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Mining education – achievements and challenges

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Abstract

This paper reviews the progress achieved through the strategic initiative taken collectively between the major mining educators and the Minerals Council of Australia some years ago with the formation of Mining Education Australia (MEA). MEA is an industry-endorsed, collaborative national engineering education programme delivering higher quality comprehensively educated mining engineers; while at the same time providing greater underpinning support to sustain the mining programmes at each member university.

Just as the mining industry is truly international, so is the education sector seeking stronger international linkages. The paper will discuss some international education issues, plus some new initiatives being pursued by MEA and member universities. The paper will further discuss some alternative education pathway options for addressing the mining skills shortages through postgraduate education initiatives at The University of New South Wales (UNSW).

The final but critical element of the paper will address the critical problem of developing a pool of suitable future academics. Without an adequate supply of young and up and coming mining academics, all of the graduate supply projections are under threat, as is the whole question of sustainability of the mining education sector. Set against an ageing academic population, there is an urgent need for fostering and developing future academics – a path that commences at the PhD enrolment stage.

1 Introduction

The skills shortage across the Australian mining industry has been well documented and crosses many disciplines and skill levels. However, a fundamental sector of the shortage is in the discipline of mining engineering. Mining engineers are the fundamental building block for planning and design of new projects and for operational management for continuing operations through to closure. Over the last decade or more, the best estimate for the Australian demand for mining engineers had been informally stated to be between 200 and 250 graduates per year, by senior representatives of individual mining companies, and by the Minerals Council of Australia (MCA). However, more recent estimates against the background of the current mining boom put this figure closer to 500 per year (Smith, 2011).

Figure 1 shows both the intake and graduation numbers for mining engineers across Australia, to 2010, based on surveys conducted by Hebblewhite (2011), on behalf of the international mining education body, the Society of Mining Professors (SOMP). Whilst this shows significant growth in recent years, it is still characterised by some short-term cyclical variations (such as the drop in commencing student numbers in 2009 following the global financial crisis). It also indicates that the education sector is well on the road to meeting the previous demand figure of 250 graduates per year, but is well short of the revised demand target of 500 graduates per year.

Figure 2 shows similar data for the United States of America, drawn from a number of sources, including the annual SOMP survey (Hebblewhite, 2011) and also the annual survey conducted by SME in the USA (SME, 2011). Interestingly, the US data shows that in 2007 there were only 125 mining engineering graduates across the whole of the US, graduating from 13 mining educational universities. A significant improvement was evident in 2008 but numbers appear to have flattened out again in recent years. The graduate numbers for 2010, at 185, are now lower than those for Australia (225). It is clear that the mining engineering graduate shortage is not just an Australian problem.

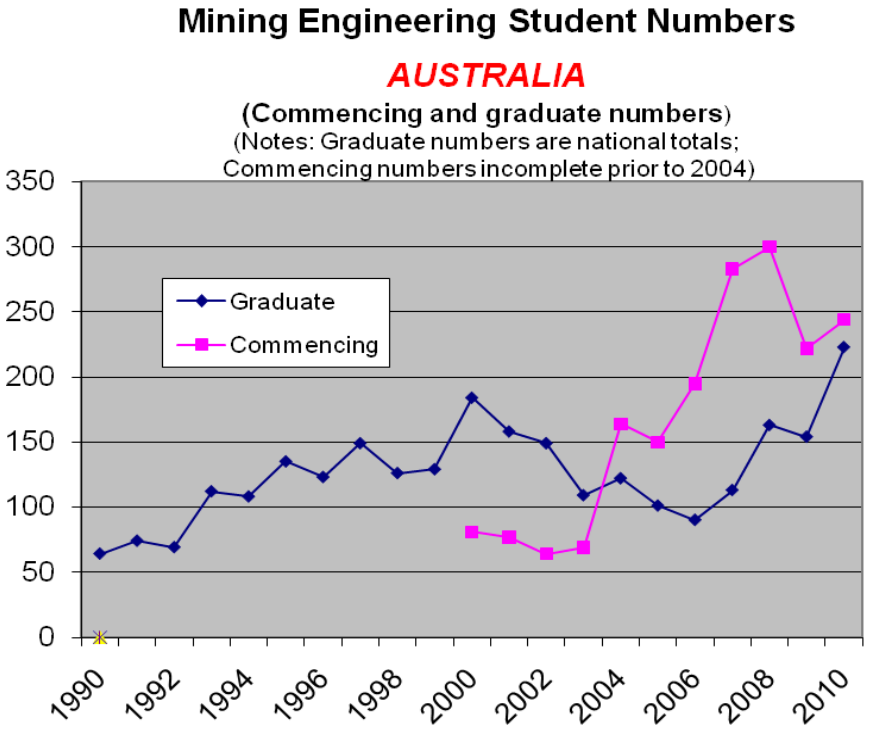

Figure 1 Australian mining engineering student numbers (commencing and graduate) to 2010 (after Hebblewhite (2011))

