A PERSPECTIVE ON THE SUPPLY AND UTILIZATION OF MINING GRADUATES IN THE SOUTH AFRICAN CONTEXT

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Abstract

The South African mining industry continues to be a major source of employment at a time when at least 25 per cent of the working age population is unemployed. At the same time the industry faces a skills shortage in many of the disciplines necessary for its future health. The University of the Witwatersrand, University of Pretoria, University of Johannesburg, and University of South Africa have historically produced mining graduates for the South African industry, with any shortfall being met by the recruitment of overseas graduates. More recently the global shortage of engineers and other mining industry professionals has seen a reversal of this trend and a very significant emigration of well-educated and highly skilled personnel.
The traditional career path for mining graduates is in production and mine management. However, there is the parallel and possibly more pressing need for specialized skills in such fields as ventilation, rock engineering, mine planning, mineral resource evaluation, and mineral asset valuation. It is in these essential areas that chronic shortages continue to hamper the development of the industry and may well frustrate its ambitions to be safe, healthy, and profitable into the future.

The permeability of skills across sectorial boundaries within the mining industry requires that skills shortages in the platinum sector are not looked at in isolation, but within the context of the entire industry. This paper reviews the efforts being made by the universities at both undergraduate and postgraduate levels to meet the needs of the South African mining industry, in terms of the required numbers and the range of specialized skills.

Introduction

The unemployment rate in South Africa has averaged around the 25 per cent mark in the past five years. This is based on the following reported rates:

- *Business Day* (2012) reported that South Africa's unemployment rate rose from 21.8 per cent in the fourth quarter of 2008 to 25.2 per cent in the first quarter of 2012

- The National Planning Commission estimated the country's unemployment rate at 27 per cent in 2011 (National Planning Commission, 2011)
- In 2009 the Department of Higher Education and Training (DHET) estimated that at least 25 per cent of the working age population was unemployed (DHET, 2009).

However, the South African mining industry continues to be a major source of employment. The Mining Qualifications Authority (MQA) reported that in 2009 the mining sector employed directly about 548 000 workers (MQA, 2011) accounting for approximately 6 per cent of the total employees in the formal sectors of the economy (MQA, 2009). At the same time the industry faces a skills shortage in many of the technical disciplines that are necessary to ensure its future health, despite it being a major source of employment. The Mining Qualifications Authority (MQA) undertakes regular surveys and updates on the skills situation in the country's mining and minerals sector (MMS). In 2011 the MQA submitted its Sector Skills Plan (SSP) for the MMS for the period 2011-2016 to the DHET. The report noted that professionals constitute a mere 4 per cent of total employees in the mining sector. Professionals are employed in technical skills areas within the mining value chain such as geology, mining engineering, metallurgical engineering, chemical engineering, geology, electrical engineering, mechanical engineering, analytical chemistry, mine surveying, and jewellery design and manufacturing. Professionals are also employed in supporting functions such as accounting, financial management, human resources, corporate services, and information technology. The MQA (2011) noted that despite the low proportion of professionals, it is noteworthy that the output of graduates increased substantially in all specialized fields of study, with the highest average annual increase (13.5 per cent) in chemical engineering. This is followed by geology (13.3 per cent), metallurgical engineering (12.9 per cent), mechanical engineering (9.9 per cent) and electrical engineering (7.8 per cent). However, these increases were not sufficient to alleviate the overall shortages experienced in these fields in the country. Furthermore, with the exception of mining engineering, the MMS competes with the rest of the economy for many of these skills, and relative to other sectors is often seen as an undesirable career choice, due to the difficult working environment and the rural location of most of the mines. Within the MMS the different commodity sectors must still compete for the limited pool of mining engineering skills available, and 'competitive poaching' is not unusual. This is why it is important that skills shortages in the platinum sector should not be looked at in isolation, but within the context of the entire industry.

