Role of Industry in Shaping Mining Curriculum in Tertiary Education: A Case Study

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1. Introduction

Between 2007- 2015, the Australian mining industry saw an unprecedented growth and at the same time was challenged by several issues, including the shortage of trained and competent professional engineers to run the business. To alleviate the prevailing situation at the time and help mining industry meet its demand for competent professional engineers, Monash University established an undergraduate mining engineering degree program, namely, the Bachelor of Mining Engineering (Honours) in 2013. This degree program was developed around the theme of 'mining of the future', incorporating automation, safety, economics, project management, teamwork, sustainability, people and community, communication skills, innovation and leadership, etc., producing profitable projects with a minimal environmental footprint in its curriculum. The mining program received provisional accreditation in 2013 by Engineers Australia (EA) and full course accreditation in early 2018.

This paper discusses the case study of new mining engineering curricula incorporating adequate industry engagement that was designed and implemented for mining engineering program at Monash University between 2013 and 2017. This paper also describes various methods adopted to enhance student engagement in mining programs, allowing them to meet the changing industry requirements both within Australia and globally.

2. Literature Review

The main focus of any engineering curriculum is to enable students to acquire relevant skills in design and problem solving so they become competent in their careers in the industry. The curriculum should be responsive to the changes in the workplace and adopt to the changes in technology (Felder and Brent, 2003 and ABET, 2010). Development of a mining engineering curriculum has always been a service to the industry as there is no need for a mining education without industry demand (Galvin & McCarthy, 2001). Historically, the large amount of gold discoveries in Australia led to a large number of immigrants, some of which being mining professionals. This led to the foundation of a mining education such as the Ballarat School of Mines in 1870, the Bendigo School of Mines in 1873 and the Western Australian School of Mines in 1902 (Grimsey, 2002).

Although, these mining schools have been developed in the past, the recruitment of undergraduate students has always been a challenge where the demand from industry has always exceeded the supply of mining graduates. This can partially be attributed to the introduction of new technologies which has resulted in more students electing to study computer science and less in engineering (Galvin & McCarthy, 2001). At a postgraduate level, the research funding by industry and government poses a serious threat to the sustainability of mining engineering programs. With a reduced postgraduate intake, there will be a shortened supply of future mining academics which will also limit the ability to recruit and teach undergraduate students. This can be seen in the United States where the limited funding provided has resulted in the number of mining education programs dropping from 25 in 1984 to 15 in 2007 (Karmis et al, 2010).

The increase use of computers and introduction of automation have introduced a skill gap within the mining industry. This has resulted in the recruitment of IT specialists to fulfil the demands instead of mining professionals who are familiar with the operation. As technology use and automated systems are projected to increase within the mining industry, this skill gap will become more apparent (Cooney & Lansbury, 2018). In addition to this, many tasks within a mine are being outsourced to contractors and consultants such as ventilation planning and ground control. This has resulted in fewer training opportunities for students and graduates to be involved with the entire industry and are employed directly with the consultants and contractors (Galvin, 2000).

In addition to the implementation of technology, there has also been an increasing expectation in the social and environmental impacts of mining. This will require future mining professionals to not only understand mining practises and the limitations of technology but also develop 'soft skills' which provide more focus on communication skills as well as cultural issues and ethics (Grimsey, 2002). A modern mining engineering curriculum will need to address these to fulfil industry requirements.

3. Approach and Methodology

3.1 Industry Focussed Curriculum Design and Development

Many engineering disciplines, including the mining, require special considerations in curriculum design and close interaction with the industry. Moreover, the mining industry has the additive challenge of a cyclative industry, a rise of technology use and sustainability awareness which have brought new considerations into a mining engineering curriculum. To address this change, the program learning outcomes of mining engineering programs must be modified to remain up to date with the industry whilst also being able to attract both undergraduate and post graduate students to remain sustainable. The designing of the curricula and resources at Monash University's mining engineering program, was aimed at the following main objectives:

- To prepare students with job-ready and foundational skills, attitudes and industry knowledge needed to enter the mining industry directly, and
- To provide the mining industry with a skilled and safety conscious workforce now and in future, through theoretical aspects, lectures by mining industry experts and field-based components.

At the beginning in 2013, being a brand new program, Monash could not join the well-established 'Mining Education Australia (MEA)' consortium. This necessitated Monash developing its own curriculum, which in many ways helped Monash University – especially to diversify into the Resources Engineering areas. We led the design of curricula and resources, which model real-world mining engineering principles that the students will put into practice in their own working careers as mining engineers. While the curriculum was built around the MEA model, it was customised in line with the unique emphasis set out in the program objectives.