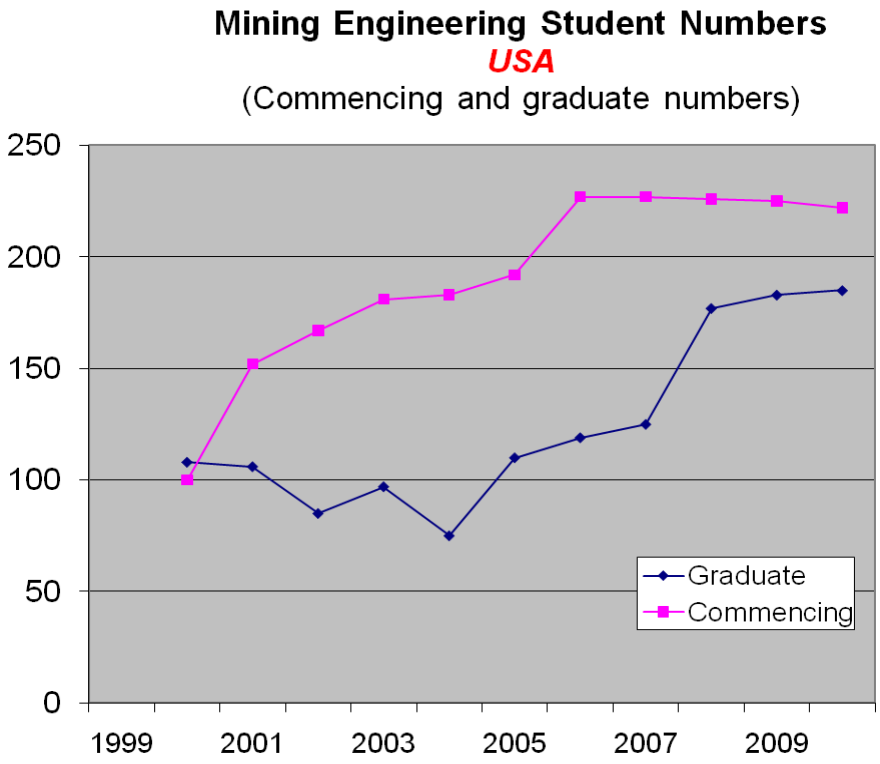

Figure 2 USA mining engineering student numbers (commencing and graduate) to 2010 (after Hebblewhite (2011))

The challenge for the mining education sector is more than just graduate supply, important as that may be. It is also about future academic supply, and the third element is viability of relatively small educational

units within comprehensive tertiary education institutions. What is needed is to provide a strengthened and strategic approach to all three of these issues:

- graduate supply
- viability of mining education entities
- future supply of academic staff.

This paper will discuss the progress and challenges facing the sector with respect to each of these issues, including some recent initiatives in postgraduate education at UNSW; together with some initial discussion on the achievements to date, in terms of the initiative commenced some years ago with the establishment of the national joint venture, MEA.

2 The MEA initiative

MEA is an unincorporated joint venture between the four major providers of mining engineering graduates in Australia: Curtin University, The University of Adelaide, The University of New South Wales and The University of Queensland. MEA was first established in 2006 between the founding three members, with Adelaide joining in 2008 and becoming a full member of MEA in 2010.

Through leadership from the Australian mining industry, under the direction of the MCA and its education body, the Minerals Tertiary Education Council (MTEC), Australia commenced down the path of mining educational collaboration in 1999/2000, culminating in the establishment of a truly national undergraduate curriculum, MEA, in July 2006.

The early developments and formative collaborations leading up to the establishment of MEA have been previously described by Tuckwell (2005) and Hebblewhite (2006, 2010).

