Engineering Collaborative Models in Minerals Higher Education: The Minerals Tertiary Education Council

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Structured Abstract

BACKGROUND
The Minerals Tertiary Education Council (MTEC) was conceived in 2000 by the Minerals Council of Australia at a time when a sustained minerals downturn was forcing minerals schools and departments to close. Since this time, MTEC has made significant investments into nationally collaborative higher education programs in mining engineering, metallurgy and minerals geoscience, involving some seventeen Australian universities, to build capacity in these core disciplines. This paper will provide an overview of MTEC, outline these successful industry/higher education collaboration models, and describe the collaborative strategies and processes that were created and employed to support the MTEC programs.

PURPOSE
This paper presents a working model of the collaborative processes utilised by MTEC and its education partners in the formation, development and growth of three national programs. It also provides an overview of the collaborative tools that can be used to support industry-led collaborative learning in specialist engineering disciplines.

DESIGN/METHOD
Key operational elements of the three unique MTEC programs are individually mapped against success factors in industry/higher education collaboration. These include the contextual, organisational and process factors that ensure the objective and subjective goals of the collaboration are reached. This approach tests whether the confidence which MTEC and the Australian minerals industry has in the success of its programs, fits an overall model of success in industry/higher education collaboration (as proposed by Thune, 2011).

RESULTS
Each of the MTEC programs respectively and collectively demonstrate the existence of contextual, organisational and process factors that define success in industry/higher education collaboration. This in turn demonstrates that the objective and/or subjective goals for each program are indicators of success. The MTEC programs predate Thune's (2011) model and have continued over a number of uninterrupted years. This validates the MTEC approach beyond the casual indicators of success.

CONCLUSIONS
The MTEC programs collectively address the various categories that define the success factors for industry/university collaborations. Accordingly, either the overall MTEC approach or any of its individual programs can be considered as successful models, which other industries or sectors could use as a basis for collaboration with higher education to achieve specific objective and/or subjective goals.

KEYWORDS
Minerals education, Higher education collaboration, Minerals Tertiary Education Council (MTEC).

Introduction

Research literature on collaboration between the private sector and the higher education sector is dominated by research partnership, knowledge transfer or commercialisation activities (Thune, 2011). Overwhelmingly, the emerging era of science-based collaborations between industry and academia offers advantages in addressing the challenges facing the wellbeing of societies globally, to the mutual benefit of both sectors (Corillon and Mahaffy, 2011). Collaborative research and strategic research partnership is focused on increasing the capacity of industry and on increasing the flow of knowledge across sectors, as well as the broader social outcomes reflected in government policy. Shapiro, Haahr and Bayer (2007) explain the concept of a “knowledge triangle” - the interaction between education, research and innovation - and the vital importance of education and training for innovation. Etzkowitz and Leydesdorff (2000) similarly express the dynamics of innovation in the “triple helix” framework of university-industry-government relations and the internal transformations within each of these elements for the good for society.

How these collaborations meaningfully influence knowledge transfer to undergraduate and even postgraduate students is less clear. Thune (2011) highlights that the role of education in university/industry partnerships is less frequently addressed, even though education-related activities in the form of university graduates represent the largest share of collaborative activities between the higher education sector and the private sector. Thune (2011) elaborates that while university/business collaboration is common and takes varied forms, it is not firmly institutionalised. Characteristically, collaboration takes the form of informal agreements between businesses and individual academics or departments, which can vary in time and frequency.

Success factors in higher education-industry collaboration

Thune (2011) explains that research literature addressing performance and success in higher education/industry collaboration first and foremost measures success in terms of subjective assessments and to a lesser extent systematic empirical data on particular performance indicators. This would imply that the assessment of such relationships do not necessarily have an impact on the outcome of the partnership. In Figure 1, Thune (2011) presents three main categories of success factors in university/industry collaboration, viz. contextual factors, organisational factors and process factors, and explains that no current knowledge exists as to the correlation between different measures of success in collaborative relationships.

