DRIVERS AND BARRIERS TO INDUSTRY ENGAGING IN ENGINEERING EDUCATION

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ABSTRACT

The CDIO Standards provide an excellent framework for the engagement of industry stakeholders in the development and operation of professional engineering degrees. This framework is echoed in the program accreditation requirements operated by Engineers Australia and other accreditation bodies. Implementing effective industry engagement is, however, increasingly challenging to both academics (faculty) and industry members, despite much mutual goodwill between the two sectors. This paper provides the findings of a recent study on the drivers and barriers to engagement by industry to engineering education. The theoretical framework for the study was that all aspects of engineering education should be comprehensively engaged with practice, thus endorsing the principles of CDIO. Data presented from a student survey reinforces the value of good industry engagement in the curriculum. The principal findings from the consultation with industry highlight barriers in terms of poor communication, different priorities and lack of resources; but also identify strong drivers for engagement in terms of industry and company visibility for recruiting and brand promotion, internal staff development, relationship development, and social (corporate and professional) responsibility. Consistent with the goodwill between engineering schools and industry, there is a general desire on the part of industry to see the barriers to engagement lowered. The broader project, of which this study is a part, provided a number of recommendations for engineering schools, individually and collectively to contribute to improved industry engagement practices.

KEYWORDS

Engineering education, curriculum development, industry engagement, partnerships, Standards: 2, 5, 7, 9, 12

INTRODUCTION

The CDIO Standards and Syllabus (Crawley, Malmqvist, Lucas, & Brodeur, 2011) provide an approach to engineering education that directly addresses the requirement for students to be

exposed to engineering practice by placing elements of practice, namely conceiving, designing, implementing, and operating, at the heart of the curriculum. Several Australian engineering schools follow the CDIO methodology. All Australian engineering schools, however, have their professional engineering degrees accredited by the national professional body, Engineers Australia (EA), a member of the Washington Accord. EA stipulates that all students of accredited programs be exposed to engineering practice, to close the gap between education and practice, develop students' capabilities and identities, motivate them and ease their transition to practice.

Traditionally, the universities have implemented the exposure to practice requirement by mandating that students must undertake at least 12 weeks of in-industry work experience, ideally before commencing their final year of study. In addition, taught units in the curriculum are expected to be informed by lecturers' industry experience, and much of the students' design and project work would be sourced from industry. All three elements of this model have become increasingly difficult to realize, as student numbers have increased and the nature of Australian engineering industry has changed. In addition, fewer engineering academics (faculty) are appointed with recent industry experience outside research laboratories, (Cameron, Reidsema, & Hadgraft, 2011), making it difficult for academics alone to provide students with insights from contemporary practice within their teaching that adequately meet the CDIO Standards and EA accreditation expectations. Therefore, at many universities in Australia, improving the quantum and quality of industry engagement in engineering education has become critical to the success of engineering education programs.

The 12 CDIO Standards ("CDIO Standards v2.0," 2010) describe features of CDIO™ programs. Engaging industry members in curriculum development and implementation is directly relevant to meeting Standard 2 (*Learning Outcomes),* Standard 5 (*Design-Implementation Experiences),* Standard 7 (*Integrated Learning Experiences*), Standard 9 (*Enhancement of Faculty Competence*), and Standard 11 (Program Evaluation). Similar industry engagement, as a key stakeholder in the engineering education process, is required in several of the EA accreditation criteria (Engineers Australia, 2011). Thus, effective industry engagement is critical in contemporary engineering education. Engagement with the students will enhance their learning, motivation and future career prospects.