2.1 Key features of MEA

Funding is managed through a small MEA Administration Unit, with responsibilities for management of course development, all course and related resource data repository, marketing and promotion, MEA staff development programmes and financial management as follows:

- a Governing Board comprising 50% industry and 50% university representation
- a national curriculum covering the final two years of the undergraduate degree programme
- course development and ongoing management by teams of academics
- comprehensive team of over 30 mining academics across the country
- innovative delivery methods
- staff sharing
- financial incentives based on participation and performance.

MEA produced its first national graduates at the end of 2008, with 122 graduates having completed the inaugural MEA 3rd and 4th year programmes in 2007 and 2008. In 2008, the four MEA universities accounted for 260 of the 290 newly enrolled students across Australia, or 90%. Figure 3 shows some of the first MEA graduates. MEA now accounts for over 85% of the mining graduates produced in Australia. In 2011 there are over 200 students in their final year of study, expecting to graduate at the end of the year.

Figure 3 Representatives from the first cohort of MEA graduates in 2008

MEA has provided the students with a far more comprehensive and higher quality education than was available at any of the individual universities previously – as a result of access to a much broader range of academic staff (faculty) experience and expertise, as well as a totally new, state-of-the-art curriculum, designed by the combined staff, in conjunction with industry, and developed with funding provided by the MCA and the Federal Government.

The curriculum has been developed along a series of programme themes, or streams, as illustrated by Scoble (2008), shown in Figure 4.

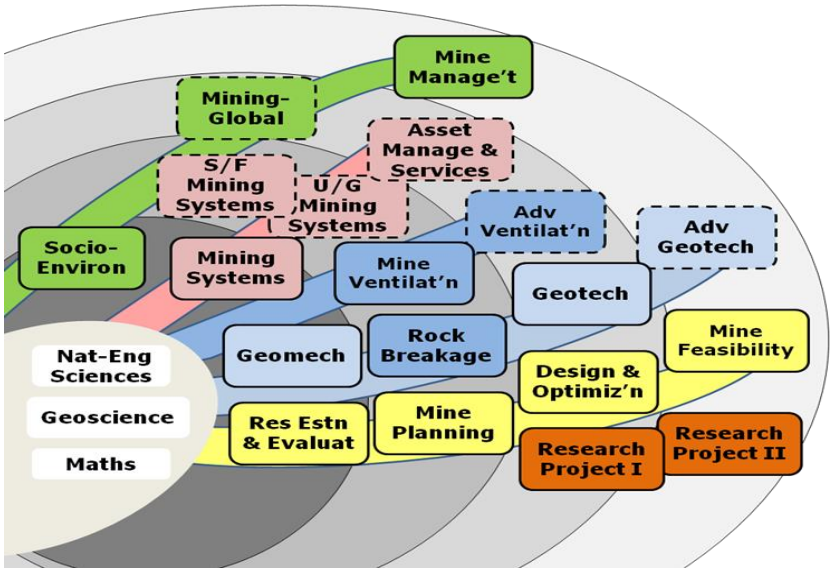

Figure 4 MEA curriculum themes (after Scoble, 2008)

The financial support from the MCA has provided initial support enabling funding for the establishment of MEA, but continues to provide sustaining support to fund the MEA Administration Unit, as well as providing a flow of funds, through MEA, back out to the member institutions, for support of mining educational initiatives. This funding stream from MEA is not a subsidy, but its value is determined on the basis of graduate numbers each year, and the distribution is determined through an MEA financial model which values collaboration, cross-teaching, course quality, effective innovation and other parameters associated with the desirable attributes of being an MEA Member.

2.2 Innovative teaching and learning

Innovative teaching and learning is one of the key elements of the MEA initiative. A number of methods have already been employed, whilst others are under development for implementation across MEA in the future. The following is a summary of the key teaching and learning methods being adopted, beyond the conventional classroom lecturing style.