The initial/original course curricula were reviewed by the mining group by carrying out a 'gap analysis' as part of the mining curriculum workshop followed by a curriculum mapping exercise (in June 2014) based on the outcomes of a 'Mining Curriculum Workshop' held in March, 2014. There were nine (9) mining industry representatives participated (see in Figure 1), providing input into curricula that assisted Monash to ensure such that its mining graduates will meet current and future industry needs.

Figure 1 Mining Curriculum Workshop 2014

Accordingly, the curricula was refined to suit the industry which was also validated, whilst making sure that it has both "essential and work readiness skills (both technical and non-technical)" components, which the mining industry has deemed necessary for 'entry-level' employment. Based on the outcomes of the workshop, the curricula and resources were updated to reflect current and changing industrial practices. One of the recommendations was to lay more stress on 'strong leadership, teamwork, management and communication skills' and accordingly a group assignments were introduced into Introduction to mining (MNE1010) and Mine Systems Planning (MNE3020) with the main aim of developing student's written and interpersonal communication skills as well as team management and leadership abilities. This is in consistent with Engineers Australia's Stage 1 Competencies (Engineers Australia, 2019).

Again, in June (2015), another 'Curriculum Retreat' was held at Monash University, where issues similar in nature were discussed focusing on resources engineering and the additional new degrees. The main purpose of this workshop was to assess the program ahead of full accreditation in 2017 and also to better understand of how each learning outcome and elements of competency are linked, and how they align with assessment.

The curriculum design was undertaken by closely collaborating with mining professionals, industry and professional bodies, such as the Australasian Institute of Mining and Metallurgy (AusIMM), which led to the development of a framework (as outlined in Figure 2) that could potentially be used as the best practice guidance. Figure 2 outlines the pedagogical design model developed and used in curriculum the development exercise, which led these developments. The design of curricula is informed by deep understanding of curriculum theory and practice. The curriculum design model real-world principles that students will put into practice in their own working careers as mining engineers in the field (see Figure 2).

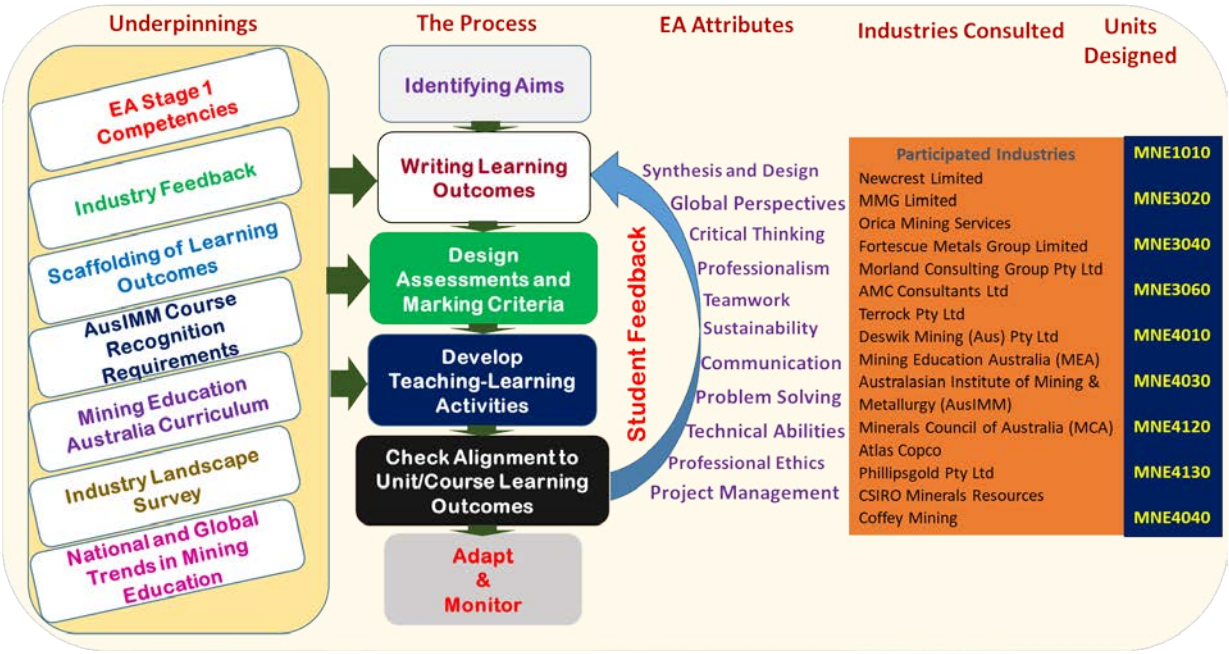

Figure 2 Curriculum development framework used at Monash University

The pedagogical design model in Figure 2 is well grounded in both theory and practice as much of it was informed by the curriculum retreat and workshop where heavy industry input was sought. The framework built around the MEA model was underpinned by a number of formal and informal requirements, such as Engineers Australia Stage 1 competencies, industry feedback, the AusIMM, course recognition requirements and national and global trends in present and future mining industry outlook. This model has been constantly evaluated in a variety of ways, both formal and informal; it aligns with the quality cycle model of Monash University; “plan-design-appraise-implement-feedback-review and improve”.

