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Enhancing job readiness in an engineering technologist program – a case study

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ABSTRACT

CONTEXT

Majority of Australian engineering faculties offer programs that lead to Professional Engineering qualifications. Several of these faculties also offer programs that lead to Engineering Technologist qualifications. The difference between professional engineering degrees and engineering technologist degrees is that they should have different levels of terminating skills and qualification for different EA Stage 1 Competencies. This paper reports on the design and implementation of a subject for a Bachelor of Engineering Science program, leading to technologist qualification. The subject was co-designed, co-delivered and co-assessed through collaboration between Western Sydney University (WSU) and TAFE NSW. The subject will enable graduating students to be job ready at Engineering Technologist level.

PURPOSE OR GOAL

The motivation of this study was to develop and offer a suite of subjects to ensure that graduates of the program had the requisite skills to practice and succeed following graduation. The focus was on ensuring graduates satisfied the Engineers Australia (EA) Stage 1 competencies for Engineering Technologists. This paper will present the lessons learnt from one of these subjects.

APPROACH OR METHODOLOGY/METHODS

The subject was the result of the partnership between WSU and TAFE NSW to co-design, co-develop, co-deliver and co-assess. This process was undertaken in various disciplines, Civil and Construction, Mechanical, Robotics and Mechatronics and Electrical Engineering. The co-designed subject was implemented in Autumn 2023. Feedback on the implementation was obtained from the students as well as the staff at both the university and TAFE NSW.

ACTUAL OR ANTICIPATED OUTCOMES

The key outcomes are the design of the content in different disciplines to capture the key hands-on skills that are required by students to work in the engineering technologist field of practice. Feedback from students and staff at the University and TAFE NSW were obtained and analysed.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The inclusion of the specialisation workshop has improved the engineering technologist degree by incorporating hands-on technical skills into the curriculum. This will ensure graduates to be job ready at technologist level. The co-design, co-delivery and co-assessment is expected to have enabled students to get a richer learning experience that allows them exposure to knowledge and facilities at both the University and TAFE NSW. A revision for future deliveries has been proposed based on the review of the design and implementation processes as well as the feedback received. Furthermore, a second specialisation workshop has been co-designed and co-developed is currently being co-delivered in the Spring semester.

KEYWORDS

Job-Ready Graduates, Engineering Technologist, Co-Design, Partnership.

Introduction

Western Sydney University (WSU) offers the Bachelor of Engineering (Honours), the Bachelor of Engineering Advanced (Honours), and the Bachelor of Engineering Science programs. The Bachelor of Engineering (Honours) and the Bachelor of Engineering Advanced (Honours) are four-year degree that result in graduates who have gained EA Stage 1 Competencies for Professional engineers while the Bachelor of Engineering Science is a three-year degree that results in EA Stage 1 Competencies for engineering technologist.

According to Engineers Australia, Professional Engineers hold an accredited or recognised 4-year degree. The qualifications for Professional Engineers are accredited by signatories of the Washington Accord which was originally signed in 1989 (International Engineering Alliance 2014). According to Engineers Australia, professional engineers have skills to "focus on overall systems, develop and apply new engineering practices, apply leadership and management skills, pursue engineering opportunities in a holistic way, taking environmental, community and social issues into consideration and solve diverse problems" (Engineers Australia 2023).

On the other hand, Engineering Technologists hold an accredited or recognised 3-year degree by signatories of the Sydney Accord which was originally signed in 2001. In terms of skills, the Engineering Technologists have the skills to "focus on interactions with the system, modify and adapt established engineering practices and advance engineering technology" (Engineers Australia 2023).