- Block teaching – key course modules taught in block-mode, over anything from half a day workshops to periods of three or four days full-time. Such sessions work well where there is a combination of lecturing plus student project work, workshop sessions, etc.
- Keynote lectures/learning sessions by subject matter experts – use of key expertise from across the MEA staff spectrum to deliver key teaching material to different universities, either as a keynote platform for the learning module, or simply to offset a skills shortage at a certain university. This can be achieved by the staff member concerned travelling to other MEA universities, or by one of the other methods discussed below.
- Interactive teaching classrooms, where MEA classes from across the country can be connected up with both video and audio capability for staff and students alike. This system also enables international connections as well as remote site location for single student engagement through a facility such as Skype.
- Where online interactive teaching is not possible due to facilities or timetabling, key lectures are being recorded as podcasts for distribution to either other site lecturers, or direct to students.
- Project and problem-based student learning – both individual and group work, including pioneering the use of software techniques for peer evaluation in group assignments.
- Fully interactive, independent web-based learning management platforms, independent of particular university systems, for managing course teaching resources and student access, etc.
- Distance-based learning modules – either provided on web, or via CD resource material – to provide full distance-based online learning.
- Use of Virtual Reality (VR) teaching modules for group or individual learning of complex mining systems and concepts, high hazard scenarios or field-oriented learnings where it may be difficult to expose students in the field to such environments. Modules developed by MEA include: mining system modules (block caving, longwall top coal caving and truck and shovel surface operations), coal outburst mechanics and a module on socio-environmental management around a mining operation.

Figure 5 shows students working in the UNSW 360 degree immersive virtual reality theatre, undertaking a problem-based learning project evaluating the interactions between mining operations and the related environmental and social impacts of mining in sensitive areas. This technology enables students to undertake virtual mine visits carried out on campus, with all the benefits of access to staff interviews, video and still photographic images; data files and documents and many other innovative capabilities.

Figure 5 Student learning through use of virtual reality technologies at UNSW

2.3 MEA - a strategic initiative

MEA was established, first and foremost, to address the industry's stated objectives of requiring more graduates. It was clearly a major strategic initiative at the time, and it required several years of careful planning and, most importantly, the establishment of a collaborative and trusting, non-competitive environment amongst the staff of the four institutions involved. MEA was the first of its kind in the undergraduate tertiary sector in Australia, and has been used as a model for others to follow.

As a totally new educational concept, the strategy behind MEA was to achieve goals that were simply beyond any one individual university. Mining Schools or Departments are inevitably small in numbers (staff and students) relative to other disciplines. This makes them vulnerable to closure as stand-alone, individual entities, when the inevitable cycles impact on student intake numbers, or when staff shortages reduce the academic staff to below a critical mass. However, as part of a much larger collaborative initiative, such viability issues are dramatically reduced as ongoing concerns.

The MEA concept has provided solutions to many issues, through delivering a supplementary supply of income from MCA, through the ability to share staff resources and cover for gaps in staff expertise. A significant additional advantage has been the improved quality of the curriculum and the learning experience for the students as a result of the collaborative and continual improvement aspect of course development. In addition, students across the country are able to have access to potentially four times (or more) the number of academic staff, and a much broader range of staff expertise, for teaching, consultation and project/thesis supervision. In 2010, MEA was awarded an Australian Learning and Teaching Council (ALTC) Award for Educational Partnerships and Collaborations with Other Organisations.

MEA is now embarking on the next logical stage in this, developing strategic initiative through establishment of international links. Through funding from the Federal Government and a seed-funding grant from the Department of Foreign Affairs and Trade under the COALAR (Council on Australian and Latin American Relations) Programme, MEA is establishing links with a number of South American universities to foster staff exchange arrangements and future collaborative teaching opportunities.

3 Graduate supply–demand scenarios

3.1 How long will the demand last?

Before focussing on the supply question, a critical question that should be considered is: how long are these projected demand levels for graduates going to continue? Is this just a short-term requirement, or is it something that will last for five or ten years, or is it a really long-term, almost permanent quantum step up in continuing demand for mining engineers?

The answer to this question is difficult, if not impossible, to answer now, only history will give us the answer in decades to come. However, the general wisdom across the industry and beyond is that this is not just a typical short-term boom, to be followed by the inevitable downturn cycle, or even bust, as has been seen during recent decades. This boom is here for the long-term. It is a boom that is driven by unprecedented levels of investment in new projects requiring new people, coupled with the need to replace a large percentage of the current ageing workforce approaching retirement.

The education sector should therefore be able to proceed, with a reasonable degree of confidence, to making some much longer-term plans to satisfy the quantum jump in graduate demands associated with it.

A recent newspaper article in the Sydney Morning Herald by Gittins (2011) made some quite logical and justifiable statements about the likely longevity of the current mining boom and why it is different from what we have seen before. He stated:

> *"This boom seems likely to last a lot longer – say, a decade or more – than previous booms. Indeed it has already lasted a lot longer than we are used to. Past booms have been based on a cyclical (and thus temporary) upswing in the developed world's demand for our commodity exports, whereas this one is based on a structural (and thus longer lasting) change in the world economy: the rapid industrialisation and urbanisation of the two most populous economies, China and India, with various other developing countries following in their wake."*

It would therefore appear clear that the projected industry demand figures are likely to stay at these new high levels for at least a decade or more, and therefore a long-term approach to addressing the supply question must be adopted.