3.2 Role of MEA, AusIMM, Engineers Australia in Mining

3.2.1 Engineers Australia Competencies

For a mining engineering course to be accredited, the graduates must be able to fulfil the Stage 1 competencies provided by Engineers Australia (Engineers Australia, 2019). These competencies include having adequate knowledge of the engineering discipline and the ability to apply it to complete engineering projects. Soft skills are also a requirement where the graduate must be able to demonstrate ethical and professional conduct as well as have effective communication, teamwork and leadership skills.

3.2.2 MEA

The Mining Education Australia (MEA) developed in 2003-04 is a joint venture consortium consisting of four universities, namely the University of Queensland, University of New South Wales, Curtin University and the University of Adelaide in collaboration with the Minerals Council of Australia (MCA). The main objective of MEA was to deliver an economically sustainable high quality mining engineering curriculum to assist the mining industry within Australia and to increase the talent pool supply to meet the increasing demand (Mining Education Australia, 2014).

3.3 Teaching workplace readiness skills through project-based learning:

The Mining Engineering curricula has also introduced popular mining industry software packages used in the industry with the specific aim to prepare students for employment within the mining industry. These are, i.e., ***MineSight*** as part of Resource Estimation (MNE/RSE 3020), ***BlastLogic*** as part of Blasting and Fragmentation (MNE/RSE 3060) and ***Deswik*** as

part of Mine Planning and Scheduling (MNE/RSE 4010). The feedback from industry and students clearly provided evidence that the training on these software packages helped the mining industry and students to experience the industrial application of theory in a laboratory setting at the university.

When mining engineers graduate, besides many other roles they often work as ‘Short-term Mine Planning Engineer’ or ‘Drill Blast Engineer’, where they are expected to be familiar with these popular mining industry-specific software programs. Training on these software packages helped the mining engineering students to experience the industrial application of theory in a laboratory setting at the university and this is reflected through their qualitative SETU comments.

There is a strong belief that one of the most important aspects of mining engineering education is instilling in students the ability to truly integrate theory with practice. Students who understand both the basis of theory and how to apply the theoretical principles to realistic problems will have a sound foundation for later work. This integration between theory and practice can be difficult, especially in the mining context, but by way of implementing project-based learning has proved effective particularly when based on real-life industry projects as in various units throughout the course. The projects greatly helped students to remain connected with field applications and help prepare students for industry and students have highly regarded the importance.

4. Outcomes

The design of curricula was greatly informed by deep understanding of curriculum theory and practice as it involved a number of practitioners besides academic staff at the university. While the industry executives brought in tremendous practical wisdom to the table, the academic staff made sure that the practical aspects were grounded in theory. As a consequence, the designed curricula and resources modelled the real-world principles that mining students are expected to put into practice for their own working careers as mining engineers in the field. The curriculum achieved the following main outcomes for our program and the students:

- working closely with the resources sector to develop the curriculum ensured our students developed the relevant skills and knowledge of the industry
- ensuring that there are close links between each of the units to produce innovative resources professionals for the future
- connected the students with industry before they graduate, allowing them to build professional networks and practical skills.
- enabled students to complete internships and often securing jobs in the resources sector before they even graduate
- prepared the students with job-ready and foundational skills, attitudes and industry knowledge needed to enter the mining industry , and
- provide the mining industry with a skilled and safety conscious workforce , through theoretical aspects, interactive sessions by mining industry experts and field-based components.

5. Conclusion

This paper has presented a case study of a design and development of mining engineering course at Monash University using an industry-centric approach which has contributed to enhancing students' engagement in learning and fostered employability. The industry-focussed curriculum design and development was successfully adopted and implemented in mining engineering program at Monash University, with a feedback-loop that informed the process. The framework proposed in this paper is worth emulating that not only satisfied the

requirement of two professional and accreditation bodies (EA and AusIMM) whilst meeting the industry needs, without sacrificing knowledge of engineering fundamentals.

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