and increased their self-confidence. One negative opinion was that there were too many oral presentations. In comparison, in a study of another 1st year engineering degree project-based learning course in which training and practice in oral presentation was not a feature of the first year program, the satisfaction rating for the oral presentations in the project-based learning program received the lowest satisfaction rating in student assessment of the various features of that project-based learning program (Palmer & Hall, 2011).

Writing workshops

To determine the impact of the writing skills workshops introduced into the program in 2013 this section presented the following question: 'How much did 'The Professional Engineering Technologist' help develop your writing skills to improve your written assignment across the program?' The results are presented in Figure 6. These results are based on the combined responses from eight 2012 students who studied the subject 'The Professional Engineering Technologist' before the writing skills workshops were introduced and the eight 2013 students who studied the subject after the writing skills workshops had been introduced. The Professional Engineering Technologist' is offered each semester to accommodate mid-year entry students so some 2013 'first year experience program' students would have taken The Professional Engineering Technologist in 2nd semester 2012. The responses from the two individual year groups are shown in Figures 7 and 8.

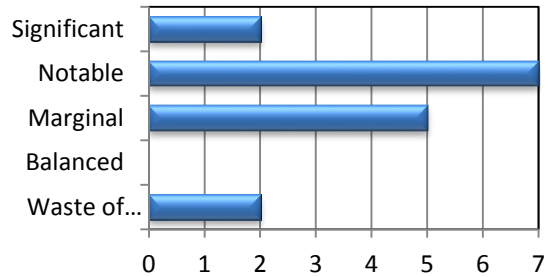

Figure 6: How much did PET help develop your writing skills? (All)

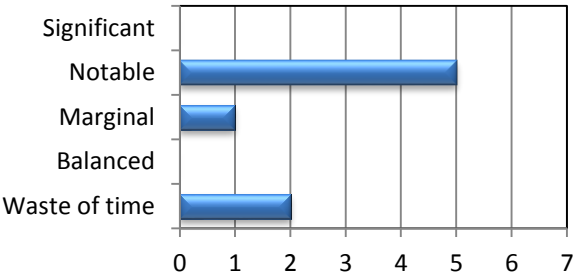

Figure 7: How much did PET help develop your writing skills? (2012)

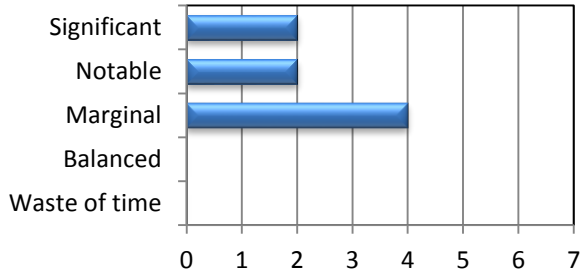

Figure 8: How much did PET help develop your writing skills? (2013)

The 2013 results show a modest improvement over 2012. However the very small sample size and significant difference in demographics between the two samples – maturity and the significant difference in students for whom English was their first language – prevent reliable inference of the positive impact of the writing workshops. Other factors affecting reliability include the major course changes introduced in 2013 and the likely impact of the plagiarism inquiry on the responses of those involved. Note that the 2012 students were unlikely to be aware of the writing workshops provided in 2013.

Industry projects

The most significant aim of the industry focused project is to provide context for their studies and provide them with a clearer idea of the role of an engineering technologist. Did it achieve this? Whilst this feature is aimed mainly at school leavers, a major demographic feature of the program in the initial year was the high proportion of mature age mid-career part time students. The results are shown in Figures 9 and 10. Many mature age students gained full or partial exemption from the first year experience program through prior qualifications and experience. However close investigation shows most mature age students in the study indicated greater appreciation than many without their experience. Nevertheless the single respondent who indicated the industry focused project did not provide context for his/her studies had one year of prior industry experience. The other responses varied from marginally to extensively providing context. The respondent indicating the industry project provided him/her no insights into the role of the engineering technologist did not provide information on his/her prior industry experience. The other responses varied from 'a little' to 'considerable' with the greatest number indicating it provided them significantly insights into the role. Figure 11 presents the responses to a question on which major aspect of the industry project was most valuable in providing context for their studies and shows most felt both the industrial project and the exposure to the industrial environment had been of value to their studies. Figure 12 presents responses to the question 'What value do you consider the industry-based project has added to your studies?' and shows all felt it had been of some value to their studies with most indicating that the value was notable or greater. It is noted that one of the participants did not complete the survey beyond this point so the number of participants for questions 11 onwards has dropped to fifteen.