3.2 Future mining engineer attributes

A second critical set of questions that must be asked, before focussing on the supply strategy, is:

- Will the industry still require mining engineers, as we currently know them, in the industry of the future? What does the mining engineer of the future look like?
- What knowledge and skills do such engineers need to be equipped with to enter the workforce in the coming 20 years?

Unless we can at least have some idea of the answers to these questions, we cannot be expected to come up with appropriate education programmes. However, given the changing nature of the industry; the dynamic cyclic nature of the commodities markets; and the rapid globalisation of mining companies, we can never expect to predict the future precisely. Therefore we must ensure that whatever education programmes are developed, they must be characterised by being adaptive to change – both the teaching programme, and the abilities of the graduates who are produced.

The following are just a few brief characteristics considered to be features of the mining engineers of tomorrow:

- grounded in good enabling scientific principles and engineering design capabilities
- sound technical knowledge of mining engineering systems, technologies and practices
- able to deal with uncertainty and ambiguity in design and management

- good communication skills at all levels
- good understanding of the principles of risk assessment and management across all aspects of mining engineering
- ability to live and work in non-urban and often remote locations
- capable of dealing with and adaptive to change
- commitment to value-adding, economic and productivity efficiencies and continuous improvement
- broad understanding of the principles and opportunities for remote control and automation, as applied to mining systems and ability to manage specialist technicians/support staff in these and related IT fields
- thorough understanding and commitment to health, safety, environment, community and cultural responsibilities and their implications for sustainable mining practices
- global consciousness and awareness in terms of all of above attributes – including appropriate development of indigenous human resources and related cultural considerations; multi-lingual communications abilities, etc.

Many of the above attributes are also applicable and valid for today's mining engineers, but some will gain increasing emphasis in the years ahead. What is clear is that there is no need to drop the fundamental enabling mining components from a current mining education curriculum, in favour of teaching detailed technical skills for using the latest mine planning software packages, or the finer details of an automation strategy. Mining engineers have just started their learning experience at university, and must be committed to a career of life-long learning. Their employers will equip them with these detailed technical skills and competencies, as and when required. It is the job of a first class mining engineering education programme to provide students with fundamental engineering skills, technical knowledge and awareness and, most importantly, an ability to learn, to analyse, to synthesise, to design and to apply such knowledge to practical situations.

There is now more scope than ever to offer a more internationally-focussed suite of mining engineering courses, as part of programmes that satisfy the above list of attributes. This then opens up the door to both national and international collaboration amongst educators who must become part of an international education industry—in a complementary manner to the increasingly global mining industry for whom we provide graduates. Failure to do so may lead to inevitable loss of education institutions and/or offering only second class mining programmes. The challenge is there to be accepted and the time is right now.

3.3 Possible supply strategies

It is clear that the need is to produce basically double the current graduate numbers, if the industry demand is to be met by locally educated graduates. In the interim, several things are happening:

- Engineers who would have expected to retire are being encouraged to continue working.
- Engineering graduates from overseas are being brought into the country to fill Australian engineering jobs – often lacking good communication skills and, in some instances, lacking adequate engineering expertise (although a number of the imported engineers have very high levels of skill).
- Other disciplines are being recruited to fill the roles of mining engineers.

Whilst these solutions are necessary, and they are helping mining companies meet their immediate needs, they are far from ideal, and much more in the tactical, short-term mode of response, rather than being a longer-term sustainable strategic solution to the problem.

It is therefore essential that the education sector, in partnership with industry, addresses some longer-term strategies if graduate numbers are going to close the gap that currently exists between supply and demand.

