Industry-university collaboration in the STEM curriculum: exploring work integrated learning in practice

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Industry-university collaboration in the STEM curriculum

Exploring Work Integrated Learning in practice

By Daniel Edwards and Julie McMillan

Introduction

Industry-university collaboration is high on the agenda in Australia. A new Prime-Minister and new ministers in the education and innovation portfolios have re-invigorated the push for improving these partnerships, and a recently announced policy promoting an ‘Innovation Boom’ has put this front and centre on the national agenda. With the Prime-Minister rebuking some leaders in the higher education sector for being ‘defeatist’ and asking for more ‘optimistic’ approaches to developing collaborations (Q&A Session - Malcolm Turnbull and Glyn Davis, 2015), the focus on the role that universities play in reaching out to industry has never been so intense.

Much of the recent attention in this area has focussed on research collaboration and investment. There is no doubt that this area of Australia’s ‘innovation economy’ is critical. But importantly, it is in another core area of universities function – teaching – that the sustainable foundations for relationships with industry can perhaps be best facilitated. As such, if greater collaborative networks are to be developed, the promotion of industry interaction through the curriculum in universities is an area that warrants increased investment and attention.

This Joining the Dots Research Briefing examines the interaction of universities and industry in STEM fields. Like industry-collaboration, STEM is another current ‘hot-spot’ in higher education policy, highlighted by the federal Minister for Education, who recently argued: ‘Science, Technology, Engineering and Mathematics subjects are a key part to Australia remaining a prosperous economy. These days, around 75 per cent of jobs in the fast growing industries demand workers with science, technology, engineering and mathematics skills’ (Birmingham, 2015).

The briefing charts the findings of a national project involving all Australian universities which collected data about the way in which science and ICT faculties incorporate industry oriented learning activities.
into the undergraduate curriculum. Known as Work Integrated Learning (WIL), this way of interacting with industry is increasingly being recognised as a means of engaging students, developing higher order skills, and offering innovative ways of assessing.

WIL involves:
- Integration of theory with the practice of work;
- Engagement with industry and community partners;
- Planned, authentic activities; and
- Purposeful links to curriculum and specifically designed assessment.

As the definition suggests, this kind of activity is more than an unstructured work-experience, and when implemented well it can be a vehicle for building sustainable relationships between universities and employers that have proven to improve the engagement of students in their learning (Radloff & Coates, 2010) and also the potential to generate other ways of interaction, such as through applied research.

WIL is a well-researched field, with a number of high quality national pieces of research undertaken in recent years placing Australia at the forefront of knowledge and practice in this area (Ferns, Russell, Smith, & Cretchley, 2014; Orrell, 2011; Patrick et al., 2008). However, within the STEM disciplines, and especially in the non-engineering areas, until recently relatively little was known about industry engagement in curriculum. This is a significant gap, as STEM enrolments overall account for 23 per cent of all bachelor-level enrolments in public universities and STEM enrolments in non-engineering areas represented 15 per cent of enrolments.

This research briefing draws on the findings of ACER work for the Office of Chief Scientist (Edwards, Pearce, Perkins, & Hong, 2015), examining industry-university interactions in the STEM curriculum and offering a ‘stocktake’ of the current landscape in this area. The briefing then explores possible ways of overcoming barriers to greater interactions through WIL and concludes by highlighting current developments in Australian science specifically using these findings to increase the prominence of industry collaboration in the science curriculum.

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1 Full report available here: http://research.acer.edu.au/cgi/viewcontent.cgi?article=1046&context=higher_education

Key findings from this research are:

- There are a range of industry-oriented activities being included in STEM curriculum in Australian universities. The term ‘Work Integrated Learning’ encompasses activities such as internships and placements, as well as on-campus industry-driven projects and simulations.

- There is a broad appetite for increasing industry engagement through wider introduction of WIL activities in Australian universities and STEM disciplines.

- Engagement with employers and industry varies substantially between universities and within STEM disciplines.

- ICT courses have high engagement with industry through on-campus industry projects – it is estimated three in every four ICT students in Australia are involved in an industry-oriented project during their degree.

- Agriculture and environmental science students are more likely than others to be involved in placements, with about one in three students experiencing some kind of industry placement during their degree.

- Science has relatively few options for students to engage with industry through WIL activities, with fewer than 5 percent of students having a placement opportunity and only about 15 per cent being offered exposure to industry through project-based activities.