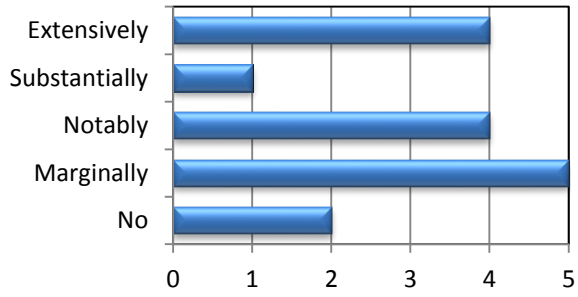

Figure 9: Provide context for your studies?

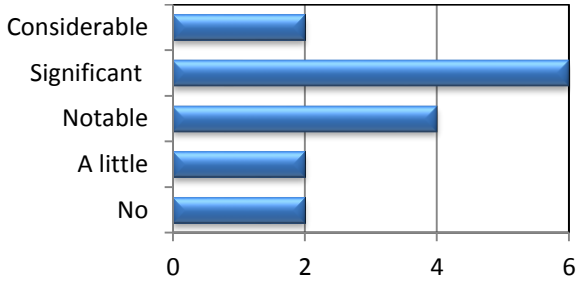

Figure 10: Clearer idea of role of Engineering Technologist to put studies into context?

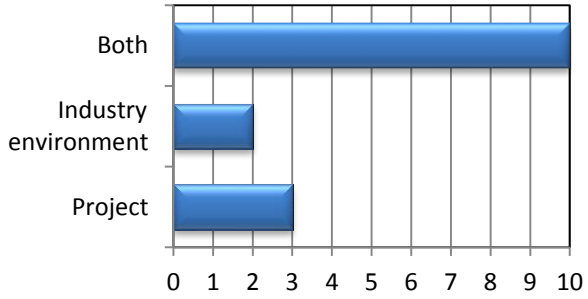

Figure 11: What aspects have been valuable?

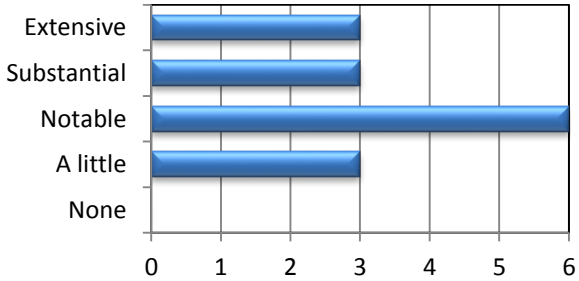

Figure 12: What value has this added to your studies?

Figures 13, 14 and 15 present the responses to questions on team work. These relate to their enjoyment of working in a team, the level of team commitment within the group and

communication within their group. It is noted that one more of the participants did not complete their survey beyond the point represented by Figure 14, so the number of participants for these and the remaining questions dropped to fourteen. From Figure 13 it can be seen that all liked working in groups to varying degrees. From the responses shown in Figure 14 it can be seen that the group experience of most respondents was of teams where most members were committed to the project. Some were in groups where most members were enthusiastically committed. Figure 15 shows most students were in groups with an agreed leadership and organisation structure but either there were deficiencies in the team communication structure or there were occasions where the leadership and/or communication structure broke down. Only two believed their group worked effectively. Figure 16 presents the students' perceptions of the time pressure imposed on them by the industry project. They confirm our concerns. Only two students considered the work load imposed was manageable with no adverse side effects. Eight indicated notable or significant pressures which impacted or compromised their other studies, but considered it worthwhile. However four considered the load substantial and that other studies were being severely compromised.

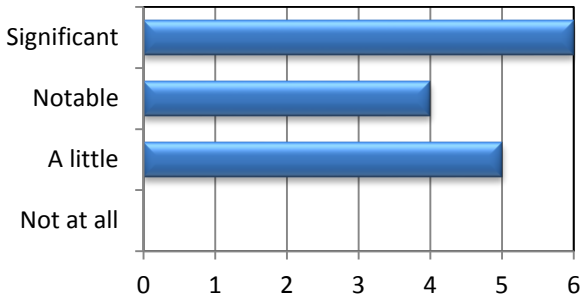

Figure 13: Enjoy working in a team?