As stated earlier, Australia's engineering education schools have sought to retain in-industry experience as a program requirement, although it has become increasingly difficult to source such placements. During 2012-14, the Australian Council of Engineering Deans (ACED), the peak national body for the 36 universities providing accredited professional engineering degrees, was funded by government to explore how students' exposure to engineering practice could be enhanced. This paper briefly outlines the project and presents the theoretical framework, methodology and key findings that elucidate the research question: *What are the drivers and barriers to industry engaging in engineering education in Australia?*

THE ACED INDUSTRY ENGAGEMENT PROJECT

The project involved twelve university partners and seven peak industry bodies. Two parallel activities were undertaken (Male & King, 2014b), with essentially separate outcomes:

i. A consultative process was used to develop "Best Practice Guidelines" for effective industry engagement (Male & King, 2014a). These include recommendations to ,the universities, industry, and peak bodies and government. They were underpinned by a literature review, a survey of 16 universities, focus groups with engineering students at three universities, and five industry-university forums attended by 149 people. Additionally, in-depth interviews were conducted with 17 people whose roles in universities included engaging with industry, and with industry as described below.

ii. Seven universities developed and trialed “industry-inspired” projects to enhance their existing curriculum in core areas of engineering science and project management, mostly to large classes. In each university, an engineering academic in each university worked with an industry partner to develop suitable curriculum material, with the partner as a consultant and adviser rather than guest lecturer. That way, the new material is potentially transferable. Industry partners were supportive in allowing non company-sensitive material to be used.

Both of these project activities have contributed to the elucidation of the drivers and barriers to industry’s engagement with engineering education, discussed below. Since students are ultimately the focus of education, it is important to understand their perspectives. Early in the project, 215 final year bachelor and masters engineering students were surveyed to identify the types of industry engagement that significantly increased their understanding of engineering practice (Male & King, 2014b). The most highly valued types were, in order: 12 weeks of vacation engineering employment or equivalent part-time engineering work; guest lectures; engineering internships of six months or more; industry-based final year projects; hearing or reading about another student's workplace experience; teaching by staff with recent, non-research industry experience; industry visits and inspections; industry-based case studies; and problem solving, projects, or evaluation tasks with direct industry input of data and advice.

These findings validate the importance of including authentic industry experiences in the curriculum, and also should motivate industry’s engagement in the education process.

THEORETICAL FRAMEWORK

Figure 1 shows the Model for Effective Exposure to Engineering Practice in an Engineering Degree which was developed in the overarching project. Within the model, exposure to practice should support students to develop (Male & King, 2014b, p. 4):

- *more comprehensive and accurate understanding of engineering practice;*
- *a sense of belonging to the faculty and the profession;*
- *motivation for learning from recognition of relevance of the engineering program;*
- *improved learning through understanding context and connections.*

RESEARCH METHOD

Examples of effective engagement practice were identified by university representatives, literature, and through Engineers Australia. These, and the drivers and barriers to engagement were further explored though interviews and group consultations.

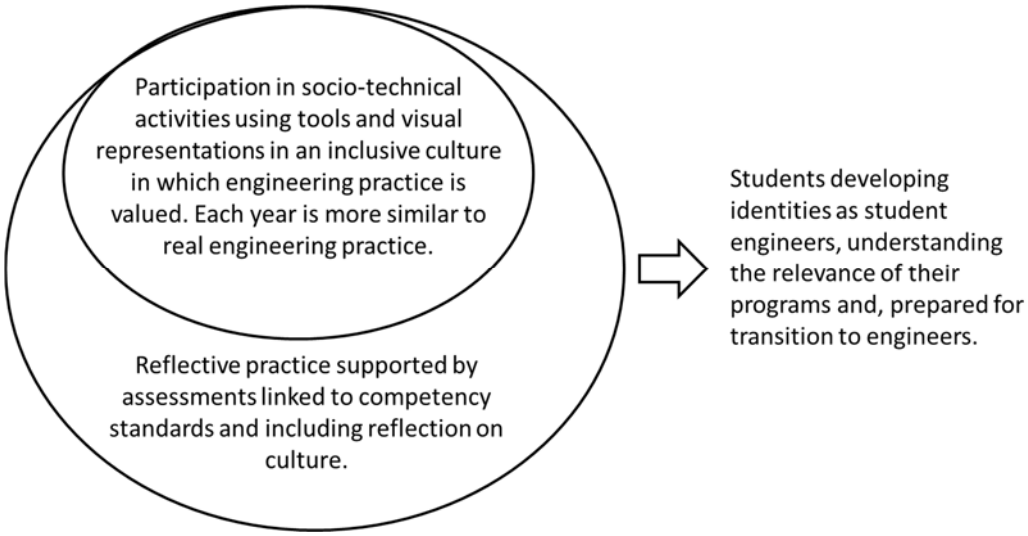

Figure 1. Model of Effective Exposure to Engineering Practice (Male & King, 2014b, p. 4)