3.3.1 Strategy 1 – Increase conventional undergraduate student numbers

The first strategy is to simply develop double the graduate capacity through the current conventional undergraduate education approach. Whilst there is no doubt scope for a significant increase in locally educated engineers through this approach, it is more likely to satisfy closer to 50% increase at best, rather than the 100% increase being called for. The reasons for this view are:

1. Current mining educational institutions (both within and beyond MEA) have finite restrictions on physical teaching resources (e.g. laboratory space, computer labs). Major injections of capital are needed to solve this problem and universities are understandably reluctant to do this for a traditionally very cyclical discipline, without significant external financial contributions.
2. Ability to provide industry experience through structured field trips and vacation industry employment is already at or beyond the limit that industry is prepared to support. Unless industry will commit to a far greater involvement in this essential aspect of an undergraduate education, then this will place a serious restriction on further student number expansion plans.
3. There is a serious restriction on greater student capacity due to the limited number of mining engineering academics available to teach. This is not just an Australian problem, but an international one. Opening new mining programmes in Australia will simply exacerbate the problem, since staff will just move from one institution to another and the net gain will be close to zero. Therefore the better solution is to grow the existing programmes, but this is still challenged by the lack of available academics (see later discussion).
4. University funding models increasingly emphasise research ahead of undergraduate teaching. This is being driven by funding programmes from the Commonwealth Government, including the recently implemented Excellence in Research Australia (ERA) initiative. University dollars are being increasingly directed to programmes that generate high levels of research activity as measured by journal publications. This can disadvantage disciplines such as mining engineering that have a very small available pool of suitable publication outlets. In short, universities are reluctant to invest in mining engineering programmes unless there is a corresponding measurable improvement in research output.
5. Probably the major issue facing this strategy is the problem of not being able to attract sufficient numbers of high school leavers to enter mining engineering programmes. This problem is quite a deep seated one, and is linked to public perceptions amongst students, their parents, and their teachers, regarding the mining industry. As a result, the majority of students either do not even know about the career opportunities within the industry and so do not consider studying mining engineering, or they know but are dismissive of it due to the many misconceptions and negative messages conveyed through the media and through community groups, parents and teachers themselves. Unless there is a major commitment to educate the broader community and school populations about the industry and the career prospects offered, then this strategy will never meet the desired success levels required. This type of marketing/information strategy will not achieve success overnight, and will require major long-term industry action, rather than it being something where universities can have any significant impact, if acting in isolation.

This strategy is therefore an important one to be addressed, even though it is only likely to address, at best, 50% of the current shortage. It will require significant changes in levels of support for education from industry, in terms of not only significant dollars, but also attitudes and logistical support for student education. It will require ongoing major restructuring and changes at universities. The MEA strategy is an excellent starting point in this regard, but is just that – the start, rather than the end of the journey. Most importantly, it requires a major level of industry support and commitment to more effectively market the industry and its career potential to the community and the school population.

3.3.2 Strategy 2 – Alternative undergraduate programmes

A second strategy (not necessarily as an alternative, but potentially as a complementary approach) is to review options for different forms of undergraduate education. This may take the form of part-time cadetships or similar part-time study/work arrangements which may make studying at university a more affordable option for some students who currently cannot afford to enter university. Another benefit of such an approach is that it may provide an early link and commitment between students and employers, whilst studying.

This strategy is not likely to deliver huge numbers, but it should be considered for development as a complementary option under particular circumstances and geographic locations. The various alternative forms of teaching currently being implemented through the MEA model, such as block-teaching, problem-based learning, and distance delivery of content and interactive teaching, are all possible means of providing this form of education. However, they are limited in their application, especially for teaching basic and enabling science and engineering subjects, and for students in the earlier years of an engineering degree.

3.3.3 Strategy 3 – Alternative pathway through postgraduate coursework programmes

An important challenge and opportunity to meet the demand requirements is to open up more alternative pathways to achieving mining engineering qualifications. One such pathway is through postgraduate qualifications. Whilst not in any way proposing that a postgraduate degree is equivalent to four years of full-time undergraduate study, nevertheless, it provides people, often coming from different disciplines or backgrounds, with a way of gaining a professional career within the mining industry.

These people are already in the system in large numbers. Figure 6 shows the rapid and continuing growth in postgraduate coursework student numbers through UNSW Mining Engineering alone.