Supply of mining skills

Mining engineering is offered at the University of the Witwatersrand (Wits), the University of Pretoria (Tuks), the University of Johannesburg (UJ), and the University of South Africa (UNISA). Wits and Tuks produce mining engineering graduates with BSc and BEng qualifications, respectively. The technologists and diplomates graduate from UJ and UNISA, which award the BTech and ND/NHD qualifications, respectively. A further point to note is that UNISA differs from the other three institutions in that it provides tuition through distance learning.

Utilization and mobility of mining graduates

The traditional career path for mining graduates is in production and mine management. However, there is the parallel, and possibly more pressing need for specialized skills in such fields as ventilation, rock engineering, mine planning, mineral resource evaluation, and mineral asset valuation. It is in these essential areas that chronic shortages continue to hamper the development of the industry and may well frustrate its ambitions to be safe, healthy, and profitable into the future. Mills (2012) noted that 40 per cent of the resource extraction industry's workforce is at least 50 years old, and that one third of them are expected to retire by 2022. Mills therefore argued that given the ageing profile of the current workforce and a lack of sufficient engineers and geologists with around ten years' experience, the mining skills requirements for new mining projects at various stages of development across the globe are simply not going to be met. Mills attributes this shortage to the failure by the mining industry to recruit and train during the tough times in the 1990s, when the price of metals plummeted, subsequently leading to the particular shortages of mid-career professionals. The message from this experience is that the mining skills pipeline system should be kept pumping if the industry is to avoid a similar situation in the future, despite current depressed prices for commodities such as platinum

It has to be recognized that mining skills are mobile and that they move following rewards ranging from monetary gains to career progression and perceived opportunities. For example, Stacey, Hadjigeorgiou, and Potvin (2008) noted that there is already a trend of mining engineering skills migrating from Australia and Canada to the USA, and in turn, technical personnel moving from South Africa to Australia. They further noted that the latter movement is already evident, as there are large numbers of South African mining professionals who have relocated to Australia. Emigration, especially of white professionals, can be expected to increase as most mining companies battle to meet employment equity targets set out in the Mining Charter for review in 2014, and whites consequently see no prospects for career progression within the South African mining industry. In fact the National Planning Commission (2011) recognized that currently immigration into South Africa is predominantly from other African countries, while emigration is mainly by white South Africans. The skills that remain in the country tend to be permeable across sectorial boundaries within the mining industry, following different rewards. Therefore skills shortages in the platinum sector cannot be looked at in isolation, but must be considered within the context of the entire industry. The MQA SSP noted that there were serious shortages of mining engineering related skills at engineer or technician level as at 31 August 2007, just before the global financial crisis (GFC,) when economies were in a boom period and the demand for minerals was at an all-time high; while as at 31 August 2011, when economies were still recovering from the GFC, the shortage appeared to have diminished, as shown in Table I.

Table I-Estimates of shortages of mining engineering related skills for 2007 and 2011

Occupation	Number Required	
	2011	**2007**
Health and Safety Manager	5	*
Programme or Project Manager	3	*
Production / Operations Manager (Mining)	38	168
Mineral Resources Manager	27	*
Rock Engineering Manager	1	*
Mining Engineer (Excluding Petroleum)	50	239
Explosive Ordnance Engineer	4	*
Safety, Health, Environment and Quality (SHE&Q) Practitioner	51	25
Sales Representative / Salesman (Industrial Products)	10	*
Mining Engineering Technologist	*	30
Mining Technician	48	845
Production / Operations Supervisor (Mining)	134	*
Miner	178	146

*Source: MQA (2010; 2011). Note: * indicates occupation not stated*

From Table I it can be inferred that the shortage of mining engineers was quite pronounced during the pre-GFC period due to the many projects that were being brought on stream to meet anticipated growing global demand for minerals. This situation can be expected to recur once the world economies fully recover from the effects of the GFC, and it is important that the mining industry ensures that the universities continue to produce even higher numbers of mining engineering graduates so that it does not find itself in a similar situation to that of 2007.

