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Virtual work integrated learning for engineering students

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List of acronyms used

ACED	Australian Council of Engineering Deans
BP	British Petroleum
CHAIR	Construction Hazard Assessment and Implication Review
HAZOP	Hazard and Operability Study
OLT	Australian Government Office for Learning and Teaching
UWA	The University of Western Australia
VR	virtual reality
VWIL	virtual work integrated learning
WIL	work integrated learning

Executive summary

Engineers Australia accredits engineering education programs in Australia. Employability skills for engineering practice have been identified in the Stage 1 Competency Standards (Engineers Australia Accreditation Centre, 2018) which are stipulated by Engineers Australia as standards that must be met by graduates of accredited formative engineering degree programs. 'Exposure to practice' has long been recognised by Engineers Australia as a necessary element of engineering education (Bradley, 2008, p. 17), especially for the development of employability skills that have often been identified as deficient such as communication and leadership (Cameron, 2009; Male, 2010; Male, Bush, & Chapman, 2010; Male & King, 2019; Nair, Patil, & Mertova, 2009).

In 2014, 12 weeks of engineering work experience were mandatory in the majority of engineering programs in Australia (Male & King, 2019). At the time, and for decades previously, the Engineers Australia professional engineering program accreditation guidelines strongly recommended work experience of 12 weeks or more:

> *It is considered that there is no real substitute for first-hand experience in an engineering-practice environment, outside the educational institution. Engineers Australia strongly advocates that all engineering schools include a minimum of 12 weeks of such experience (or a satisfactory alternative)* (Bradley, 2008, p. 18).

Work experience had two significant limitations as the predominant approach to developing employability. First, the quality of the experience was unreliable. Second, not all students could secure work experience and consequently there were students who completed their coursework but could not graduate. Other weaknesses included the limited breadth of experience offered from a single employer, and the limited opportunities for work experience before the final years of coursework.

The here-reported project was a study of virtual work integrated learning (VWIL) — work integrated learning in which the work has been created for the purpose of learning rather than any true work for an employer or client. The aims were to: design, develop, and test VWIL examples to complement traditional opportunities for engineering students to achieve employability; integrate VWIL in curricula; and prepare a guide for educators on developing and implementing VWIL modules.

In VWIL, students undertake learning activities that involve industry but are not true employment (paid or unpaid). Students complete authentic tasks, using authentic tools and/or processes, and engage face-to-face or electronically with real or simulated workplaces and/or practitioners.

At all stages, the VWIL Project involved consultation with engineers, students, and educators.

The Project addressed the following questions.

1. How can VWIL be designed to support reliably large numbers of engineering students at various levels of their degree programs to develop employability skills?

2. How can engineering practitioners be engaged to support engineering students' VWIL?
3. How can VWIL be integrated in engineering curricula?

Requirements for VWIL were developed and refined through consultation. Engineers were interviewed to identify important learning for engineering practice and authentic scenarios to use in VWIL modules. Informed by literature and the interviews, modules were designed for students to learn about engineering practice, and to develop skills for: communicating in engineering using professional approaches including visual representations, undertaking authentic safety processes, and practising engineering ethically and in a manner that includes all members of diverse teams. Various electronic tools were tested in the modules, including interactive virtual reality (VR), 360 degree videos, and interactive computer simulations. Modules were initially piloted with small numbers of students (fewer than 25).

To support students and educators to give sufficient attention to developing employability, VWIL modules were integrated into credit-bearing units. Learning in credit-bearing units is aligned with learning outcomes, assessed, and graded, and therefore taken seriously by students. Integrating VWIL into existing units is authentic and efficient. Credit-bearing units attract student fees and have budgets for resources. Engineering practice is socio-technical in nature. Engineers work in teams using technical and social skills to serve society. Employability and technical skills can be developed and practised together in units, as in practice. In the VWIL Project, modules were integrated into credit-bearing units at all year levels, taken by as many as 430 students.

Workshops, presentations and discussions combined dissemination and stakeholder consultation. Key findings are below.

1. VWIL incorporating combinations of face-to-face and electronic engagement with real and simulated workplaces and practitioners and authentic engineering processes is feasible in units taken by hundreds of students, as an approach to supporting students to learn about engineering practice and to develop skills for engineering practice.
2. Reflecting with peers or practitioners contributes to students' learning in VWIL, as well as to their development of self-directed learning skills. For example, students can discuss their learning experiences with engineers to consider the context, actions, and consequences, plan how to improve, and plan when they might next apply their learning. Engineers can be recruited to engage with students in VWIL, even for hundreds of students in a single unit. Relationships with individual engineers such as university alumni and industry advisory panel members and board members are valuable in the volunteer recruitment process. Additionally, relationships with organisations provide reliable continued support.
3. Integration of VWIL into credit-bearing units is efficient because the VWIL learning activities can enhance achievement of the original learning outcomes in the unit. However, it is necessary to plan well in advance, especially when for the first time VWIL is integrated into any unit.

Research papers have been published in:

- the Australasian Association for Engineering Education Conference, about teaching safety in design in large classes using VR (Male et al., 2018)

- the Australasian Association for Engineering Education Conference, about the emerging suite of VWIL modules for engineering students (Male, Hargreaves, & Pointing, 2017)

- the Students Transitions Achievement Retention Success Conference, about VWIL to support engineering student transitions (Male, 2017).

Simulations and and other resources that have been developed and tested during the project are available for educators to use by directly contacting the Project Lead. A 'Virtual Work Integrated Learning Guide for Educators' reporting learning about how to design, implement, and integrate VWIL modules is currently being developed. It will be disseminated in workshops. The project website provides details about the ouputs, and includes links to presentations and other dissemination activities (www.ecm.uwa.edu.au/vwil).

This VWIL Project has demonstrated how engineering students can be supported to develop employability skills using alternatives to real work experience. The Project has demonstrated that VWIL is a reliable, efficient, and scalable approach to support engineering students to learn about engineering practice and develop a wide range of employability skills.

More than 1600 students have completed VWIL modules to develop understanding of engineering practice or to practise an employability skill. Project team members' final-year research students, and coursework students who have completed VWIL, have reported transferability of skills learned that have assisted in acquiring graduate employment.

The VWIL Project has contributed to a national movement in higher education in Australia in which the importance of quality WIL has been recognised. In engineering specifically, momentum and capability to diversify WIL, beyond work experience, has been established. More than 500 participants from engineering and across the higher education sector have attended workshops, presentations or discussions about VWIL. The transformation in the approach to WIL in engineering is evident in the engineering accreditation process. In December 2018, Engineers Australia implemented changes to the accreditation of engineering degree programs supporting the use of simulated workplaces to ensure students are better equipped for employment.

> *[Engagement with professional practice] must culminate in a set of meaningful experiences that result in the habituation of professional working styles through placement in activities engaged in actual or simulated commerce, internships, volunteering or similar activities*
> (Engineers Australia, 2018, p. 18).

The recommendations in the Guide are expected to be valuable for engineering educators designing curricula to meet the revised accreditation criteria. The publications will be relevant in engineering and generally in higher education.