The Bachelor of engineering science degree started in 2010. It was designed to cater for high school students who who has set engineering technologist as their future career. This programme also accommodates mature age and students with diplomas and advanced diplomas from vocational institutions. These students would typically have relatively lower science and mathematical skills than students in other programs. In its inception, the Bachelor of Engineering Science had fewer mathematical subjects in its structure compared to the Bachelor of Engineering (Honours) program. Initially, the structure of the Bachelor of Engineering Science replicated the first three years of the Bachelor of Engineering (Honours) program other than the mathematics component. This initial structure allowed students to upgrade to the Bachelor of Engineering (Honours) without losing any time for the study they had already completed. This also meant, that students from the Bachelor of Engineering (Honours) could exit with the Bachelor of Engineering Science degree if they wanted to leave university after completing three years of study. While this design enabled students to easily transfer from one degree to another, it meant that the Bachelor of Engineering Science degree did not have the necessary terminating skills of an engineering technologist. This also meant that the Bachelor of Engineering Science did not have the necessary structure for EA accreditation. In 2019, the School of Engineering decided to develop a program structure to ensure that the Bachelor of Engineering Science could be considered for full accreditation. In doing so, the structure of the Bachelor of Engineering Science was modified to have subjects that would allow students to have terminating skills such as hands on skills and research skills (EA, 2019).

A review of literature shows that over the years engineering education has evolved. Prior to the 1950s engineering education was characterised by foundational studies, visualisation and graphical skills in drawing rooms (Lamancusa *et al.*, 2008). Lamancusa *et al.*, 2008 also points out that in the 1960s, the so called "Golden Age" of research, increasing enrolments and the availability of computers meant that the focus shifted to students doing less practicals as engineering training shifted to the use of computers for routine work. Lang *et al.*, 1999 also supports this view and notes that engineering educators after World War II were largely PhD trained with little industry experience which increased the gap between engineering schools and industry. Lamancusa *et al.*, 2008 acknowledges that today, there is agreement that a balance between engineering science and engineering practice is essential in educating engineers. In his analysis of the redesign of a mechanical engineering subject, Liu 2017 pointed out that with the rapid changes in economic growth and high expectations of employers, new graduates are expected "to perform in their organisation as soon as they are hired" and to have "career skills such as teamwork,

communication, project management and leadership.”. This shows the importance and pressures on new graduates to be job ready. This realisation has also driven the revision of the Bachelor of Engineering Science curriculum at Western Sydney University.

The modified structure of the Bachelor of Engineering Science was designed to have both engineering project subjects and newly developed specialisation workshops. The specialisation workshops were co-designed in partnership with TAFE NSW. The specialisation workshops were designed for three different disciplines, respectively: (a) Civil and Construction engineering, (b) Electrical engineering, and (c) Mechanical and Robotics & Mechatronics engineering. This paper outlines the design of Specialisation Workshop 1, one of the subjects that forms an indispensable part of the revised Bachelor of Engineering Science program. The specialisation workshop subjects were co-designed using the partnership pedagogy principle (Barrie & Pizzica, 2019) and were co-delivered and co-assessed by staff from both WSU and TAFE NSW.

Program Structure of the Bachelor of Engineering Science

The generic program structures for the old and revised Bachelor of Engineering Science are compared and listed in Table 1. The Table shows the subjects that are common to all engineering disciplines as well as a description of subjects that are undertaken by students in Year 1, 2 and 3 for both program structures.

Engineers Australia Stage 1 Competencies

In both the old and revised program structures, year 1 students focus on mathematics, science, and introductory engineering subjects. The first year of the program allows students to gain Engineers Australia Stage 1 competencies on knowledge and skill base. Similarly, for both the old and the revised program structures, the second year allows students to gain Engineers Stage 1 competencies in engineering application ability. In the third year of the old program, there was an emphasis on engineering application ability as the old course had been designed as an exit program that lacked subjects that enabled students to gain Engineers Australia competencies in professional and personal attributes and engineering application abilities essential for engineering technologist graduate training (EA, 2019). In addition, the revised program design was the result of the adaptive strategy adopted by the School (Hu *et al*., 2022).