- Barriers that exist to broadening industry involvement in science curriculum include a lack of value placed on WIL activities in academia, difficulties attracting employers and problems integrating industry-inspired activities in an often inflexible curriculum.

- To overcome these issues, recent initiatives have been implemented to systematically and proactively broaden engagement with industry and increase WIL opportunities in STEM in Australian universities.
Background

Over the past decade, research has shown that Work Integrated Learning (WIL) is an important and effective means for preparing university students for active participation in the workforce on completion of their studies. This is an area of immense importance for the productivity of the Australian workforce. In the case of STEM – an area at the forefront of innovation – this importance is arguably even more profound.

The recently launched National WIL Strategy, a joint undertaking between universities and business groups, highlights the growing recognition of the importance of WIL. The strategy ‘is designed to increase opportunities to participate in WIL, recognising the benefits to students, employers, universities and the economy’ (ACEN, UA, ACCI, AiGroup, & BCA, 2015, p. 2). It proposes action in eight key areas:

1. Provide national leadership to expand WIL
2. Clarify government policy and regulatory settings to enable and support growth in WIL
3. Build support - among students, universities, employers across all sectors and governments - to increase participation in WIL
4. Ensure the investment in WIL is well targeted and enables sustainable, high quality experiences, stakeholder participation and growth
5. Develop university resources, processes and systems to grow WIL and engage business and community partners
6. Build capacity for more employers to participate in WIL
7. Address equity and access issues to enable students to participate in WIL
8. Increase WIL opportunities for international students and for domestic students to study off-shore. (ACEN et al., 2015, p. 3).

Within STEM fields more specifically, the Chief Scientist has called for ‘every Australian STEM degree course to maximise the opportunities for industry placements or projects for academic credit’ (Prinsley & Baranyai, 2015, p. 1).
University-Industry Partnerships in Curriculum

Many outside the ‘WIL practitioner community’ conceptualise successful university-industry partnerships in teaching as being only those activities which involve a one-on-one, student-employer relationship in the form of a placement. In fact, there are other forms of WIL that are very effective, far more efficient, and widely used in Australian universities. There are also specific elements of placements, such as their length, which influence their effectiveness and are often missed in over-simplified discussions of WIL. A typology of WIL activities, based upon the literature and discussions with universities about their WIL activities in the STEM field, is provided in Figure 1. The typology was developed so as to avoid over-generalisation of WIL, and to enhance recognition of the different types of activities that can foster university-industry links through effective WIL.

University curricula are structured in a variety of ways in Australia. Within the STEM fields, the research that underpins this briefing identified a number of different models of curriculum structure that influence the way in which industry is (or is not) included in the teaching of students. Generally, the way in which curriculum is structured is dependent on the university context, i.e. approaches to learning, the existence of ongoing relationships and the overall value placed on these kinds of interactions in the teaching of students. Three generalised models are presented below that influence the approaches of universities towards industry involvement in the curriculum through WIL in the STEM curriculum.

![Figure 1](image-url) A basic typology of Work Integrated Learning activities

<table>
<thead>
<tr>
<th>On campus simulations</th>
<th>Activities integrated into course/units that are specifically designed to simulate a work environment. Often designed in consultation with industry.</th>
</tr>
</thead>
<tbody>
<tr>
<td>On campus projects</td>
<td>Long (usually at least one semester) industry sponsored projects. Conducted on campus rather than in industry. The industry partner is presented with a ‘solution’, report, and/or presentation at the conclusion of the project. Usually undertaken by a team of students.</td>
</tr>
<tr>
<td>Short term placements or internships</td>
<td>Planned experiences in industry, off campus for up to 5 weeks.</td>
</tr>
<tr>
<td>Medium term placements or internships</td>
<td>Planned experiences in industry, off campus for between 6 and 11 weeks.</td>
</tr>
<tr>
<td>Long term placements or internships</td>
<td>Planned experiences in industry, off campus for 12 weeks or more.</td>
</tr>
</tbody>
</table>
The first is the ‘trust transfer will happen’ model, where there is no direct focus on the ways in which graduates might apply theory in a work or industry context. In courses that adopt this model, the likelihood of any industry involvement is low. This approach is very theory-oriented and works on the assumption that theoretical background is paramount and the practical application of this information will happen once the student is in the workforce. This model is the traditional and stereotypical approach to university teaching. In the STEM fields across Australia, the application of this approach is not prevalent, but it does still exist, especially in some of the science disciplines.