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Chapter 1. Introduction

Employability skills identified for engineering graduates in Australia closely match the Stage 1 Competency Standards defined by Engineers Australia in engineering program accreditation criteria (Engineers Australia Accreditation Centre, 2018). By 2016, studies on deficiencies in employability skills of engineering graduates, had identified weakness in employability skills such as communication and leadership (Male, 2010; Male et al., 2010; Nair et al., 2009; Ramadi et al., 2016). Such deficiencies in employability skills in engineering had been attributed to insufficient practical and work experience (Cameron, 2009; Male & King, 2019).

The term 'work integrated learning' (WIL) refers to 'the process of bringing together formal learning and productive work, or theory and practice' (Cooper et al., 2010, p. xiii). WIL had been recognised as effective in developing students' employability skills (Smith et al., 2014). Engineering education in 2014 included WIL, however, given the deficiencies in engineering employability skills, improved WIL was overdue.

In 2014, all but one of the 34 Australian institutions that offered formative professional engineering programs required students to complete a specified period of engineering-related employment, usually either 12 weeks or a longer internship. Such 'engineering work experience', when effective, had been rated by engineering students in 2014 as the best way to develop employability skills (Male & King, 2019). However, the traditional engineering work experience had two significant weaknesses.

One weakness in the quest towards gaining engineering work experience in actual employment was that it had become difficult for students to obtain that employment. In a survey of engineering students at 11 Australian universities in 2014, 29 per cent of 215 students in their final year of their bachelor or master's degrees reported that they had not completed either 12 weeks of vacation employment or an internship (Male & King, 2019, p. 110). Some students were unable to graduate, despite completing coursework, because they had not obtained workplace experience.

Another significant weakness of the traditional engineering work experience was its low reliability as a learning activity. In 2014, engineering work experiences were most often not in credit-bearing units, with minimal if any oversight by the university (Male & King, 2019). Even with increased oversight, engineering practice is diverse and a work experience opportunity usually provides exposure to only one industry such as mining, or one sector, such as consulting, limiting students' exposure to a fractional breadth of practice.

In response to challenges associated with work experience, alternatives to traditional work experiences were being proposed in engineering and the university generally. In the Final Report for the OLT project, *The impact of work-integrated learning on student work-readiness*, Smith et al. (2014) recommended future research into simulated WIL. In April 2015, the Australian Council of Engineering Deans (ACED) established a working group to investigate the issue of engineering work experience. In response to the situation, increasingly, universities are allowing students to accumulate exposure to practice through alternative means such as attending industry events and interviewing engineers.

The present 'VWIL Project' has been study of virtual WIL—of work integrated learning in which the work would be created for the purpose of learning rather than any true work for an employer or client. In VWIL, students would undertake industry-engaged learning activities that are not employment (paid or unpaid). They would complete authentic tasks, using authentic tools and/or processes, and engage face-to-face or electronically with real or simulated workplaces and/or practitioners. Virtual work integrated learning (VWIL) would be intentional, integrated into the curriculum, and aligned with program learning outcomes and assessments. Compared with traditional WIL in engineering which had involved engineering-related work with an employer, virtual WIL would provide increased reliability and breadth, for larger numbers of students, throughout the program—from first to final year.

Theoretical framework

The VWIL Project adopted the model in Figure 1 developed as part of a national project led by the ACED (Male & King, 2019, p. 106). The model was devised based on literature and through analysis of the ways in which tertiary institutions in Australia provide students with exposure to engineering practice throughout their degree (nearly ubiquitously though 12 weeks of engineering work experience), and identifying notable limitations to this approach.

When working within the model of effective exposure to engineering practice, curriculum developers should design activities that provide opportunities for engineering students to engage with engineering practice throughout their degree programs. These activities become more realistic and similar to real engineering practice (with decreasing scaffolding) as the student progresses through their coursework years. Reflective practice is a critical element of all WIL—consolidating students' learning and ensuring that students are prepared to apply their learning when an opportunity to do so arises in practice. Effective exposure to practice supports students to develop the employability skills identified for engineering graduates in Engineers Australia's Stage 1 Competency Standards (Engineers Australia Accreditation Centre, 2018). In addition to the Stage 1 Competency Standards, outcomes for students include identity development, motivation towards their studies, and skills to secure or create employment, and take responsibility for their learning.

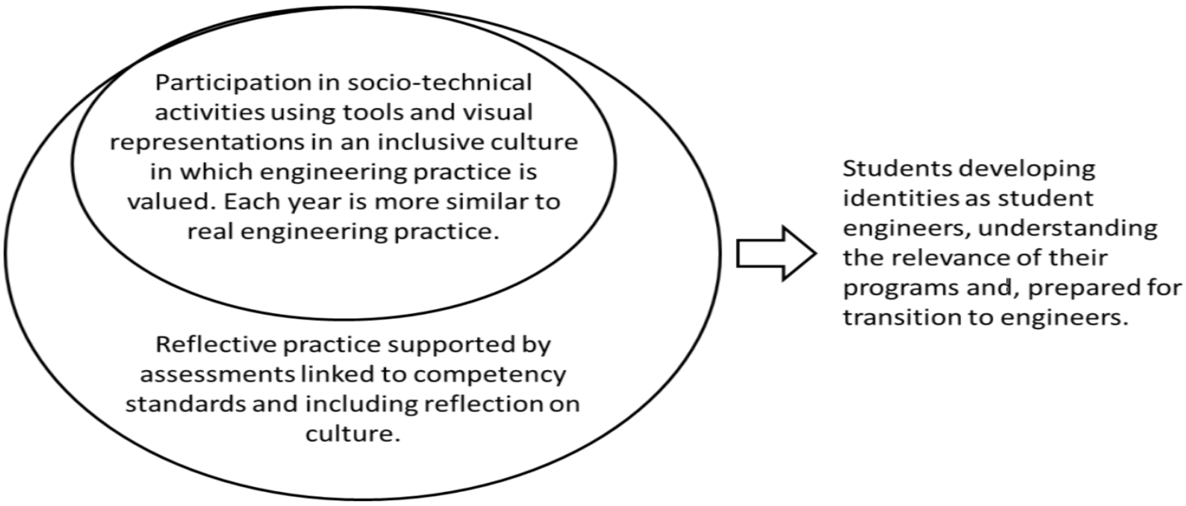

Figure 1. Model of effective exposure to engineering practice in an engineering degree (Male & King, 2019, p. 106)

By studying the feasibility of providing students with effective exposure to engineering practice and opportunities to engage in reflective practice individually, with peers, and with engineers through VWIL (in addition to, or instead of, engineering work experience), the VWIL Project focused on preparing students for understanding the role of an engineer, and transition to the engineering profession.

Aims

The VWIL Project had three aims as listed below.

1. The first aim was to design, develop and test VWIL examples to **complement traditional opportunities** for engineering students to develop employability skills, through methods other than engineering work experience.
2. The second aim was to develop the VWIL examples, designed to support engineering students to develop employability skills, to **achieve four improvements** over engineering work experiences. The VWIL examples would: (a) be accessible to eventually thousands of students; (b) be designed for learning, making them more reliable than engineering work experience; (c) offer more diverse experience than a single engineering work experience opportunity; and (d) allow students to experience a range of sites they would be unlikely to experience in a single engineering work experience opportunity.
3. The third aim was to **develop a guide** for educators on developing and implementing VWIL modules, and integrating VWIL into engineering curricula.