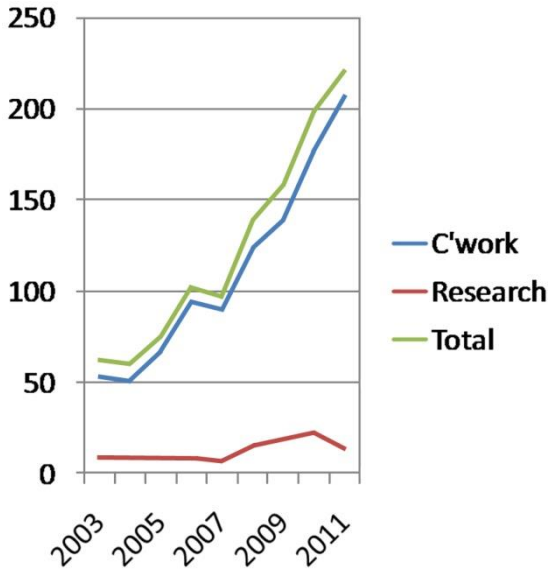

Figure 6 UNSW Mining Engineering postgraduate coursework numbers

This graph indicates that there are over 200 current postgraduate coursework students in the various programmes. Whilst a small percentage of these are studying specialist postgraduate degrees, the majority are enrolled in either the Graduate Certificate, Graduate Diploma or Masters of Mining Engineering. This graph indicates a remarkably consistent growth in numbers, at least 20–30% per year, for at least the past four years since 2007. In fact, currently UNSW has a total of 221 enrolled postgraduate students compared to 216 undergraduate students—the first time in the School's history when undergraduate numbers have not dominated, albeit that the undergraduate student total is also the largest it has ever been in 62 years.

So the challenge is there to ensure that many of these people – often coming from civil or mechanical engineering, surveying, geology, or even straight from the industry workforce – can enter the industry in various managerial and professional roles, with some form of recognised mining engineering qualification. The biggest obstacle to this aim being realised is the difficulties with differing state Qualifications Boards and recognition processes. At the present time there are a number of quite restrictive and extremely inconsistent approaches taken to this issue between the different states. This problem must be overcome, in the interests of satisfying the industry graduate needs without compromising professional or safety standards.

3.3.4 Strategy 4 – Australian educational pathways for international mining students

The fourth strategy to consider is to tap into the large numbers of mining engineers being educated in some other parts of the world, including developing nations, and bring them to Australia to provide them with an Australian "top-up". This is considered vital in terms of both the education standards that are considered important for the well-being of the industry, but also for the students to gain a better understanding of the Australian industry; the types of mining practices in this country; the standards of professional practice, ethics and attitudes, especially with respect to safety standards and cultures, and no doubt many other benefits.

How can this be achieved? There are at least two generic pathways for this to occur. The first is through an undergraduate "2 + 2" programme – common in many disciplines – where students do two years of a mining engineering degree in their home country, and then actually transfer to an Australian university to complete the final two years and graduate with an Australian degree. The MEA programme and others are able to cope with this concept well, apart from the resource limitations identified in Strategy 1. This concept is very popular with many Chinese universities and is currently being explored with them as well as with other countries that produce a large number of mining engineers.

The other main option is to take graduate students from other countries – mining graduates primarily, but possibly other engineering disciplines as well – and bring them to Australia to do a one year full-time intensive "top-up" or "sandwich" course in Australian mining. This could tie in with existing postgraduate coursework options, but would be a full-time offering, requiring additional modules. There are a number of countries that this scheme could be applied to, such as parts of South America, as well as Asia. However, it would require a significant and sustained financial and logistical commitment from industry to fund these students and the required educational programmes, and to work with government to facilitate appropriate visas and subsequent employment options.

4 Viability of mining education entities

The issue of viability of small, stand-alone mining engineering departments and schools has been raised earlier in this paper. The MEA initiative was a major strategic move to ensure that through a combination of industry income, together with shared teaching resources, these programmes would remain viable for the longer term. This is not just an idle, or hypothetical concern. History across the world is littered with closed mining education programmes. Often these have been preceded by merged programmes with disciplines such as civil engineering.

Collaboration in any form, together with partnerships with industry, are therefore the key ingredients to ensuring that existing programmes do not close down. MEA is just one form of such an arrangement, but there could be others. International collaboration is a logical extension of this concept for the future. Such collaboration may be informal, but may also see more formal ties established. MEA has already established international links, with selected MEA modules being taught into the University of British Columbia in Canada, for example and, more recently, the links with Peru and Chile through the COALAR project mentioned earlier.