The second model, generalised as the linear ‘Theory to Practice’ model (Figure 3) is the most common way in which curriculum is developed and delivered in the STEM disciplines explored in the research on which this briefing paper is based. It is estimated that about three quarters of the science, ICT and agriculture courses in Australia adopt an approach along these lines in their design and delivery. In this model, industry interaction and WIL activities are ‘bolted on’ to the existing traditional academic curriculum. In most cases, the industry component of the course occurs at the end of the degree, often in a capstone unit designed to build on theory and help to apply it in practice. However, as the diagram shows, there are other examples within the course which these activities are seen. Where such activities exist, they are usually there because of the interest and impetus of a single academics who often fosters connections with industry and runs the WIL activities through the particular units of the course they are responsible for.
The third approach shown here represents a fundamentally different approach to industry involvement in university curriculum and is not commonly encountered in Australia, described here as the ‘Industry-oriented course’ (Figure 4). Rather than building up a theoretical base prior to industry exposure and immersion, it involves an orientation to direct industry involvement, ideas and problems from the beginning of the degree. Experiential learning plays a key role and the problem dictates the theory students need. Industry associations and members are often involved in developing and the ongoing evaluation of these courses. The relationships with industry in such courses have often been facilitated by university leadership and have clear administrative support structures, promoting ongoing sustainability. While uncommon, the approach generalised here is embedded or is in the process of being embedded in a number of Australian universities.

In terms of the administration and logistical support for industry engagement in teaching, in institutions where there is an industry-oriented approach to WIL, centralised systems and administration of WIL are likely to exist. In the more common ‘bolt-on’ approach, support is characterised by decentralised approaches with less formal structures and is usually driven solely by a single academic or a small team of academics in a department. A number of academics who run these programs were keen to emphasise the ‘12 month effort’ required to implement a WIL activity. As a result of the model on which they operate, subjects with embedded WIL activities that use this model are generally small and selective.

Usually WIL units are funded in the same way as any other academic subject – with funding allocated to student enrolment numbers. However, the research behind this briefing found a common argument from within universities that ‘WIL costs more’ than traditional academic units of study, although the full costs generally unknown. The main reason given for higher costs tends to be the time and effort that required in developing and maintaining industry relationships, allocating students to placements or projects, and supervision.
National Stocktake of engagement in WIL activities

How much industry-university collaboration is happening in the teaching of science, ICT and agriculture undergraduates in Australian universities? The key quantitative findings from the project that underpins this briefing are outlined below. The findings here are based on interviews and data collected from every university in Australia and while coverage was wide, there are caveats to keep in mind when interpreting this data. In particular, that this information is intended to be indicative rather than comprehensive – while every effort was made to collect data from every discipline in every university, the limitations of the project meant that this was not always possible. Nonetheless, the data provided below encompasses the most detailed collection of information about university-industry collaboration in the STEM curriculum available in Australia.

On campus activities

Almost every degree program in the sciences and ICT incorporates some campus-based industry-focused activities, with guest lectures being by far the most common element, but simulated experiences involving authentic approaches to laboratory sessions and other hands-on practical approaches increasing in popularity. Actually measuring the extent to which these kinds of activities are covered in each institution and course is difficult, mainly because of the different ways and the ad hoc nature in which they are undertaken, and the specific information required to identify them. As such no attempt to quantify these activities has been undertaken here.

Industry projects

Industry projects are a key way of facilitating WIL across the STEM disciplines and should be recognised for their efficiency in terms of employer to student ratios, and for their abilities to draw out graduate capabilities in relation to teamwork.

Industry projects typically involve creating a team based activity for students centred on solving a problem, creating something, undertaking applied research, monitoring an issue, or being engaged in a consultation process for a ‘real world’ industry client. The business or organisation involved will propose the project to the academic coordinator, and a team of students (most commonly four) will be engaged to undertake the task. In many cases, the task is predominantly completed on campus, with specific hours built into the semester for students to congregate and work on the task. The majority of project units run for a whole semester, and usually culminate in a report and presentation to the employer based on the task undertaken. These units are sometimes a mandatory element of the course, and in other cases are electives.