The VWIL Project addressed the following questions.

1. How can VWIL be designed to reliably support large numbers of engineering students at various levels of their degree programs to develop employability skills?
2. How can engineering practitioners be engaged to support engineering students' VWIL?
3. How can VWIL be integrated in engineering curricula?

Chapter 2. Approach

VWIL modules, consisting of one or more activities with associated learning resources, were developed and tested using a design method involving: requirements analysis, prototyping and conceptual testing, and cycles of development, implementation and evaluation. The VWIL Project involved seven stages, with stages 3 to 6 concurrent. Stage 7 is due to be completed in December 2019.

Stages of the research

1. *Requirements analysis and prototyping*: based on literature, requirements for the VWIL modules were drafted, and four hypothetical modules were developed as prototypes.

2. *Prototyping and conceptual testing*: planning workshops were held with stakeholders to refine the requirements and ensure stakeholders' needs would be met.

3. *Development and testing*: learning modules were developed and pilot studies were conducted to test the modules and evaluate feasibility.

4. *Dissemination and further stakeholder consultation to explore and share opportunties for integrating modules into curricula*.

5. *Expansion and integration:* trials were expanded into curricula.

6. *Further dissemination*: presentations were held throughout the VWIL Project, and a workshop was held to share learning about integration of VWIL into curricula.

7. *A guide for educators is being created on developing VWIL and integrating VWIL into curricula*. This will be disseminated through workshops held around Australia.

The stages are described in greater detail below.

Stage 1. Requirements analysis and development of hypothetical modules as prototypes

Principal requirements for the VWIL modules were identified based on aims of the VWIL Project and the model for effective exposure to engineering practice presented in Figure 1 (Male & King, 2019). The first requirement was that modules should be consistent with the accreditation requirement that students engage with engineering practice (Engineers Australia Accreditation Centre, 2018, pp. 16–19).

Outlines of VWIL module designs that met the principal requirements were developed for review. The hypothetical modules involved (a) a decommissioning process, (b) competing to win a tender, (c) planning a maintenance event, or a root cause analysis for a safety incident or a failure and (d) working with others (Male et al., 2017, p. 401).

Stage 2. Planning workshops

Workshops were held in Melbourne, Perth ad Brisbane, to refine the requirements of VWIL modules to meet stakeholder needs (Male et al., 2017). Engineers, university staff members, Engineers Australia staff members, engineering students, and a senior recruitment manager in an engineering company participated in the workshops (*N* = 43).

Participants recorded hand-written group responses. Audio recordings and notes were also made during group reports and plenary discussion among participants. The workshops were three hours long, including refreshments. The recordings were transcribed. Participants' responses to the modules were analysed to identify the important stakeholder requirements and also potential solutions to meet these.

Workshops were also held at the Australasian Association for Engineering Education Conference 2016 (*N* = 25), and meetings of the ACED (in 2016, at University of Canberra, *N* = 40), ACED Associate Deans Teaching and Learning (in 2016, at The University of Queensland), and the Australian Council of Deans of Information and Communication Technology (ACDICT) Learning and Teaching Academy Forum (in 2016, at University of Technology Sydney). Three Reference Group members who were not available to attend the planning workshops were consulted individually by telephone.

The engineering deans noted that VWIL should not aim to achieve the same as engineering work experience because it provides different opportunities. They also emphasised the importance of including in VWIL the disruptions and uncertainties that exist in workplaces. The engineering associate deans noted the challenges of adopting resources developed as outputs of past projects. Guidance on how to develop and implement VWIL was considered more valuable than learning resources.

The ICT associate deans noted that the engineering WIL context is different from the ICT context because there had traditionally been less WIL in some disciplines of ICT than in engineering. Many participants indicated that their universities were seeking, developing or planning to develop processes for recognising WIL alternatives to work experience.

Based on the feedback from workshop participants, requirements for the learning modules were refined.

Stage 3. Development and trial of learning modules

VWIL approaches (learning activities, resources, and modules involving one or more learning activities) were developed. The intended learning outcome(s) of each activity and module were aligned with the theoretical framework. Every module involved reflection, and every module involved face-to-face or electronic interaction with real or simulated practitioners, workplaces, and/or engineering practice.

Authentic scenarios used in several of the modules were identified through semi-structured interviews with engineers, students who had completed engineering work experience, and consultation with the Honorary Industry Consultants. Participants were asked about key learning for practice, and critical incidents when that learning had been important or would have been valuable. Participants' examples were adapted to create authentic scenarios for VWIL.

Consistent with the theoretical framework, the range of VWIL approaches included activities designed for first-, second- or third- year students in a formative engineering education program, and others designed for third- to fifth- year students. As the intended year of the student increased, the learning activities increased in complexity, decreased in the level of definition, increased in authenticity (meaning the similarity of the activity to practice), and increased in the depth of interaction with practitioners and/or workplaces and likelihood of disruption.

The VWIL activities for the early year levels involved only brief interactions with practitioners or workplaces. The durations of learning activities extended from 30 minutes to two days. The VWIL activities for students in first to third year supported students to:

- identify engineering roles; their value to society; capabilities important for those roles; and how students can develop and demonstrate engineering capability to secure work for identity development, motivation, and to recognise the value of their learning and how to optimise their time at university
- improve their communication and self-management skills for learning and for engineering practice
- identify ethical issues in engineering, and make ethical decisions in engineering.

The VWIL activities designed for third to fifth-year students involved complex systems, authentic engineering processes used in real or simulated engineering workplaces, and extensive interaction with real or simulated workplaces and/or engineers. The duration of the VWIL activities for students in third to fifth year ranged from two hours to semester-long authentic projects with at least weekly professional interaction with an engineer. Activities included: hazard analysis and remediation activities, planning for safe work practices, preparation of a tender, evaluation of a tender, and team design on a project offered and co-supervised by industry. The VWIL activities for students late in their degrees support students to learn to:

- authentically apply technical theory
- use professional engineering processes for design, communication, teamwork and project management
- make and justify professional engineering judgements within time and knowledge constraints
- apply strategies to practice engineering ethically and safely, compliant with legal and regulatory obligations, and within commercial constraints
- confidently articulate their professional engineering capabilities.

Pilots

Workshops were held with small numbers of student participants (at least 8 but not more than 24) to test the feasibility of activities, resources, and iterations of modules. The workshops typically involved students completing a learning activity or module, being observed while doing so, and completing an evaluation questionnaire. For the modules and activities that involved interaction with an engineer, the engineers also completed evaluation questionnaires. Analysis of responses focused on features that students and engineers considered useful for learning, suggestions to improve learning or convenience and, where relevant, comparison on different implementations (e.g., paper vs serious game,

VR simulation with and without various features). Where useful, students' written responses during activities were also analysed.

Stage 4. Dissemination and further consultation to explore and share opportunities for integrating VWIL into curricula

The VWIL Project spanned more than three years, at a time of great interest in WIL. Stakeholder consultation during Stage 4 had multiple purposes: dissemination, gauging change, and influencing the national engineering education environment.