This can be achieved through stronger partnerships between the mining industry and universities supplying the requisite skills.

Problems associated with shortage of skills in the mining industry in South Africa

The South African mining industry remains vulnerable to skills shortages. The consequences of skills shortages in the mining industry are varied and many. The significant ones are:

- Safety is negatively affected by a lack of skills (CDC NIOSH, 2008)
- There is inability to develop new projects (Stacey, Hadjigeorgiou, and Potvin, 2008; Deloitte, 2012) which are the lifeblood of the future of the mining industry
- Projects that proceed to development are often completed over budget and behind schedule (Stacey, Hadjigeorgiou, and Potvin, 2008; Deloitte, 2012). In recent times, financiers of such problematic projects have started resorting to litigation against the project proponents, claiming that they were misled into investing in a project that would neither be completed on time nor within budget. A case in point is the litigation case on the Galore Creek project, in which Nova Gold faced a shareholder lawsuit claiming that the project was two years behind schedule and capital costs were over budget by CDN$3 billion, equivalent to 127 per cent of original capital estimates (Mineweb, 2008)
- Productivity and profitability decline as a result of the inability to satisfactorily operate and manage existing mining operations (Stacey, Hadjigeorgiou, and Potvin, 2008)
- There is an increased workload strain on existing workers, resulting in them demanding higher wage and salary increases such as the recent 14 per cent wage hike for gold miners demanded by the National Union of Mineworkers in South Africa and 33 per cent increase in mining salaries awarded to workers in Argentina (Deloitte, 2012).

In the South African platinum mining sector, professional skills are required specifically to address challenges faced in the delivery of projects, mine planning, and overcoming ventilation constraints and complex rock engineering challenges. These needs are dictated by the following characteristics of the sector:

- The virgin rock temperature (VRT) gradient on the Bushveld Complex is about 2.2°C for every 1 km increase in depth, which is almost twice that of the gold mines on the Witwatersrand Basin,, thus requiring the design and installation of bulk air coolers (BAC) and refrigeration plants at shallower depths than the gold mines (Biffi *et al.,* 2007)
- The rich Merensky reef is nearing depletion on most shafts of the Western Bushveld Complex, and the major source of Merensky reef is at greater mining depths where geotechnical conditions are more challenging

- The lack of adequate infrastructure, particularly water resources, on the eastern limb of the Bushveld Complex, where most new platinum projects are located, requires innovative planning in order to deliver projects on time and within budget
- Introduction of mechanized mining into the platinum sector continues to face technical operational challenges, resulting in intermittent trials of mechanized mining by the sector (Nong and Musingwini, 2011) For example in 2012, Lonmin which had been at the forefront of the mechanization drive, announced plans to suspend mechanization on its operations and revert to conventional mining.
- The mining industry's safety statistics indicate that the platinum sector has continued to be the second-largest contributor to fatalities after the gold sector, although its fatality frequency rate has been gradually declining from 2001-2010 (Chamber of Mines of South Africa, 2010).
- The Eastern Bushveld Complex has a hilly terrain in most areas that are host to new projects and existing operations. The terrain introduces uneven stress distribution over mining areas, making rock engineering analysis more complex.

Mining graduates a scarce skill in South Africa

The shortage of professional mining skills is both national and global in dimension, and Phillips (2005), and Stacey, Hadjigeorgiou, and Potvin (2008) identified this shortage as a strategic issue. Since the skills are in short supply, they are scarce. The MQA (2010, p. 3) described a scarce skill as a skill in, *'those occupations in which there is a scarcity or shortage of qualified and experienced people. This scarcity can be current or anticipated in the future, and is usually due to the fact that either people with these skills are simply not available, or they are available but they do not meet the organisation's employment criteria'*. Scarce skills can arise from relative scarcity, absolute scarcity, or a combination of both. Relative scarcity occurs when suitably skilled people are available but do not meet other employment criteria such as unwillingness to work outside urban areas or not satisfying employment equity considerations. Absolute scarcity occurs when suitably skilled people are not available in the labour market due to the fact that there is an emerging discipline such as the mineral resources management (MRM) specialization or a complete lack of people with the requisite qualifications and experience. The skills shortage globally and in the country in general, with some reference to the mining industry is, captured in the following statements:

- Endemic skills shortages is one of the top ten trends mining companies continue to face, resulting in labour turnover reaching as high as 40 per cent being fuelled in part by 'competitive poaching' (Deloitte, 2012).