Figure 5 illustrates the number of universities identified with offering industry projects and an estimate of overall participation across the undergraduate population for the three key disciplines of focus in this research. As the figure suggests, a large number of universities undertake industry projects in their ICT disciplines – 25 specific programs were identified in this research, compared with 17 in the natural and physical sciences, and 10 in agriculture and environmental sciences.

Within the universities where ICT industry projects exist, student participation in these activities is near universal – that is they are generally embedded in compulsory units. In many cases in the other disciplines explored here, these units are offered as an elective and attract a minority of students.

In total, it is estimated that industry projects are undertaken by 73 per cent of ICT bachelor students in Australia during their degree, compared with 27 per cent of agriculture and environmental studies students, and 15 per cent of natural and physical science students. In the past academic year, it is estimated that approximately 7000 ICT students, 4000 science students, and 900 agriculture and environmental science students engaged in some kind of industry project.
Placements and internship programs

Almost all Australian universities have some kind of WIL placement or internship program that potentially any student from any discipline can apply for. However, many of these programs are highly selective and focus less on discipline specific knowledge.

The data discussed here are restricted to WIL placements and internships specifically co-ordinated by science and ICT faculties and targeted in some way towards providing specific involvement in industries with direct relevance to the discipline being studied. The project explored the implementation of this kind of university-industry activity based on length of placement, i.e. short (less than 6 weeks), medium (6 to 12 weeks) or long (more than 12 weeks).

Across the placement programs identified, there were no instances in which a placement program in the natural and physical sciences was a mandatory element of the curriculum, but examples of this did exist in ICT and agriculture and environmental sciences. As shown in Figure 6, nationally placement and internship participation rates are highest in agriculture and environmental sciences, with short-term placements (less than 6 weeks) undertaken by 37 per cent of students during their degree, medium-term placements undertaken by 20 per cent of students, and long-term placements undertaken by 18 per cent of students. Placements and internship participation rates are substantially lower in the ICT field, and almost negligible in the natural and physical sciences.
In the past year, it is estimated that about 2500 students from each of the three disciplines (an estimated 7500 overall) were involved in ‘for credit’ industry placements or internships, with science and agriculture student numbers concentrated in short term placements and ICT student more likely to undertake long term placements.

A key difference between STEM disciplines that influences WIL activity is the existence of external accreditation requirements and the more vocational nature of some disciplines. For example, on graduation the vast majority of engineering students in Australia have undertaken an internship or placement which is traditionally used to satisfy accreditation requirements of the peak body, Engineers Australia.

The Australian Computer Society (ACS), which accredits ICT courses in all Australian universities, does not specifically require WIL placements or industry projects as part of accreditation but it does ‘strongly encourage’ these kinds of activities (ACS, 2014, p. 13), thus making them a generally accepted part of the ICT curriculum. In contrast, the natural and physical sciences traditionally have less structured or no external accreditation requirements and generally have far broader employment pathways.
Expanding university-industry teaching activities and achieving ‘Good WIL’

‘Good WIL’: What works

Based on discussions conducted during the research on which this briefing is based, six key elements were identified which are important in developing successful and sustainable WIL units.

‘Good WIL’:

• is clearly linked to theoretical aspects of courses, ideally providing an ‘ah-ha’ moment to the student when the practical and theoretical merge;
• has strong engagement with industry;
• has well articulated expectations of both students and industry partners;
• has clear induction processes at the beginning and facilitated opportunities for reflection on experiences at the end - for both students and industry;
• has well established processes for logistics and support of students and industry;
• has support from leadership and dedication from academic staff.

Identifying impediments and facilitating expansion

The research identifies a number of crucial issues that need to be addressed if current WIL activities are to be expanded and ‘Good WIL’ is to become a common standard.

Valuing WIL by institutional leaders and the academic community is a critical precursor condition for enabling the expansion of WIL activities, requiring expression in centralised policies and targets, adequate funding for support and administrative staff, and recognition of the contribution of those who commit to the year round task of building and maintaining industry connections. An important element of valuing WIL is appreciating and accepting WIL development and co-ordination as a legitimate and important academic task. More broadly, the value of WIL – for students, universities, industry and government – needs to be emphasised in a transparent, effective and convincing way.