WIL Guidance Note

During Stage 4, the Australian Government Tertiary Education Quality and Standards Agency (2017) published the 'Guidance Note: Work-Integrated Learning' indicating tightening of the regulation of WIL. An appendix of the draft Guidance Note had described common practice for engineering work experience as an example of unsatisfactory practice. The published Guidance Note reminded educators of their responsibilities, especially to ensure appropriate supervision of students engaging in WIL. The majority of engineering faculties, having previously had compulsory engineering work experience with minimal oversight, were now reviewing their WIL practices.

Meeting with Australian Council of Engineering Deans

In October 2017, as part of Stage 4, two of the VWIL activities were demonstrated at a meeting of the ACED in Canberra attended by 32 deans or their representatives from almost as many organisations. Members were supportive of the demonstrated activities. They also provided the following three pieces of advice.

First, project outputs such as guidelines that are platform independent would be preferred by ACED members over platform-specific deliverables. This was because universities had already invested in various hardware and software for simulations, visualisation, collaboration, and learning management systems.

Second, ACED members were not enthusiastic about developing the proposed pool of Engineers Australia members as volunteers for VWIL, and instead were more interested in recommendations for identifying opportunities to engage their universities' industry connections in VWIL with their students.

Third, ACED members had no interest in identifying a common process for tracking and assessing engagement with professional practice, because many engineering faculties had already invested in developing their own. Consequently, although VWIL should be assessed, it would be unlikely to be useful to deliver assessment processes as outputs of the VWIL Project.

Conference workshop: 'Planning engagement with professional practice throughout the program'

Reflecting the interest in WIL at the time, the theme of the Australasian Association for Engineering Education Conference 2017 was 'Integrated Engineering'. A conference workshop (*N* = 18, in Sydney) entitled 'Planning engagement with professional practice throughout the program' was held in Stage 4 of the VWIL Project.

The purposes of the workshop were for dissemination and to discover the appetite for integrating WIL into curricula in credit-bearing units, remembering that most engineering work experience, although compulsory, had not been in credit-bearing units. At the workshop, the suite of VWIL modules was introduced, and participants shared details of how they were integrating WIL into the curriculum.

VWIL Project Reference Group Member, Dr Lincoln Wood, presented Engineers Australia's draft revised guidelines on engagement with professional practice. As alternatives to engineering work experience, Engineers Australia had always listed examples such as projects and guest lecturers. The revised accreditation guidelines, since published (Engineers Australia Accreditation Centre, 2018), demonstrated a strengthened emphasis on VWIL.

In addition to the indicators of a changing WIL climate in engineering presented above, the conference workshop participants confirmed that their universities were starting to invest significantly in university-wide WIL initiatives. Participants reported various definitions of WIL being recognised in their universities—some that would include VWIL and others that would not. Participants reported that engineering faculties were indeed revising their approaches to meeting accreditation requirements for professional practice and starting to recognise WIL that was integrated into credit-bearing units—an approach that Engineers Australia had long accepted, but few engineering faculties had taken. For the VWIL Project, the changing context led to sharpening of the focus on integrating VWIL into credit-bearing units.

Stage 5. Integration into curricula

Table 1 presents the modules developed. Modules I to V were designed for students in years 1 to 3 of a formative engineering education, and Modules VI to XI were designed primarily for students in years 3 to 5. As can be seen in Table 1, six modules have been integrated into units taken by more than 100 students.

Table 1. VWIL suite of modules (Male et al., 2017)

Module	*Main learning activities*	*Interaction with workplace, practitioner or practice*	*Development informed by*	*Testing*
I. Engineering roles	Interviewing engineers and senior students about their jobs, important capabilities, and how they secured opportunities; preparation of position description and rehearsed interviews with engineer	Interviews of and with engineers	Planning workshops	- One-day symposium on employability for engineering students (N = 22) - Interviews of engineers integrated into assessment in first-year unit taken by 430 students
II. Construction engineering	Watching day-in-the-life of an engineer videos and reflecting in facilitated discussion	360-degree videos of four daily tasks on site: meetings and inspections	Consultation with engineers on site	Workshop (*N* = 21)
III. Communication and self-management	Communicating, and managing self in authentic engineering scenarios in: - paper-based interactive activities - serious game - two 5-minute 360-degree videos in which the viewer is talking with an engineer	- Simulated workplace scenarios in serious game - Engineers played by actors in videos - Reflection with engineer	Interviews with seven engineering students who had completed work experience, and with six engineers	- Activities and game tested in a workshop (*N* = 8) - Revised activities including individual reflection over internet or telephone with an engineer, tested in a workshop (*N* = 9) - Videos tested individually with 11 students
IV. Ethics	- Watching brief video of actors performing as engineering graduates discussing ethical challenges - Completing interactive serious game	Simulated workplace scenarios in serious game	Interviews with three recent graduates	Integrated into assessed workshops in first-year unit taken by 430 students

Module	*Main learning activities*	*Interaction with workplace, practitioner or practice*	*Development informed by*	*Testing*
V. Visualising a 3D system from a diagram	Identifying parts on a piping and instrumentation diagram in a VR simulation	Interactive VR head-mounted display simulated hot water system	Based on threshold capability theory and a parallel threshold concept in electrical fundamentals (Scott & Harlow, 2011)	Workshop (*N* = 18)
VI. Maintenance task on site	Pump isolation for maintenance, in interactive virtual refinery	Interactive virtual refinery	- Refinery from OLT project (Cameron et al., 2009)	Integrated into Process Safety and Risk Management unit taken by 130 students
VII. Job safety analysis	Online activity involving completing a job safety analysis using interactive virtual refinery	- Interactive virtual refinery - Authentic safety process	- Based on student's site experience - Refinery from OLT project (Cameron et al., 2009)	16 students completed and evaluated independently
VIII. Safety meeting	Hazard and operability meeting	- Interactive virtual refinery - Authentic safety process	- Refinery from OLT project (Cameron et al., 2009)	Integrated into Process Safety and Risk Management unit taken by 130 students
IX. Safety in design	Safety in design workshop based on real design involved in fatalities, and using Construction Hazard Assessment and Implication Review (CHAIR) process used in industry	- Interactive VR head-mounted display simulated crane - Students used CHAIR process	Cases sourced through Safe Work Australia and state regulatory authorities, meeting with two safety engineers	- Workshop (*N* = 24) - Integrated into workshops in fifth-year mechanical engineering design units taken by 180 and 150 students, and in assessed workshops in fifth-year electrical & electronic engineering design unit taken by 150 students
X. Preparing and evaluating tenders	- Preparing a tender - Evaluating a tender	- Video of site safety induction - Virtual water pumping site	- Four interviews with senior engineers	- Three focus groups with engineers, academics, and

Module	***Main learning activities***	***Interaction with workplace, practitioner or practice***	***Development informed by***	***Testing***
		- Video of advice from four senior engineers about tendering	- Site visit	students to test feasibility of modules and resources (*N* = 11; *N* = 5; *N* = 5) - Workshop to test videos (*N* = 5)
XI. Design project	Semester-long design in teams of approx. 5 students, offered and co-supervised by an engineering employer	- Design brief offered by employer - Engineer from employer meets students fortnightly - Processes used for technical queries, design review, agendas, minutes, version control, reports - Practicing and retired engineers on teaching team - industry-based engineers as guest lecturers	- Consultation with engineers - Processes from OLT Project Management Systems for Engineering Education (Foley, Gill, Senadji, Palmer, & Martinez-Marroquin, 2017)	Integrated into fifth-year electrical & electronic engineering design units for seven semesters with 30, 30, 80, 80, 150, 150 and 160 students

Stage 6. Dissemination

Workshops and presentations have been held throughout the project.