Fifty five participants from universities and industry were interviewed as a purposive sample of informed participants. The focus on this paper is on those from industry. The 38 Industry participants included senior engineers, HR managers, or innovation managers who were essentially representing their organization; and individuals who were directly involved with engineering education and students. Their broad characteristics are summarised in Tables 1 and 2. Interviews began with an explanation of the project as already provided by email or telephone. All interviews were semi-structured, with planned core questions and additional prompts to delve into arising topics of most relevance, especially features relevant to the framework for effective exposure to engineering practice. The interview questions covered:

1. *How is your organisation/you engaged with students in engineering degrees?*
2. *What do you see as the benefits for individuals and the organization?*
3. *Could benefits be enhanced – how?*
4. *What are the features that make engagement possible or difficult?*
5. *Are there risks to the current engagement initiatives continuing?*
6. *Are there processes, structures, or other factors contributing to the initiative continuing?*
7. *What would improve the chances of your organization/you continuing with this engagement or expanding engagement?*
8. *Are there other forms of engineering education engagement that your organization/you would like to be involved in if the opportunity arose?*

Most interviews were 30 minutes in duration, but in about five percent of cases, continued for another hour. Most interviews were face-to-face but some were conducted by telephone or on-line. The interviews were all individual, except in three interviews each with two participants from the same company, and two interviews each with four participants from the same company. Notes and transcripts of the interviews were analysed to identify examples of effective industry engagement, informed by the framework for effective exposure, and to identify the drivers (benefits) and barriers for engaging in industry. In the following sections of the paper we have allowed our findings to be largely expressed by the interviewees.

Table 1. Current Level of Engagement of Industry Participants

Level of Engagement with Engineering Education	*N*
In organization involved in engaging with engineering education	25
Individual engineers engaging in engineering education	6
Industry-based engineers teaching in engineering faculties	5
Industry-based engineers interested in engagement	2
Total	**38**

Table 2. Type of Organisation at which Industry Participants were Based

Type of organisation	*N*
Consulting engineering company	11
Mining	6
Public utility	5
Engineering Procurement Construction Company	4
Oil and gas company	3
Construction company	2
Auto manufacturing	1
Auto parts manufacturing	1
Mineral sands company	1
Total	**34**

Note. Four 'industry-based' participants were retired from industry and do not have an organisation categorised above.

FINDINGS: BARRIERS TO EFFECTIVE INDUSTRY-UNIVERSITY COLLABORATION

Common reasons reported for not engaging are listed below with sample supporting quotations from interviews.

B1 Difficulties in Engaging with the University

The most common barrier to industry engagement was a lack of approach from universities or lack of a clear, convenient, coordinated system of contact in and across universities. The quotes below demonstrate the persistence of this problem.

> *I think it is very hard for employers if there's not that kind of role in uni: you know, whether it's a central career service or someone who is the focal point for industry in faculty. It is quite hard for employers to navigate around the university and how do they get in touch with students and can they get in touch with academics or lecturers and is that appropriate because some unis are okay with it and some aren't…. Some kind of industry relations or careers adviser and that being… a clear person who has probably got a good marketing background who… is out there talking to employers proactively. That's… the key to success.* (National head of human resources in an oil and gas company)

> *The difficulty is maintaining relationships to a number of universities…The five universities or so each with different structures and politics, with different expectations*

around support and different programs. (National head of human resources for a consulting engineering firm)

(Have you been involved on industry advisory boards or panels or anything like that?) *I find that the universities don't seek that out. I think it needs to be motivation from both sides but if the engineering deans were to be more specific about what they were looking for I think they'd be surprised at the sort of support they get… I think if there were industry consultation committees and things like that we would participate quite readily in those. If the universities or the engineering faculties were running them then we'd be more than happy to participate in those*. (CEO of mining company A)

Personnel changes, because the relationships – my relationships with people in both University A and University B, have only ever been – as far as the turning up in the classroom and say, hey look at me, have only ever been on a personal relationship level with that individual lecturer. (Engineering manager in oil and gas operator, referring to guest lecturing and why it discontinued)