Some options for a larger national and international collaboration framework could include:

- Staff exchange initiatives – for periods from just a few weeks to a full semester, possibly across non-teaching periods between different hemispheres (e.g. a southern hemisphere academic could exchange to teach in the northern hemisphere during his/her summer non-teaching period, and vice-versa).
- Greater use of industry guest lecturers/adjunct appointments, for either face to face, or interactive lectures – within an institution, a network such as MEA, or across the globe.
- Cross teaching of modules of courses into other universities – in block mode, or interactively.
- Greater flexibility to allow students to enrol in an external course offered by an approved provider – by distance delivery.
- Licensing of existing developed course teaching resources to other educators.
- Joint development of new courses (possible electives or future postgraduate courses) to reduce development costs, and provide students access to specialist electives based on world best practice and experience.
- Offer collaborative degree programmes at postgraduate level where students are required to take courses from each of the course owner institutions – each institution only has to support a part of the development and teaching load.
- Use of third-party online training providers, such as EduMine from Canada.

As a further example, UNSW is currently exploring a collaborative postgraduate Masters programme, in partnership with two or three other international universities, where students would be able to enrol at any of the universities, but would be compelled to study 50% of their coursework through an international partner university. This is just one avenue for future international collaboration. The clear message though is that our industry is global, so the education sector must also become global in its operations, and collaboration is the key to ongoing viability and relevance.

5 Future supply of academic staff

This issue is 'the sleeping dog in the room'. Unless the future supply of academic staff is addressed, Australia runs the risk of either having no mining education programmes in 10–15 years time, or suffering from some very second-rate programmes. The problem is two-fold.

Firstly, our current mining programmes are staffed by a modest population of academics with quite an ageing demographic. Laurence and Hebblewhite (2011) reported that across the Australian mining universities, 57% of the academic teaching staff in 2011 were over 50 years old, and 27% were over 55 years old. The mining education industry is therefore facing a major challenge to renew itself (quite apart from any growth) within the next ten years before it starts losing a significant proportion of the current staff to retirement.

This then leads to the second and more fundamental problem. Where will the new academics of the future come from? Most, if not all, of the Australian mining universities are also research-intensive universities where it is an essential pre-requisite for any new staff that they hold a relevant PhD degree. The problem is that with such shortages of graduates in industry, very few, if any mining graduates, are staying on or returning to do a PhD when they can command such significant salaries in industry, let alone contemplate a post-PhD career as a mining academic, where the current highest possible starting salary for a lecturer is AU$ 96,231 (top of the Level B Lecturer scale at UNSW), and yet the mean starting salary package for UNSW mining graduates in 2010 was AU$ 103,800, the vast majority of which was direct salary.

What is needed is a sustained level of commitment to encourage and support both future PhD students, and financially support university salary supplements for mining academics. This cannot be a campaign for just one or two years, but a commitment for support for at least ten years and beyond. Key elements for such support from industry need to be:

- Encouragement and recognition of the value of a PhD in the industry – these people are not only future academics, but also future specialist consultants on whom the industry is becoming increasingly reliant.
- Provision of high value PhD scholarships, linked to industry-funded research projects.
- Funding of salary supplements (or equivalent, innovative remuneration schemes) for future mining academics.
- Mentorship of junior academic staff – as part of the first two or three years of a new junior staff member's teaching career, they need to have not only university mentoring, but can benefit greatly from industry exposure (possibly embedded part-time with a mining company), and overseas experience, in order to strengthen their industry understanding and also develop an international network of academic peers. During such times, teaching can be back-filled by temporary placements of experienced industry personnel. Elements of these strategies are already being pursued at both University of Queensland and UNSW.

6 Conclusions

The mining education sector in Australia has made great strides in the last ten years. Initiatives such as MEA have become a reality in a very short space of time and have largely met and exceeded the original objectives and expectations set by MCA and MTEC, not to mention the individual universities. MEA is a role model within Australian universities generally, as well as an international role model for other mining educators.

But the bar has now been raised again, and we need to rethink and re-commit to even higher targets, whilst not selling out on the quality and innovation achievements already put in place. The growth and hence demand across the Australian mining industry is here for the long-term and the mining education sector must respond, in partnership with industry.

Several strategies have been described above, and there are initiatives in place already to explore a number of these and no doubt other strategies. These all require educators to work outside their normal paradigms, and industry to come along as part of, and as a supporter and partner in this brave new world. Without such support, it is not so much the universities that will suffer (as they can quickly replace mining students with any number of other student varieties), but it is the industry itself that will suffer.

The greatest challenge apart from simply recruiting more students to study mining is to encourage and support future academic staff. This is not a short-term fix, but requires a sustainable and strategic long-term strategy, with universities and industry once again working in partnership.

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