During 2019, a guide for educators is being prepared on developing VWIL and integrating it into the curriculum. The guide will be disseminated at workshops in capital cities around Australia. A workshop proposal has been accepted for the Australasian Association for Engineering Education Conference in Brisbane 2019.

Chapter 3. Project findings and outputs

The VWIL Project has demonstrated that virtual WIL appropriate to the students' year-level can be successfully integrated into large classes to enhance the employability skills of engineering students. Throughout the project, engineers' responses were generally enthusiastic. They noted that working in geographically disparate locations is common in engineering practice, and that many of the activities supported learning that was important and yet often received insufficient, if any, attention in engineering programs.

Findings

The VWIL Project addressed three questions.

1. How can VWIL be designed to reliably support large numbers of engineering students at various levels of their degree programs to develop employability skills?

The project demonstrated that VWIL can be designed to support large numbers of engineering students using combinations of face-to-face and electronic engagement with real and simulated workplaces and practitioners and authentic processes. The activities can be varied in complexity, definition, scaffolding and depth of interaction, and authenticity of the activity, to suit the year level and learning outcome. Reflective practice is critical, as for any WIL.

Features of the design and use of simulations can significantly affect students' learning. For example, increasing the fidelity of simulations can be distracting rather than beneficial for learning. Testing is essential before implementation in large classes.

2. How can engineering practitioners be engaged to support engineering students' VWIL?

VWIL relies on support from engineers with experience of engineering practice. Having experienced engineers on the curriculum development team and the teaching team is ideal, although not always possible.

Videos and interactive simulations involving avatars can be designed with and reviewed by engineers and then used in learning activities with hundreds and thousands of numbers of students. These options involve no ongoing involvement except to update resources and activities.

It is feasible to recruit engineers to volunteer in VWIL synchronously with the students. Expectations of engineers and students must take into account the numbers and year levels of the students. For example, in the VWIL Project in a large first-year unit, individual engineers were interviewed by small groups of students and these interviews were video-recorded for viewing by hundreds of students in the unit. Over 100 engineers were recruited as volunteers through a snowballing method by initially approaching individual connections (many originally through Engineers Australia), the university's industry advisory panel members, and alumni, and then reaching further engineers through these existing contacts.

In contrast to the commitment involved in a single interview for first-year students, in final-year units, engineers were invited and agreed to volunteer extensive knowledge and time,

offering and co-supervising student teams throughout the semester. For this level of commitment, initially engineers known to university staff were recruited as volunteers. Through successful experiences, relationships were established with the organisations that employed these engineers. Those organisations then committed to offering and co-supervising semester-long projects for multiple consecutive semesters. When, inevitably, a volunteer became unavailable, their employer provided a substitute.

Engineers vary in the level of commitment and the modes of communication that they prefer. For example, some preferred face-to-face interactions and others were available only for electronic interaction. It is necessary to ensure expectations are aligned. Clear advice for students, engineers, and teaching team members about the purpose of interactions and the expectations of all stakeholders is essential.

3. How can VWIL be integrated into engineering curricula?

Integration of VWIL into a curriculum requires significant planning and lead time. VWIL must be aligned to unit learning outcomes and assessments. It usually requires coordination of technology and/or engineers, and training for the teaching team, or additional technical or coordinating support.

Resources and outputs

The 'Virtual Work Integrated Learning Guide for Educators' currently under development includes:

- guidelines on how to develop and integrate VWIL modules into curricula
- a map of examples of learning modules that educators may adapt and integrate into various stages of engineering curricula
- factors that are important to the success of developing and integrating VWIL modules.

Research papers have been published in:

- the Australasian Association for Engineering Education Conference (Male et al., 2018), about teaching safety in design in large classes using VR
- the Australasian Association for Engineering Education Conference (Male et al., 2017), about the emerging suite of VWIL modules for engineering students
- the Students Transitions Achievement Retention Success Conference (Male, 2017), about VWIL to support engineering student transitions.

Simulations and resources that have been developed and tested during the project (Table 1), are available for educators to use by directly contacting the project lead. Resources include those listed below.

- 360-degree videos captured during the completion of real industry tasks on a construction site, to help inform students about their career path in the engineering industry

- VR interactive simulation for the safety module suitable for the HTC Vive™ system
- brief videos on tendering
- a serious game developed in Articulate Storyline™ on communication and self-management in an engineering workplace
- videos, and a serious game on ethics in Articulate Storyline™
- various 360-degree videos to be used in activities such as practising presenting in a meeting, identifying gender bias in a meeting from a male and female perspective, and improving tone and body language in communication.

The project website provides details about the ouputs, and includes links to presentations and other dissemination activities (www.ecm.uwa.edu.au/vwil).

How the project used and advanced existing knowledge

The project was framed by the model of effective exposure to practice in an engineering program theory and guidelines, which resulted from the study of industry engagement in engineering education led by the ACED (Male & King, 2019). This model was based on literature in the fields of WIL, and engineering education. The project has demonstrated how VWIL can reliably support large numbers of engineering students at various stages in engineering degree programs to develop employability skills, as recommended by the ACED project.

Several of the VWIL activities used the BP virtual refinery developed in a past project (Cameron et al., 2009). The VWIL Project has explored diverse approaches to using the refinery and increased awareness of the resource.

Disciplinary and interdisciplinary linkages that emerged as a result of the project

The Project Lead, Male, presented at an Engineers Australia WA Division *Engineering Student Practicum Forum* and serves on the Student Practicum Working Group of the WA Division. In this role she has been able to promote the possibilities of VWIL to engineers and employers in university–industry forums hosted by Engineers Australia.

As a result of the VWIL Project, Male has developed a UWA Community of Practice on Developing Technological Leaders to create interdisciplinary VWIL. This involves links with the discipline of architecture at The University of Western Australia.

Engaging students with practice is a challenge in many disciplines. Numerous presentations on the VWIL Project have been in interdisciplinary forums (The University of Western Australia Innovative Teaching Community of Practice, 2019; The University of Western Australia Teaching and Learning Conference 2018; Edith Cowan University Blended Learning Forum 2018; Transforming Assessment webinar 2018; webinar for Swinburne University 2017, Student Transitions Achievement and Success Conference 2017; HERI Bite-sized Seminar, Department of Education and Training 2017; WA Teaching & Learning Forum presentations 2017, 2018, 2019; Australian Collaborative Education Network Conference

2017; Australian Council of Deans of Information and Communication Technology (ACDICT) Learning and Teaching Academy Forum 2016).