B2 Perceptions that University People are Out of Touch with the Industry and Beyond

Interviewees and forum participants expressed perceptions that academics were not sufficiently aware of the needs of industry or society, as demonstrated by this quote:

I think it requires the universities themselves to recognise who the stakeholders here and what their stake is in the issue. It's not – it shouldn't be – the driver shouldn't be the curriculum and the funding and – that's there for a purpose which should be based on industry need and... in fact I think it's beyond that too. It becomes the social and physical climate as well because that's going to drive what becomes important in the near future, you know, we've got a megatrend is really… much more connected to society and that's bringing with it opportunities and real risks and that should be debated and discussed. (National head of human resources for a consulting engineering firm)

B3 Time and Inconvenience Involved in Supervising Students on Placement

Time and inconvenience involved in supervising students or engaging with teaching and especially placements in other ways can be a barrier to engagement, especially in a tight economic climate, as expressed by the human resource manager below. Much of Australian engineering work is contract based, with no provision for undergraduate or graduate training.

We're not set up just to get anyone come through the door any old time to do 12 weeks of work. Because we've got to fit in with all the project people are doing and what everyone's doing so it's a lot of effort. (Human resource manager 1 in mining company A)

B4 Industry Experience being Undervalued for Teaching, and Pay Disparity Between University and Industry

Engineers who had industry experience and taught in universities were at a time in their lives when the income was not critical and noted that their industry experience was not recognised in the university human resource system, and the university pay levels did not compete with those in industry. The engineer quoted below explained the impact of this on recruiting experienced engineers.

The disparity between the amount of money people out in industry and the amount of money paid for university lecturing, sessional lecturing is a big problem…. I've actually

been looking, and [another engineer who teaches] has too, for other younger people to be taking on this role. It's not worth their while. In their late 40s and early 50s when they've got a lot of work out there, it just isn't worth their while to forego a very sizeable amount of their income to come and lecture. (Experienced engineer working as a sessional teacher in engineering)

FINDINGS: DRIVERS FOR INDUSTRY TO ENGAGE IN ENGINEERING EDUCATION

Benefits to engineers and organisations that engage with engineering education are important to the study because these are critical to gaining the ongoing and future support of industry partners. Reported benefits to industry partners included development of relationships with university researchers leading to future collaborations, access to university resources such as laboratories, libraries, and experts, in addition to the following.

D1 Enhancement of the Organisation's Brand among Future Engineers who become their Future Employees, Clients, Contractors and Alliance Partners

For people in senior levels in organisations, the benefit to their brand was important, as described by participants below.

*I guess a lot of it is to do with the profile of the company, from my community point of view, as well as raising awareness of the organisation to engineering fraternity and engineering education fraternity. You see, at that time, we probably had a lower profile than we have currently. (*Senior engineer who was involved in establishing industry engagement of multiple types)

I actually approached the university. There was a couple of reasons for that. One was that we had just, that year, started to recruit graduates… seven or eight years ago. And I remember interviewing one of these students, and it's a thing that will stick with me for probably the rest of my career. I said to this student, 'What do you know about us as a company'? And they said, hand on head the student said 'I know you're a big company, but you're not as big as [company A that had engaged heavily by offering scholarships and funding projects at the local universities for decades]. And I thought, we were 25,000 people as a global organisation, and they're a great company, but they're about 4,000 people. (Engineering manager in a company that performed engineering, procurement, and construction in the oil and gas industry)

D2 Improved Understanding of Working for the Organisation held by Prospective Graduate Recruits

In addition to visibility of the organisation, engaging with education was recognised as improving students' understanding of working for the organisation and therefore graduate retention:

We had a mechanical engineering student who did such a good job during the holiday employment that we kept him on during the year a couple of days a week to do bits and pieces for us to the point where he got a job afterwards and he's still here. That's a classic example of someone who, holiday employment, did really really well, got them involved in some more interesting stuff, they were like 'This isn't too bad, I like this place. (Electrical engineer 1)

D3 Prospective Recruitment and Opportunities to Influence the Capabilities of Future Graduates

Several interviewees spoke of the value of industry placements for future graduate recruitment. Company expectations of students on placement may not be particularly high, so that students who do well and develop their skills and company knowledge are likely to be recruited as graduates. The fourth of the following quotes identifies the value of a company systematising its placement and university engagement program.