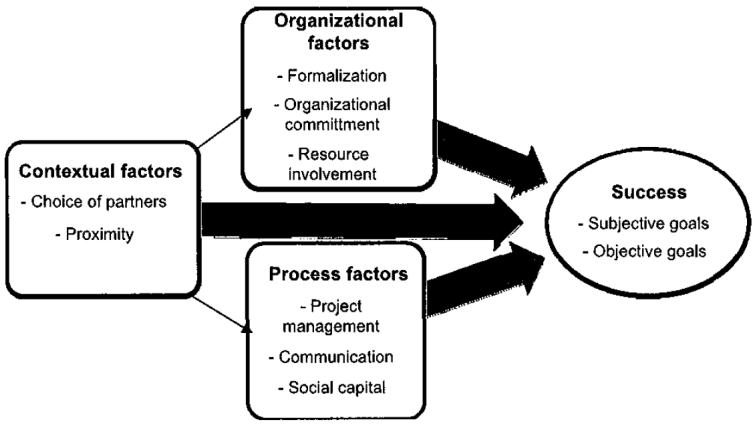

Figure 1: Factors of success in university-industry collaboration (Thune, 2011)

This paper will present an example of collaborative models in Australian higher education in minerals engineering (through the Minerals Tertiary Education Council) against the factors of success postulated in Figure 1.

Australian minerals higher education-industry collaboration

The MCA represents Australia's exploration, mining and minerals processing industry, with member companies accounting for more than 85 per cent of Australia's annual mineral output. The Australian minerals industry, through the Minerals Tertiary Education Council; (MTEC), is a proud initiator and supporter of national collaborative initiatives in higher education to build capacity in the core disciplines of mining engineering, metallurgy and minerals geoscience to deliver high quality graduates which industry desires (Figure 2).

Minerals Geoscience	Mining Engineering	Metallurgy
University of Tasmania	The University of New South Wales	The University of Queensland
The University of Western Australia	The University of Queensland	Curtin University (WA School of Mines)
James Cook University	Curtin University (WA School of Mines)	Murdoch University
The University of Adelaide	The University of Adelaide	
The University of Melbourne		
Monash University		
The Australian National University		
Curtin University (WA School of Mines)		
University of Newcastle		

Figure 2: Minerals Tertiary Education Council (MTEC) partner universities

The Australian minerals industry continues to experience professional skill shortages in its core disciplines and recognizes that its investment in higher education is one way to ensure the future employment pipeline. The Minerals Council of Australia established its Minerals Tertiary Education Council (MTEC) in October 1999 to foster partnership between industry, government and academia to provide and promote opportunities in the tertiary education arena by working with a network of selected university partners. MTEC was established in response to university departments and schools delivering specialist minerals related programs closing (or facing closure) in the mid-1990s (Minerals Council of Australia, 1998). The core disciplines of mining engineering, extractive metallurgy and minerals geoscience traditionally have low student enrolments but involve high costs to the universities that offer any of these. Some key contributors to the increasing teaching costs of these core disciplines include:

- The failure of past Australian Governments to index higher education funding, which has resulted in a growing inability of university departments to be viable under its student numbers based system – especially when student numbers are low;
- A failure by the Australian Government to recognise mining engineering, extractive metallurgy and minerals geoscience as a disciplines of national interest and accordingly afford it appropriate levels of funding;
- The investment of universities in teaching and learning capabilities for high enrolment, low teaching cost courses (i.e. volume-driven programs);
- Shortages of skilled academic staff, compounded by the ageing profile of academics.

As of 2014, MTEC is funded as a compulsory part of MCA membership, rather than the opt-in approach taken since MTEC's formal constitution in October 2000. This is a signal moment for MTEC, illustrating that MTEC is viewed by the industry as an essential part of the

long-term vision to successfully secure and maintain the supply of quality graduates in the core disciplines of mining engineering, metallurgy and minerals geoscience.