Male has used her experience on the VWIL Project and other WIL projects to contribute to WIL policy and strategy at UWA beyond engineering. She prepared pre-reading for the WIL Symposium held at UWA in 2018, and facilitated the WIL Panel Session at the UWA Learning and Teaching Conference in 2018. In 2018 she was a member of the Science WIL Taskforce, and she is the Deputy Chair of the UWA WIL Strategy Group. In all these roles she has promoted VWIL to complement work experience. Beyond UWA, Male spoke about WIL and VWIL as an invited member of the Employability Panel at the Students Transitions Achievement and Success Conference in Auckland in 2018.

Factors that were critical to or impeded success

Critical to the success of the project was the support and involvement of project partners including the ACED and Engineers Australia. Engineers Australia provided access to professional engineers to review the modules, participate in the modules, and evaluate the experience. Being involved in review of revisions to accreditation guidelines (through Reference Group Member Wood) was critical to the team maintaining the relevance of the project for educators. Regular meetings with the ACED and the Associate Deans Learning & Teaching were critical to dissemination and ensuring relevance.

Several new team members joined after commencement of the project and have provided valuable additional support, especially in the areas of integration into curricula and technology expertise.

The University of Western Australia's Educational Enhancement Unit provided access to virtual reality equipment, and supported embedding the Safety in Design module into units at The University of Western Australia.

The involvement of project partner CingleVue in fortnightly meetings with students provided students with critical and cutting-edge guidance.

The Pawsey Supercomputing Centre provided advice and equipment for generating 360-degree videos early during the project. This was used to develop resources for the tendering modules.

The appointment of the Project Lead to a full-time teaching and research position reduced her availability on the project. This was addressed by employing two PhD graduates as Research Fellows, and a PhD student as a Research Associate to work on the project during 2019.

Extent to which the approach and outcomes are amenable to implementation in a variety of institutions or locations

Participants of the workshop held at the Australasian Association for Engineering Education Conference 2018 expressed interest in adopting and adapting existing VWIL learning modules, as well as developing their own VWIL learning modules. Many participants were able to identify ways in which existing course content may be developed into a stand-alone learning module.

As presented in Chapter 2, Engineers Australia recently revised the guidelines for accreditation of engineering degree programs. Specifically, the guidelines for engagement with professional practice have been revised to clearly highlight that engagement does not have to be limited to internships or placements, and can extend to suitable activities in which students learn about engineering practice. Moreover, the guidelines now explicitly state that virtual WIL is an appropriate method to engage students with practice. With this change, it is anticipated that there will be an increasing demand and opportunity over the following decade from tertiary institutions to be able to make use of alternative approaches to engage students with engineering practice that supplement real engineering work experience.

Links between the project and other projects in the priority areas

Module XI used engineering process resources from the recently completed OLT project led by Foley, Senadji, Palmer, and Martinez-Marroquin (2016–2018) entitled ID16-5400: 'Transforming engineering students into student engineers: improving learning outcomes and employability'.

OLT Senior Teaching Fellows, Professor Dawn Bennett and Associate Professor Anne Gardner, supported the Employability Symposium for Engineering Students in which students completed Module 1 face-to-face. At the start and end of the Symposium, students completed Bennett's employability instrument (Bennett, 2017), which at the time was in development stages. At the Symposium, Gardner held a short workshop using resources from her OLT fellowship on engineering students' agency for learning (Gardner, Goldfinch, & Willey, 2017).

Chapter 4. Impact, dissemination, and evaluation

Dissemination activities

The project website was established at the start of the project. The website lists the project outputs and past and upcoming dissemination activities.

A 'project' was created by the Project Lead on ResearchGate™ at the start of the VWIL Project. Research publications and updates were posted to the project on ResearchGate. Throughout the project when updates were published, this information appeared in the information feed of ResearchGate site members who followed members of the Project Team.

Dissemination included published papers, workshops, presentations at conferences and meetings (Table 2).

Table 2. Dissemination activities

Presenter(s)	Event	Activity	Location	Date
Male	Australian Council of Deans of Information and Communication Technology (ACDICT) Learning and Teaching Academy Forum	Workshop	University of Technology Sydney	31 March 2016
Male, Hargreaves, Pointing	Australian Council of Engineering Deans Meeting	Discussion	University of Canberra	4 April 2016
Male, Pointing	VWIL Project Planning Forum	Forum	Engineers Australia, Melbourne	27 April 2016
Male	OLT Conference	Panel Session, 'STEM'	Melbourne	28 April 2016
Male, Boussaid, Garrett, Maynard, Sohel	VWIL Project Planning Forum	Forum	The University of Western Australia	4 May 2016
Cameron	VWIL Project Planning Forum	Forum	The University of Queensland	9 May 2016
Male, Pointing	ACED Associate Deans Learning and Teaching Meeting	Workshop	The University of Queensland	7 June 2016
Male	UWA Faculty Academy for Scholarship in Education Lunchtime Seminar	Seminar	The University of Western Australia	19 July 2016
Male	Engineers Australia WA Roundtable, 'Sustaining our Engineering Students' Industry Experience'	Presentation	Georgiou Pty Ltd, Osborne Park, WA	16 August 2016
Male, Hargreaves	Australian Collaborative Education Conference	Presentation	Sydney	29 September 2016

Presenter(s)	Event	Activity	Location	Date
Male, Boussaid	Electrical & Electronic Engineering Industry Advisory Panel Meeting	Discussion	The University of Western Australia	19 October 2016
Male	ACED Engineering Exposure to Practice Working Party Meeting	Discussion	Sydney	2 November 2016
Male, Cameron, Pointing, Hargreaves	Australasian Association for Engineering Education Conference	Workshop	Coffs Harbour	6 December 2016
Male, Pointing, Hargreaves	ACED Associate Deans Learning and Teaching Meeting	Discussion	Coffs Harbour	7 December 2016
Male, Maynard	WA Teaching & Learning Forum	Presentation	Curtin University, Bentley, WA	4 February 2017
Male	HERI Bite-Sized Seminar	Seminar	Australian Government Department of Education and Training, Canberra	19 March 2017
Male	Swinburne University Webinar	Webinar	Online	26 April 2017
Male	Students Transitions Achievement Retention Success Conference	Presentation	Glenelg, South Australia	3 July 2017
Male, Hargreaves	Australian Council of Engineering Deans Meeting	Presentation and discussion	Canberra	5 October 2017
Male, Hargreaves, Pointing	Australasian Association for Engineering Education Conference	Paper presentation	Manly	11 December 2017
Male, Hargreaves, Pointing	Australasian Association for Engineering Education Conference	Workshop	Manly	11 December 2017
Male	WA Teaching & Learning Forum	Presentation	Notre Dame University, Fremantle	2 February 2018
Male	Edith Cowan University Blended Learning Meeting	Presentation and discussion	Edith Cowan University, Joondalup, WA	24 July 2018
Male	Transforming Assessment	Webinar	Online	5 September 2018
Male, Hargreaves, Hassan, Guzzomi, Valentine	Australasian Association for Engineering Education Conference	Workshop	Hamilton, New Zealand	10 December 2018

Presenter(s)	Event	Activity	Location	Date
Male, Kenworthy, Hassan, Guzzomi, Van Der Veen, French	Australasian Association for Engineering Education Conference	Paper presentation	Hamilton, New Zealand	11 December 2018
Male	ACED Associate Deans Learning and Teaching Meeting	Discussion	Hamilton, New Zealand	13 December 2019
Male	Lunch and Learn Community of Practice – VR in Higher Education	Presentation	The University of Western Australia	30 January 2019
Male, Van Der Veen	WA Teaching & Learning Forum	Presentation	Notre Dame University, Fremantle	1 February 2019

Impact

The current and expected impact of the VWIL Project is mapped in Table 3.