> *So the intent with the vacation program is ultimately if they're successful throughout their vacation duration. So they do the vacation program over two or three years, the intent would be that they would become our graduates in an ideal world. If they want to and if they perform to the level that we would like.* (Human resource manager 1 in mining company A)

> *Yeah you're seeing them perform, whether they're a good fit for the business. We don't get all of our graduates through our vacation program though.* (Human resource manager 2 in mining company A)

> *They can really hit the ground running [after graduation] because they've had that exposure*. (Human resource manager 1 in mining company A)

> *We'd get experienced people in and they'd work and finish an assignment and then leave and so we had no continuity. We had very little - they take away your body of knowledge… I started looking around and we had some quite good recruits from our own university who were managing the work that we were doing quite well. So I thought, look, I think we'd better spend some time developing the graduates, enticing them into the business and having a look at the quality of graduates available in engineering. I've been marking - they have external markers come in and help with the presentations at the end of fourth year…. We are recruiting from the graduates and we have a graduate program in our business and we're doing quite well out of it.* (Process engineer 1)

D4 Opportunities for Professional Development for Staff

Human resource managers and senior engineers recognised professional development opportunities for their employees in engaging with students on placement as described below.

> *At the undergraduate level, we – actually, we get involved every now and then with architectural schools, and that's really because it's good for our business. We do a lot of work with architects, so by going out and helping architects in their design tutorials and giving them feedback on their designs and structurally from other engineering points of view, we're building brand around architects and the future in our industry. And we're also giving our younger [engineers] good practice at the skills of going out and working up buildings with architects which is what they have to do in their careers.* (Principal engineer in a large consulting engineering firm)

D5 Appeal to the Organisation's Employees; Personal Satisfaction for those Engaged in Working with Students

Individual engineers reported great satisfaction in giving back to the profession and working with students, as described below.

> *I have mentored every year, I've done that for about five or six years as well… Every year I have an electrical engineering student and we come and chew the fat, talk about what it's like to be an engineer. That's really a rewarding project and thing to do as well because you're seeing the challenges of what the students have to do… It's more about being able to just talk to students about the different real practises of engineering as opposed to fourth order or differential equations. 'What is the actual*

thing I have to do when I become an engineer?'... A part of it is actually giving a little bit back as well it often helps you to explain where you're going in your own head because you're never really truly settled in terms of your own education as well. (Electrical engineer 1)

[Chairing the industry advisory board] is satisfying, I feel like I'm actually giving something back and doing something Look this is important. You don't want to see us in a situation where we don't have a continuous path at the flow of good engineers that you can actually use in the industry. It's not just me, it's not just [my employer], you'd hate it if we'd be in a situation where we don't produce our own engineers. That's just crazy. (Electrical engineer 1)

I've been an engineering practitioner for over 30 years… I find it enormously satisfying to get through to young minds and expose them to particularly experiences I've had… I also find it satisfying to lift the lid on possible career paths for them and to try and motivate them… and I tell them about lots of other things they will never find in a text book. (Experienced engineer who was teaching full-time at a university)

D6 Social License for the Organisation

Finally, senior staff for several organisations recognised that it was good for a company to be seen by the local community to be contributing:

And then I guess there is a third corporate citizenship piece right, say for a corporation like ours that is a larger player in industry, there is something that goes with us being able to give back a little bit. (Head of human resources in mining company B)

CONCLUSIONS

The quotations above demonstrate that the benefits to industry stakeholders of engaging with engineering education are numerous and strong. However, universities are not doing a good job approaching industry members in a manner that is coordinated both within and between universities and convenient to potential industry partners. Even the formal processes of having industry advisory committees (which is a requirement of the Engineers Australia accreditation process) may not be widely known. The most important opportunity for enhancing industry engagement is for universities to ensure they have a proactive and coordinated system for contacting and maintaining relationships with industry partners. This is the principal focus of the Guidelines and Recommendations of the over-arching project of which this study was a part.

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