Tuckwell (2000) explains the original strategic intent of the MTEC as "*the opportunity for a true partnership to develop between industry, government and academia that will reshape minerals education in Australia and secure the future supply of the specialists industry needs to maintain international competitiveness*". Lind (2014) further expands on MTECs continued success, some fourteen years later, in that "*the all-of-industry approach delivers results on an uninterrupted education and training pathway presents a mechanism for industry and academia to collaborate to address future professional skills needs in the minerals industry globally*".

The following portion of this paper sets out the various MTEC programs and maps key aspects of those programs against the factors of success (as depicted in Figure 1), with the relationship indicated in [*e.g. contextual factor: choice of partners*].

Mining engineering: Mining Education Australia (MEA)

Mining Education Australia (MEA) is an unincorporated joint venture between four universities (Figure 2). MEA is governed by a Members Agreement (signed by the Vice-chancellors of the partner universities) and overseen by a Governing Board and Executive body comprising representatives from industry and academia from each MEA partner university [*organisational factor: formalisation; organisational factor: organisational commitment*].

MEA was established in 2007 by the three founding members (Lind and Andrews, 2007a and 2007b) through an expression of interest process, with the University of Adelaide joining in 2011 [*contextual factor: choice of partners; organizational factor: formalisation*].

The MEA partner universities developed a common/uniform third and fourth year Mining Engineering curriculum, including commonality in all forms of assessment in those years of study [*organisational factor: resource involvement; process factor: project management; process factor: communication; process factor: social capital*].

Andrews and Lind (2007a and 2007b), Mitra *et al* (2009) and Saydam *et al* (2009) detail the issues for successful collaboration in MEA, including consistency in assessment across MEA partner universities. The MEA partner universities produce some 85 per cent of Australian mining engineering graduates annually [*contextual factor: proximity*].

There is a formal funding agreement between the MEA unincorporated joint venture and the MCA which sets out the MEA objectives and the funding mechanisms (linked to graduate output) [*organisational factor: resource involvement; organisational factor: organisational commitment*].

With the key goals of the MEA program being to increase the number of Australian mining engineering graduates [*success factor: objective goal*] and ensure quality in the supply of Australian mining engineering graduates [*success factor: subjective goal*], Figure 3 indicates that the collaboration has achieved that objective goal.

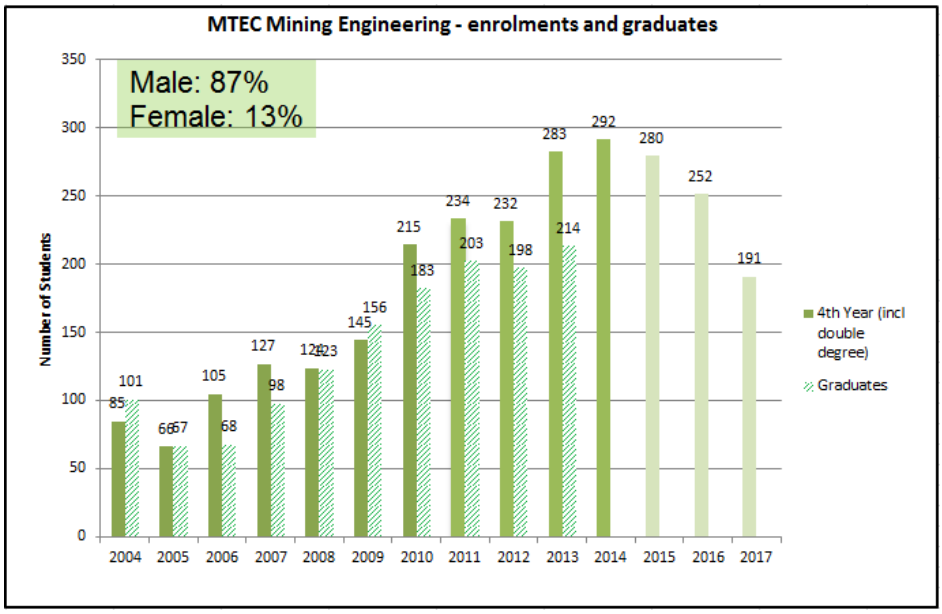

Figure 3: Mining engineering graduates (2004-2013) and fourth year projected enrolments (2004-17) from (MTEC) partner universities (MTEC, 2014)