The revised Bachelor of Engineering Science program has been designed to address this deficiency by including subjects that enable students to develop both professional and personal attributes and engineering application abilities essential for engineering technologists. The Specialisation Workshops (1 and 2) provide students to gain essential hands-on skills in their respective disciplines. Specialisation Workshop 1 and Specialisation Workshop 2 also allow students to work in environments that to a great extent simulate the authentic work environment.

In addition, the workshop subjects in the revised Bachelor of Engineering Science program prepare students to successfully complete the two capstone projects, Engineering Science Project 1 & Engineering Science Project 2. These project subjects provide terminating experience where students work in groups to develop their teamwork skills and communication skills. This enables students to gain competencies in professional and personal attributes including life-long learning attributes. As the main difference between the Professional Engineer and the Engineering Technologist is the ability to focus on overall systems, the newly designed Bachelor of Engineering Science program replaced design subjects that had a system thinking focus with hands on specialisation workshop subjects.

Table 1: Generic program structure for the Bachelor of Engineering Science

Year	Semester	Old structure	Revised Structure
Year 1	Autumn	• Mathematics for Engineers Preliminary • Physics and Materials • Engineering Computing • Engineering, Design and Construction Practice	• Mathematics for Engineers Preliminary OR Mathematics for Engineers 1 • Engineering Computing • Engineering Physics • Introduction to Engineering Practice
	Spring	• Mathematics for Engineers 1 • Fundamentals of Mechanics • Electrical Fundamentals • Engineering and Design Concepts	• Mathematics for Engineers 1 OR Mathematics for Engineers 2 • Fundamentals of Mechanics • Introduction to Materials Engineering • Electrical Fundamentals
Year 2	Autumn	4 Civil or Mechanical or Electrical Discipline Theory Subjects	• 3 Civil or Mechanical or Electrical Discipline Theory Subjects • **Specialisation Workshop 1**
	Spring	4 Civil or Mechanical or Electrical Discipline Theory Subjects	• 3 Civil or Mechanical or Electrical Discipline Theory Subjects • **Specialisation Workshop 2**
Year 3	Autumn	4 Civil or Mechanical or Electrical Discipline Analysis and Design Subjects	• 4 Civil or Mechanical or Electrical Discipline Analysis and Design Subjects • **Engineering Science Project 1**
	Spring	4 Civil or Mechanical or Electrical Discipline Analysis and Design Subjects	• 2 Civil or Mechanical or Electrical Discipline Analysis and Design Subjects • **Elective** • **Engineering Science Project 2**

Specialisation Workshop subject

This paper focusses on the design and implementation of Specialisation Workshop 1, a subject in the first semester of the second year of the program (see Table 1).

The subject was developed to augment technical skills development in the Bachelor of Engineering Science graduates. It was designed to enable students to undertake workshop practice that deals with development of products, manufacturing, development of infrastructure and the delivery of services depending on the discipline students are enrolled in - Civil and Construction, Electrical and Mechanical and Robotics & Mechatronics. As a workshop practice subject, the subject was designed to give students hand-on experience in simulated workplace environments. This subject enabled students to gain skills in planning, communication, operation and management of workshop, laboratory and work sites in a safe and collaborative team environment. Each of these

aspects have been found to be critical for health and safety in a teamwork environment (Shaikh et al., 2023).

Subject Content

The workshop practice content for Specialisation Workshop 1 depends on the discipline the student in the subject is enrolled in. The subjects have been co-designed to ensure that students gain the most relevant experience based on the working environment they are most likely to work in after completion of their course.

The Civil and Construction Engineering students have workshop practice in the following areas:

(a) Engineering drawing and Computer Aided Drafting (CAD)
(b) Civil and Construction Design
(c) Civil and Construction Management

The Civil and Construction Engineering workshops were designed in collaboration with TAFE to ensure that the workshop practice utilised the workshop and laboratory infrastructure that was unique to TAFE and not available at the university. The workshops covered the following areas: Risk Management, Work Safety & WHS Policy, Construction Plans & Specifications, Regulations, Site investigations & Preliminaries, Surveying & Earthmoving, Loading on Structures, Underground Services, Foundation Design and Small Plant & Equipment.