Table 3. Project Impact mapped to the IMPEL Model

	Anticipated changes at:			
	Project Completion	**Six-months post-completion**	**Twelve months post-completion**	**Twenty-four months post-completion**
1. Team members	• **recognition** of the Project Lead's and a Project Team Member's contributions to teaching and learning through appointment to continuing positions, and university roles influencing WIL policy and planning		• Post-docs hired on the project will be prepared to implement VWIL where they find their next employment	
2. Immediate students	• Project team members' final-year research students, and coursework students report transferability of skills learned which assisted in **acquiring graduate employment.**		• Students who participate in VWIL will be **better prepared for engineering practice** and more successful in obtaining employment and in their work	
3. Spreading the word	• Views of the project website	• Four journal articles will be under review,	• VWIL graduates will volunteer as engineers	

	Anticipated changes at:			
	Project Completion	**Six-months post-completion**	**Twelve months post-completion**	**Twenty-four months post-completion**
	• an updated online website with resources that were developed during the project to support **integration of modules into curriculum**	and three conference papers published **conveying key findings** of the project and lessons learned • **dissemination of key project findings** and recommendations through developed guide and nationwide workshops	engaging with students in VWIL and encourage their colleagues	
4. Narrow opportunistic adoption	• integration of VWIL modules into **project team members' units** at UWA and Curtin			
5. Narrow systematic adoption	• draft definition of WIL at UWA accommodates VWIL	• VWIL modules will be integrated into engineering curriculum at UWA, and recognised as engagement with practice	• VWIL will be supported by revised policies and strategies at UWA • VWIL will be demonstrated in interdisciplinary projects between engineering and architecture at UWA	

	Anticipated changes at:			
	Project Completion	**Six-months post-completion**	**Twelve months post-completion**	**Twenty-four months post-completion**
6. Broad opportunistic adoption	• Members of Engineers Australia, engineering deans, and associate deans learning and teaching in engineering are aware of VWIL • Conference delegates who have attended relevant events are aware of VWIL	• Workshop participants will have used the guide and have the knowledge, skills, and evidence to implement VWIL	• Workshop participants at universities around Australia will have adopted VWIL • Engineers Australia's WA Division Student Practicum Working Group will have shared VWIL successes with industry and university staff in WA	• Project Lead and a Team Member will be convening combined Australasian and international engineering conferences at UWA in Dec 2021, and showcasing VWIL
7. Broad systematic adoption	• In Dec 2018**, Engineers Australia** implemented changes to the accreditation of engineering degree programs supporting the use of simulated workplaces to ensure **students are better equipped** for employment.			• Workshop participants will have integrated VWIL into engineering curricula to meet accreditation requirements, and will then share their success

Significance of evaluation

The project evaluator guided the project team throughout the project. The project evaluator was critical in keeping the project team focused on the aims of the project, and provided advice regarding scope and what was achievable.

The project evaluator recommended dissemination of key findings from the project through the creation of a guide for educators on developing VWIL approaches, integrating them into curricula, and the learning outcomes that can be achieved.

The evaluator's report can be found in Appendix B.

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Appendix A

Certification by Deputy Vice-Chancellor (Education)

I certify that all parts of the final report for this OLT grant provide an accurate representation of the implementation, impact and findings of the project, and that the report is of publishable quality.

Professor David Sadler
Deputy Vice-Chancellor (Education)
The University of Western Australia

Date: 02/07/2019

Appendix B

Evaluator's Report

Dr Lesley Jolly
Strategic
Partnerships

This is the final report of the evaluation of the OLT-funded project *OLT Intensive Mode Teaching Project ID15-4951.* It is necessarily restricted in that the project team have been given permission to continue activities to the end of 2019 and therefore work remains to be done that this report cannot evaluate. Instead this report attempts to:

- Identify the ways in which the project has changed direction and what consequences follow for the research,
- identify the relevance and direction of interest in WIL in engineering education more broadly and to assess the project development against that, and
- identify questions of interest arising from the project so far requiring future research.

The discussion that follows is based on reading of project documents, attendance at a project meeting in Perth in February 2019, analysis of an online module and four interviews with senior members of the engineering education community around Australia.

Changes to target impacts and deliverables

The following table compares the original statement of planned impacts with insights gained in the course of the project:

Planned Impact	Changes made
During this project approximately 100 engineering students in 10 universities will develop employability skills by immersing in a suite of virtual WIL modules that will be equivalent to 12 weeks of employment.	It has been realized that it will take some time to roll out modules to 10 universities. However more than 100 students have been exposed to relevant modules at the development stage. **A major outcome of this project has been the realisation that classroom modules can never replace all aspects of the learning gained through 12 weeks of employment. Crucially the project is now working to specify which learning objectives can be encompassed in the classroom and which cannot. Modules need to be COMPLEMENTARY to workplace experience rather than totally replace it.**
The option to participate in virtual WIL will reduce students' vulnerability that currently arises from the difficulty of securing a good industry placement. Nationally, the engineering profession and	Interviews with senior members of the discipline indicate that the vulnerability mentioned here persists and that there is intense interest in finding means to reduce it including use of this project's modules when they are released. Links are also being made to a wider discussion on the nature of

society will benefit from the improved employability skills of graduates.	employability skills and how to develop them.
Engineering educators will be able to use new and existing immersive environments to integrate professional practice throughout the curriculum, giving engineering students better exposure to practice from the first year of their engineering studies.	It has been realised that immersive environments, apart from their resource implications, need to be carefully tailored to reproduce the learning gained from work, rather than just to reproduce the look of the workplace. This relates to the earlier point that there needs to be precise specification of the desired learning outcomes. The danger is that technology becomes a classroom toy rather than a tool. Test modules have been found to be useful earlier in the degree than professional exposure usually happens and they provide a greater diversity of experience for students.
Engineers will interact virtually with students in the virtual modules, thereby developing from the experience, and meeting potential recruits.	This is indeed happening although the virtual tool used in some universities is the telephone or computer. Industry, academics and students all seem to value such contacts.
Across the sector, educators and developers who are building and using simulated immersive learning environments, interactive online student learning communities, and virtual WIL, will be inspired and informed by the findings, leading to new and enhanced learning opportunities for students.	Early in the project it was suggested that sets of guidelines for the building of modules might be provided to interested universities. It now seems as though, while lessons learned here would be useful to others, a clear statement of desired learning outcomes for exposure to professional practice might be the most universally applicable tool.

A similar set of changes, arising from similar realisations apples to the project deliverables:

Original deliverable	**Standing as of March 2019**
A website for interested stakeholders including students, engineers, engineering educators, educators across the sector, and researchers	This is being housed at the University of Western Australia.