Extractive metallurgy: Metallurgical Education Partnership (MEP)

Metallurgical Education Partnership (MEP) is an informal arrangement since 2008 between Australia's only three universities (see Figure 2) offering extractive metallurgy programs (Lind, 2012 and 2014) [*contextual factor: choice of partners*]. Without direct industry involvement the potential remains that Australia will lose teaching capability in this specialist discipline [*success factor: objective goal*].

The three universities are incentivised to participate in the MEP through individual funding agreements signed by their respective Vice-chancellors and the MCA. The program is overseen by a Steering Committee and an Implementation Committee comprising industry and academia from each MEP partner university and MTEC [*organisational factor: formalisation; organisational factor: organisational commitment*].

Ibana (2014), as well as Hannah and Hayes (2014) detail the complexities of collaborating on an industry-led final (fourth) year capstone process and plant design unit across three partner universities that deliver different degree structures (two offer engineering degrees and the other a science honours degree) [*organisational factor: resource involvement; organisational factor: organisational commitment; process factor: project management; process factor: communication*].

The collaboration sees final year students work in intra and inter university groups to produce a process and plant design from real data provided by industry, with the commodity focus changing annually. All students and staff form the MEP partner universities attend and participate in a week-long industry masterclass at the beginning of the second semester of the fourth year (which is commodity specific), and the culmination of a six-month planning period by the MEP Implementation Committee [*organisational factor: resource involvement; organisational factor: organisational commitment; process factor: project management; process factor: communication*].

The students obtain real-world and industry-relevant experience, to better prepare them for industry-readiness upon graduation. To ensure the integrity of these outcomes, the MEP underwent an industry review in late-2013, with recommendations being implemented by the MEP Implementation Committee in 2014 [*process factor: project management; process factor: communication; organisational factor: organisational commitment; organisational factor: resource involvement*].

Along with the key goals of the program being to prepare metallurgy graduates for the industry and to maintain teaching capacity, the fact that the program in its current form is in its seventh consecutive year attests to the achievement of this strategic collaboration [*success factor: objective goal*; *success factor: subjective goal*].

Nonetheless, the longer-term graduate output remains flat-line. Figure 4 indicates that the long term average graduates for extractive metallurgy has been stable (with little growth), the option for a quality industry/university collaborative education exists in this niche discipline (irrespective of quantity).