On the other hand, content for the Electrical Engineering workshop focused in the following areas:

(a) Industrial Electronics and Control
(b) Power Electronics and Communications
(c) Renewable Energy

Students were to be trained to design, construct and analyse circuits at different levels of difficulties. Students are to be fully involved in the development processes of these circuits under strict supervision of qualified professional staff. The content has been designed to boost their competencies, professionalism and practical knowledge. Circuits are then tested using a simulator and oscilloscopes. Students are strictly assessed by their supervisors on how these circuits work and their principle of operations to ensure in-depth knowledge is gained. The hands-on practical training equips students with sufficient skill sets to tackle their final year projects should they decide to enter Bachelor of Engineering program. Otherwise, the training is important for students to further their career developments as technologists.

The Mechanical and Robotics & Mechanical Engineering students have workshop practice in the following areas:

(a) Engineering drawing and Computer Aided Drafting (CAD)
(b) Mechanical Design
(c) Mechanical workshop

The contents (a) and (b) were delivered by academic staff at the university. The content was designed to let students learn fundamental knowledge in design, strain and stress analysis, safety analysis using engineering software. The third part (c) was delivered in workshops and labs. It is designed for student to learn practical skills through manufacturing simple machine parts using engineering machines and tools, including CNC machines, welding machines, 3D printers, folding machines and hand tools. The engineering design and analysis in Parts (a) and (b) were implemented and tested in Part (c). This allowed students to establish the link between the theory and practice.

Assessment

The learning outcomes of Specialisation Workshop 1 were related to students designing solutions in real work environments, applying project management procedures, developing safe work procedures, teamwork and communication. The learning outcomes for the subject are as follows:

1. Design engineering solutions by applying engineering fundamental principles, methods and tools to real world problems
2. Apply project management and engineering procedures and processes for engineering solution development and delivery
3. Develop safe work procedures in workshops, laboratory settings and work sites and in discussion with peers and the facilities team
4. Develop collaboration skills in managing teamwork and team projects with respect for diversity and inclusiveness to achieve project outcomes
5. Communicate concepts, solutions and project outcomes clearly and ethically in a range of formats

The assessments shown in Table 2 were designed to enable students to gain the stated subject learning outcomes. There are four assessments in this subject.

The weekly assessments are designed to enable students to gain knowledge in the different topics prior to doing the workshop practicals. While nominal marks were awarded in the weekly tutorial submissions, these formative assessments allowed the students to gauge their learning in addition to the teaching team to assess progress of individual students throughout the semester.

The fortnightly submission of workshop sheets then enabled students to be assessed in the hands-on practice sessions that were linked to their weekly tutorial assessments. This ensured that individual students were competent in the skills required in the real-world practice environment.

As part of the assessments, students were also required to work in small groups of 2 or 3 to write a report on a project that included the key content items as well as relevant subject learning outcomes for the discipline. The assessment of the group report also considered both individual and group contributions. The group report was complemented by a group presentation that students make following the submission of the report. The oral presentation also allowed the teaching team to get a better understanding of the depth of students' understanding of the subject matter.

Table 2: Assessment Details

Assessment	Individual (I) / Group (G)	Weighting
Weekly Submission of Tutorial Worksheets	I	20%
Fortnightly submission of Workshop Worksheets	I	40%
15-minute Group Presentation	I, G	15% (5 (I), 10 (G))
Report	I, G	25% (5 (I), 20 (G))

Implementation

The implementation of the Specialisation Workshop 1 into the Bachelor of Engineering Science program was approved by the university as well as TAFE. The academic leadership team in the University and the Managers at TAFE facilitated development and signing of the agreements that allowed the university students to use facilities at TAFE for conducting the workshops.

Following the co-design of the subject by Directors of Academic Programs and TAFE Team Leaders in the various disciplines, approvals for the subject were sought through the School Academic Committee and the Senate Academic Planning and Courses Approvals Committee (APCAC), ultimately gaining the approval of the Academic Senate.