Recognition that engaging industry is resource intensive and difficult: Difficulty attracting enough employers to participate in WIL activities was by far the most significant impediment to expanding WIL activities mentioned by the academics and support staff in who participated in the project. Within the sciences and agriculture, the non-vocational nature of many disciplines and the dispersed nature of potential industries and employers made it difficult for some interviewees to identify ‘where to start’ and how to do this efficiently, while the very large cohorts of science students in some institutions had practical implications for large scale expansion of WIL. More generally, industry engagement is complicated by the competition among universities for employers willing to participate in WIL programs and the necessity that WIL opportunities have an element of flexibility built into them so that employers can engage in different ways. A one size fits all approach often leads to disengagement of employers or significant restrictions on the value gained for students.

Processes to ensure sustainability: A key limitation on expansion is the fact that many WIL activities, especially in the sciences, were run based on processes that were developed by an individual academic. The infrastructure required for up-scaling these activities, such as established processes, administrative support, and systems for vetting employers, either do not exist or are not well understood by anyone except the individual academics responsible. Developing such systems is a significant task. Academics who have run successful WIL programs observed that creating sustainable and scalable programs requires some sharing of industry contacts, and more centralised coordination of processes. This is potentially difficult terrain, and processes and procedures to enhance the sustainability of WIL must recognise the extent to which many academics have a sense of ownership.

Under-resourcing of WIL was also highlighted as a hurdle to expansion. As noted above, while WIL units were generally funded in a similar manner as traditional academic units, there was a general consensus that WIL costs more. The areas most requiring increased resources were generally seen as support for academic co-ordinators through basic administration and management of industry relationships.
Policy and practical suggestions

There is a growing recognition of the importance of WIL, reflected in calls by the Chief Scientist to expand student participation in WIL across the STEM disciplines and more generally in the recently released National WIL Strategy. The stocktake of WIL activity, and an understanding of the factors contributing to ‘good WIL’ and the impediments to expanding current WIL activities achieved through the research highlighted in this briefing, show there are effective and efficient alternatives to stereotypical WIL internships and placements. Below are some suggestions designed to promote opportunities for greater engagement with industry in the future.

**Emphasise industry projects**

A key impediment to WIL is a lack of employers to link students with. Generally placements and internships are seen as the ideal way of embedding WIL in a course. Yet there are logistical and practical considerations, especially in science, that prevent this from occurring more widely. Industry inspired projects are an efficient way of engaging larger numbers of students across a smaller number of employers. More than one university involved in the research suggested the possibility of allocating more than one team of students to each industry inspired project so that more students can participate.

**Centralised resource hub**

The development of a central online hub for STEM employers is another avenue for generating industry links. A hub would be accessible to universities who are developing WIL activities and potentially to students looking for projects, placements or internships. Significant work in this area has already been undertaken by the Australian Collaborative Education Network (ACEN), which has developed a National WIL Portal. While the traction and momentum that initially inspired the development of this portal has been lost, with reinvigoration it could potentially be used to undertake the tasks suggested here.

**Building a value proposition for WIL**

Evidence from objective national data is an essential element for harnessing support to expand WIL in STEM. This research collected data from academics and support staff, but also highlighted significant difficulties with consistent and robust data collection at the national level. Adding questions to existing national surveys of students or graduates, such as the Student Experience Survey or the Graduate Outcomes Survey, many offer an effective means of collecting more nuanced and objective information about WIL activities and their benefits without having to establish a whole new data collection.
Change underway

The research highlighted in this briefing, ongoing work by the Chief Scientist and the underpinning national emphases towards WIL have led to some significant policy reactions and actions in recent months – especially in the area of natural and physical sciences, where the outcomes shown here reveal the least interaction with industry among the STEM disciplines.

Specifically, the Australian Council of Deans of Science (ACDS) have secured funding support from the Office of Chief Scientist to genuinely increase the value placed on university-industry WIL activities within science and mathematics in particular. Funding to facilitate best practice in the development of links with industry in curriculum delivery through WIL activities is being offered through ACDS ‘Lighthouse Projects’. In addition, the ACDS has instigated a WIL in Science National Forum (held on December 11) and is developing a close leadership network of Associate Deans from each university to promote industry links to the curriculum and help in raising the profile of WIL in the sciences.

The identification of the importance of industry engagement in university curriculum and teaching as a potential source of significant benefit in the future – to both the skill development of student and the future research prospects of the university – has happened more slowly in some disciplines and some universities than others. But this example of change within the science disciplines suggests that as long as this recognition continues, the figures shown here for the sciences are unlikely to remain stagnant into the future.
References


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