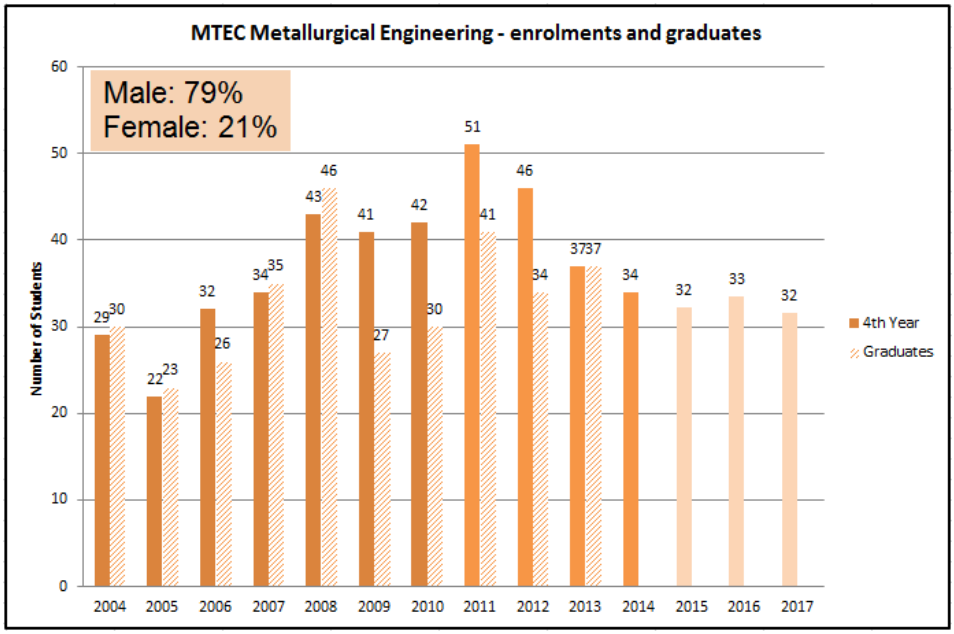

Figure 4: Metallurgy graduates (2004-2013) and fourth year projected enrolments (2004-17) from (MTEC) partner universities (MTEC, 2014)

Minerals geoscience: Minerals Geoscience Honours (MGH)

Minerals Geoscience Honours (MGH) is a unique collaboration between nine Australian universities (Figure 2) through which honours students from any of the partner universities can participate in any two of nine short specialist minerals-focused honours courses to enhance their minerals geoscience knowledge [*contextual factor: choice of partners; contextual factor: proximity*].

Similar to the MEP, the nine universities agree, through individual funding agreements signed by their respective Vice-chancellors and the MCA, to participate. The MGH is overseen by a Steering Committee and an Implementation Committee comprising industry and academia form each partner university [*organisational factor: formalisation; organisational factor: organisational commitment*].

Honours students are incentivized to attend these specialist courses through MCA travel bursaries, with all honours short courses being available in the first semester of the honours year (Alexander, 2010). None of the MGH partner universities offer comprehensive minerals geoscience, so the MGH offer the unique opportunity for students nationally to access these specialist courses, irrespective of their location [*process factor: communication; organisational factor: organisational commitment; organisational factor: resource involvement*].

The MGH underwent an industry review in 2013, with the Implementation Committee applying the recommendations in 2014 [*process factor: project management; process factor: communication; organisational factor: organisational commitment; organisational factor: resource involvement*].

With the transferability of a geology qualification across multiple industries, the key goals of the MGH program to increase the exposure of honours students to minerals geoscience topics. In fact student participation in the program since its formalisation in 2008 has increased (Figure 5) [*success factor: objective goal*; *success factor: subjective goal*], leading to an increased pool of potential graduates for the minerals industry.