The delivery of the subject was coordinated by the Directors of Academic Programs and TAFE Team Leaders through discussion with the TAFE teachers and University lecturers and tutors. The delivery of the subject at both TAFE and the University included the coordination of the timetabling teams, as well as consideration of workplace health and safety. Through this process, the students were informed of the personal protective equipment (PPE) requirements prior to each of the workshops.

Feedback

Feedback was sought from students to gather their perceptions of the subject content and delivery. The feedback centred on the best aspects of the subject, the experience in the workshops and possible areas of improvement. A selected list of the feedback from students (paraphrased for clarity) is presented below.

What were the best aspects of this subject?

- This subject content dealt with safety in construction. Various building rules and regulations were adequately covered.
- Teaching technique adopted in this subject was helpful in learning.
- The teachers were approachable and helpful.
- Engineering Workshop 1 is a like a comprehensive orientation for students in preparation to the real field work.
- The hands-on practical sessions exposed us on how to deal with chemical substances using the safety data sheet. The importance of personal protective gears were emphasized in all practical sessions.

How was your first workshop experience at TAFE?

- Great! Really liked it!
- The first workshop was interesting with extensive information on concrete and safety data. However, it was poorly organized and could be improved.
- The first workshop at TAFE helped gain better understanding of the theoretical knowledge learnt at the university.
- First workshop mainly focused on demonstration where the TAFE teacher provided detailed clear explanation.

What can be improved in the subject?

- The option should have been available across all campuses.
- Additional hands-on learning, like those in soil mechanics and fluid mechanics practical will be useful.
- Some site visits to increase the understanding about the practical side of construction world would have been beneficial.

Conclusions and Recommendations

This paper provided a brief discussion on conversion of the Bachelor of Engineering Science program from an exit program to a standalone program designed to enable graduates to gain Engineers Australia Stage 1 competencies for Engineering Technologist. The paper focused on the co-design and co-delivery of Specialisation Workshop 1. Student feedback suggests that they enjoyed the workshop which provided hands-on experience. The second workshop is being administered in the Spring semester, reflecting the learnings from the first workshop.

Conclusions

The following observations were made through experience of the co-design and co-delivery process between the university and technical education providers.

1. Co-design, co-deliver and co-assess
   This paper presents a good example of workshops co-designed and co-delivered by multiple organizations. It combines the strong academic and practical skills of universities and technical education institutes, respectively, to train engineering technologists that meet the requirements of EA.
2. Implementation of the subject
   This subject was aimed at students who needed to gain both theoretical knowledge and hands on experience. This was achieved through theoretical knowledge, design software and practical tools and machines using integrated projects. The projects were designed to integrate the abovementioned knowledges and skills together with the ability to solve engineering problems. The assignments were also to test the learning outcomes. Workshop project subject 1 was delivered in 2023 Autumn semester.

Recommendations

1. Involvement of industry to compliment simulated work environment in the workshop

   The projects in the workshop subject were co-designed by the academics and workshop supervisors together based on their experience in teaching. It is desirable to have industry partners involved in the co-design process to let the delivery of contents and assessment more authentic. This will also ensure students are industry ready when they graduate.

2. Challenges of multi-institution delivery

   Multiple challenges were presented due to multi-institution delivery. The first challenge was related to the timetable difference. This was satisfactorily addressed by aligning theoretical and practical components to be delivered with as little impact as possible to each institute's teaching of their other programs. Another challenge was related to the incompatibility of the LMS of the two institutions. As the result, the subject coordinator in the university had to act as the messenger to bridge the communication between students at the university and the workshop teacher at TAFE. Having a teaching website that can be shared by all the teaching team is important as we move forward.

3. Challenges of multicampus delivery

   There were logistical challenges to manage students from multiple campuses within the university and a separate campus of the technical institution. This was resolved through regular communication with the students. Due to the proximity of different university campuses and the technical institution, this challenge was satisfactorily resolved.

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