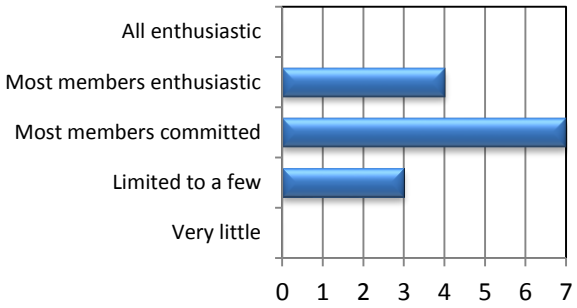

Figure 14: Team Commitment?

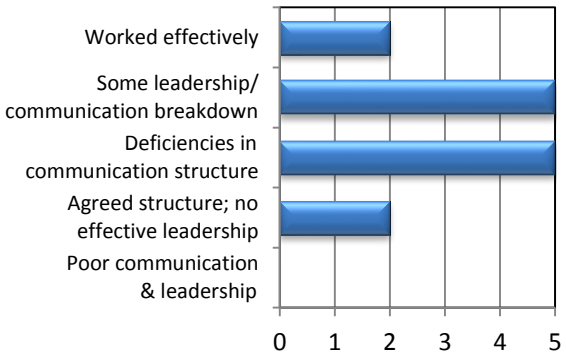

Figure 15: Team Organisation and Communication

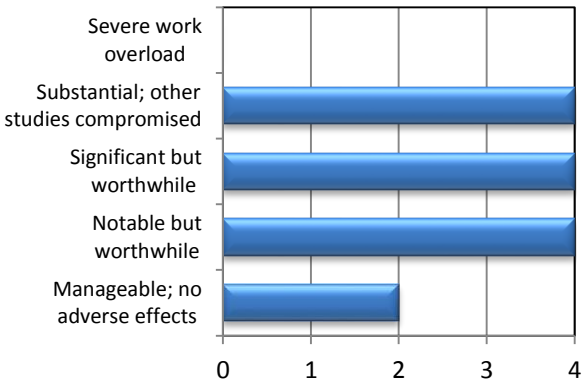

Figure 16: Time pressure

Conclusions

Overall the oral presentation program has been shown to be worthwhile. Maintaining it in this form as the program expands will be problematic as the oral presentations consume an increasing proportion of the program delivery time with increasing enrolments. One strategy is to establish tutorial groups in which the oral presentations and individualised guidance and training can be given through smaller cohorts of students. Whilst overall the results would seem to indicate the writing workshops are worthwhile, the very small number of respondents in each comparative year group, significant differences in student demographics between the years, the significant changes to the program delivery that took effect in 2013, and the significant overlap of the results between the two years, suggest no conclusions can be reliably drawn from this part of the study. Nevertheless it is anticipated that the support provided would significantly reduce student workload across the program and more than compensate for the time spent in the writing workshops. The study shows clearly that the

industry-based project-based learning had worthwhile outcomes, but strategies must be developed to contain the significant time pressures placed on the students. More guidance and support in team skills may contribute. However a review of the total workload of the degree program is also to be undertaken.

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The paper is dedicated to Dr Brian Edmund Lloyd AM 30/6/1929 – 2/3/2014. It is hard to over-estimate Brian's impact on engineering and engineering education in Australia. Aside from a distinguished career in engineering practice, he prepared much of the evidence for the landmark Professional Engineers Case in Australian industrial law, which achieved salary increases of more than forty percent for employee engineers in the 1960s. Arising from the Case was a passionate concern for the education of the engineering workforce, and his publications over three decades were a reference point for the preparation of professional and para-professional members of the engineering workforce. His 1989 book 'New Pathways in Engineering Education' established principles for educational articulation from technical to higher education, and described the occupational classification of engineering technologist, the subject of this paper. Brian was a past national President of the Institution of Engineers, Australia, and a friend, professional colleague and co-author in the endeavour of Engineering Education.

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