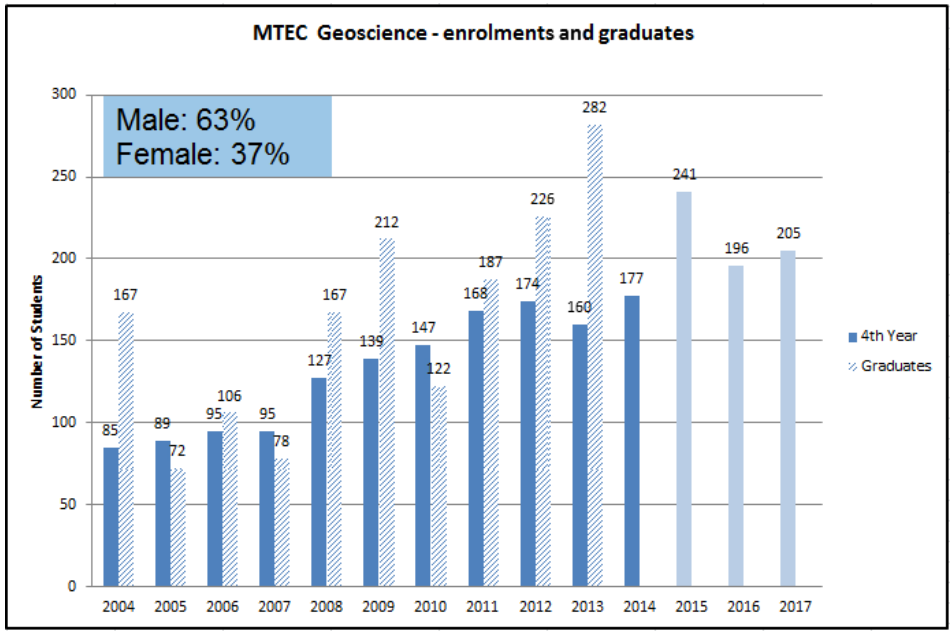

Figure 5: Minerals geoscience graduates (2004-2013) and fourth year projected enrolments (2004-17) from (MTEC) partner universities (MTEC, 2014)

External MTEC awards – a government link

Lind (2014) presents a comprehensive list of key MTEC achievements over the period 1998-2011 in achieving its overall objective goal of building capacity in higher education through national collaborative programs. Additionally, MTEC has been awarded funding and prizes to further develop its university-industry relationship as follows:

- Award of a Science Lectureships Initiatives (SLI) grant in to assist in building and delivering collaborative courses in earth science, mining engineering and extractive metallurgy (2001)
- An Australian Museum Eureka Prize for Industry in the Research and Innovation category, for the creation of the Minerals Tertiary Education program which encourages cooperation between universities and the minerals industry to provide enhanced education opportunities for students and graduates of geoscience, mining engineering and metallurgy (2001)
- Receipt of a Collaboration and Structural Reform (CASR) grant to establish Australia's first and only 4 university national undergraduate program in mining engineering - Mining Education Australia (MEA) (2007)
- A prestigious Australian Teaching and Learning Council (ALTC) award for Educational Partnerships and Collaborations with Other Institutions MTEC's flagship mining program – Mining Education Australia (MEA) (2010)
- A Council on Australia and Latin American Relations (COALAR) grant to explore the possibility of taking MEA to a global audience based on the teaching of sustainable mining practices (2011)
- An Australian Commonwealth Government grant under the Workforce Innovation Program to undertake a feasibility study and prepare for implementation national

Associate Degrees in Mining Engineering and Geoscience, known as the Minerals Industry National Associate Degree (MINAD) Project (2012)

- Recognition of leadership in tertiary higher education management with the MTEC Executive Director (Dr Gavin Lind) being awarded the 2013 ATEM/Campus Review LH Martin Award for Excellence in Leadership

In addition to the recognition of MTEC's collaborative effort with universities, the award of competitive grants indicate that there is the potential to include another layer beyond the demonstrated university/industry collaboration benefits. This third element is the potential to provide benefit to both government and society through innovation (Etzkowitz and Leydesdorff, 2000).

Conclusion

To secure a future supply of quality professionals for the minerals industry, direct investment by the industry remains, as it has been in the past, a requirement. Industry involvement facilitates the delivery of undergraduate programs that equip students with the relevant high quality technical and decision making skills to incorporate the social, environmental and financial aspects of development. Graduates who have these skills can actively play key roles in delivering on the national innovation agenda. Thune (2011) suggests that since university/industry relationships are voluntary arrangements, continued investments in partnerships over time indicate that the partners are reasonably satisfied with the partnership. MTEC has existed continuously for fifteen years, and has evolved and adapted in supporting the partner universities who deliver to its core disciplines. The MTEC model comfortably fits factors of success in university/industry collaboration (viz. contextual, organisational and process factors) and adds to the subjective body of knowledge that predates the model as suggested by Thune (2011). Importantly, the MTEC model is shown to be successful across three disciplines and accordingly could be applied across any discipline or collaborative partnership. Furthermore, the addition of competitive grants and external awards to the evaluation of success may be an enhancement for further consideration of the Thune (2011) model.

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