Learning outcomes and learning activities for the virtual WIL modules	As noted, the importance of this deliverable is paramount. Several modules have been developed and feasibility trials have been carried out in classrooms but these trials are only able to demonstrate that the modules can be used in classrooms. They cannot demonstrate how well they compare with other approaches nor which aspects of exposure to professional practice they replace. That work will take place during 2019 and beyond.
A complete set of relevant engineering process documentation, including existing and custom-designed documents, for students to use in the virtual WIL modules	These are in use in one module which has been in operation for some time at Curtin University and are under development for other modules.
Training materials for honorary engineers and engineering managers in the virtual modules	Yet to be addressed
A new immersive simulated environment, in the water industry, using a dynamic modelling technique to create enhanced immersion	In development
A larger immersive environment in which students will learn about contextual practicalities beyond the immediate site	Yet to be addressed
Virtual WIL modules that will be offered to engineering students from any university to learn by interacting on authentic engineering projects - including materials for the module coordinator, students, honorary engineers and engineering managers, and the representatives of universities with participating students	In development
Conference and journal papers on the research findings about students' experiences and learning in the virtual WIL modules and environments	Papers have been produced on the development process and workshops have been held in universities and at conferences. These have been well received but evidence of student learning is needed. More papers are in preparation.

A sustainable model for universities to support, use, and expand the virtual WIL modules	In preparation but work remains to be done on specifying desired outcomes in order for them to be measurable, and to produce evidence of student learning.
The final report.	This is to be submitted in March 2019 but the project will continue throughout 2019 and is generating enough research questions to provide a research agenda for years after that.

Broad relevance of project

Interviews were held with senior members of the engineering education community to explore the continuing relevance of this project to that community. This included an interview with the author of a recently completed project on behalf of the ACED on *The Future of Exposure to Professional Practice in Tertiary Engineering Education.* That report was mainly concerned with what WIL programs had to do to comply with TEQSA requirements but like the other interviewees, the author had no doubt that the issue of finding appropriate work exposure for all students continues to be a problem and that simulated or virtual work has the potential to address it. His report also identifies the need for diversity of experience in work exposure, an issue that virtual modules can address more easily than actual workplaces.

When interviewees were asked what the main learning from workplace exposure should be they all alluded in some way to increased employability and competency through being able to apply theoretical knowledge in a practical setting. When asked to be more specific, interviewees tended to offer examples from their own experience and their own discipline. For instance, one civil engineer described how she would know how to "simplify the numbers", which sets of data to use and when in order to progress a project. As she said "it's not just about using formulae". Learning outcomes might there4fore need to be tailored to individual work experiences, albeit many learnings occur across all settings.

All of the interviewees agreed that more work needed to be done to improve students' access to relevant workplace experience and they were all keen to see more sharing of experience on this topic. The identification of the crossover with employability may indicate a good place to start but in any case there is clear relevance for the present project going forward.

Research arising from this project

It will be helpful at this point to return to the original evaluation questions as set out in the 2016 evaluation report. It is remarkable that these questions do not address the issue of to what extent the modules replace or complement workplace exposure, but that will be dealt with in subsequent discussion.

QUESTIONS
Appropriateness 1. How easy was it for diverse universities to adopt modules? 2. How well did it work across sub-disciplines? 3. How well did the guidelines meet local needs?
Effectiveness 4. What was the impact of the project on employability?
Efficiency 5. Do stakeholders think the effort involved is worth it?
Sustainability 6. Did alignment with curricula improve ongoing resourcing? 7. Were the modules built into curricula and accreditation in such a way as to support their ongoing use and development?

Taking each question in turn, it can be seen that the project has progressed towards its goals and seems likely to be useful not only in producing usable modules for deployment across universities, but in uncovering research questions of moment for the future.

1. How easy was it for diverse universities to adopt modules?
   Some modules are being trialled at other universities in 2019 and formal evaluation will be attempted on those modules, with the cooperation of staff at those institutions and the evaluator. Ideally, we would like to pursue the C/M/O method discussed below, if circumstances permit.

2. How well did it work across sub-disciplines?
   Some interviewees mentioned that virtual environments might work better in disciplines such as civil engineering than in for instance electrical engineering. The implication here is that what is being reproduced is the physical world but this misses the point that what needs to be provided is virtual **work**. It should not be impossible to reproduce the work of any kind of engineer once we know what exactly it is students in that discipline have to learn. Many of the lessons are likely to

be the same no matter the discipline, relating as they do to issues of communication and interaction.

3. How well did the guidelines meet local needs?
   For individual modules, this is still to be decided by this year's evaluation. Theoretically, any work which clarifies specific learning outcomes for exposure to professional practice is likely to have wide applicability across the profession and beyond.

4. What was the impact of the project on employability?
   It will not be possible to track employability for individual students or cohorts but the opportunity exists to draw on existing employability research to refine the aims and procedures of this project.

5. Do stakeholders think the effort involved is worth it?
   Colleagues implementing modules during 2019 will be invited to discuss this question but it should be noted that interviewees were all keen to share insights and procedures and explore the adaptability of modules to their programs.

6. Did alignment with curricula improve ongoing resourcing?
   This remains to be seen from 2019 evaluations.

7. Were the modules built into curricula and accreditation in such a way as to support their ongoing use and development?
   Again this waits detailed investigation later this year and into the future. It should be noted that the emergence of research questions about the nature of workplace exposure and associated learning outcomes carries on the work of the ACED project into the future of workplace exposure mentioned above. It also permits overlap with questions of employability which are always of interest to universities. Both of these developments ought to contribute to the sustainability and evolution of both this project and the modules it produces.

Evaluation to be conducted this year

Several modules including one on ethics and another on safety procedures are to be fully implemented this year. Members of the project team will be conducting research on these modules and it is planned to include data gathering activities that will allow for the evaluator to carry out a C/M/O analysis. This analytic framework comes from the Realist Evaluation work of Pawson and Tilley (1997). This approach to evaluation is based on the premise that it is not enough to ask whether an intervention works or not. What works in one place may not work equally well under different circumstances, and various factors will account for the different outcomes. In order to be able to elicit the kind of understanding that will allow us to generalise our findings we must identify what factors in the context make a difference, and the range of possible responses to the intervention. Pawson and Tilley express this as a formula:

$$C + M = O,$$

where C stands for “contexts” (understood as the sociocultural conditions that set limits on the efficacy of the intervention), M stands for “mechanisms” (the decisions to change that are triggered by the intervention) and O stands for “outcomes” (which may be unintended as well as intended) (Jolly 2012, p.12). Isolating the contributing factors in this way allows subsequent adopters to make decisions about how the intervention may work in their circumstances and to plan how to compensate where necessary. This analysis thus has the potential to contribute substantially to any guidelines the project may develop for implementation.

In summary, the project is well on its way to successful outcomes, even if the aims and scope have changed somewhat with experience. Moreover the project is significant for addressing an ongoing need in engineering education for more and more diverse workplace exposure and raises significant intellectual questions about the nature of that learning that have the potential to apply across many disciplines.