- *'A lot of people ask me what is my biggest concern. What keeps me awake? Having skilled people available to do the job and go to locations that ordinarily they might not be too keen to go to … That is one of the biggest challenges'*, Nick Holland, CEO of Gold Fields, at the Reuters Global Mining and Metals Summit in Johannesburg (Reuters, 2012).
- *'The world shortage of skills in all technical fields is well known and mining is no exception'* (Stacey, Hadjigeorgiou, and Potvin, 2008, p. 245).

A more sobering thought about the qualitative magnitude of the problem is invoked when one considers the rhetoric questions posed by Mills (2012,, p. 2): *'Who is going to teach the aspiring mining engineers, metallurgists, and geologists when most of the professors and academics are also at, or close to, retirement age? And when they do get trained who is going to mentor and guide the green, fresh out of school, workers in the field - who is going to be left to pass on the years of accumulated wisdom and knowledge, the practical hands on experience - garnered over decades of pounding rocks and actually building mines - that's so necessary to reduce the drastic learning curve and achieve success?'*.

Strategies by South African universities to combat mining skills shortages

Skills shortages continue to plague the mining industry, yet, in some ways, as argued by Deloitte (2012), the industry continues to respond in the same manner each year while expecting different results. To some extent the traditional industry responses to the skills shortages help to partially resolve the problem, but the industry cannot do it alone. Stronger, long-term industry partnerships with universities producing mining engineering graduates, so as to increase enrolment in mining engineering programmes, become more relevant as noted by Deloitte (2012). This is already happening in South Africa, as highlighted by the cases discussed later on about the initiatives being undertaken by each of the four mining universities. These efforts being made at both undergraduate and postgraduate levels are aimed at producing the required numbers and range of specialized skills to meet the needs of the South African mining industry.

The Deloitte report (2012, p. 17) proposes that in order to address the skills shortage, *'On the one hand, the solution may lie in building even stronger relationships with universities and tertiary institutions to encourage higher enrolment in mining engineering programs. On the other hand, it also requires greater effort to counter some of the potential negative perceptions associated with career paths within the industry – not only among university students but perhaps also among younger children who ultimately will populate the graduate programs'*. The initiatives discussed later on that are being undertaken by the four mining schools further highlight the benefits of stronger partnerships between universities and industry.

Table II shows the response of the mining schools in producing more graduates for the mining industry. It is important to bear in mind that it usually takes about 10 years of training and development after graduating with a bachelor's degree (BEng, BSc) before a mining graduate is appointed to their first substantive managerial position, when they start to make a full contribution to the mining company (Phillips, 2005). This time frame dictates that the education and development of mining engineers (as opposed to 'competitive poaching') should be treated as a corporate strategic decision (Phillips, 2005).

Table II-Trend in student numbers graduating in mining over the past decade

Year	Wits	Pretoria	Total engineers	UJ	UNISA	Total diplomates and technologists	Engineers/ echnologists ratio
2002	20	12	**32**	56	5	**61**	1:1.9
2003	22	16	**38**	28	7	**35**	1:0.9
2004	26	19	**45**	15	1	**16**	1:0.4
2005	33	10	**43**	21	1	**22**	1:0.5
2006	25	33	**58**	29	2	**31**	1:0.5
2007	57	24	**81**	40	2	**42**	1:0.5
2008	47	23	**70**	45	2	**47**	1:0.7
2009	62	28	**90**	72	12	**84**	1:0.9
2010	79	23	**102**	51	14	**65**	1:0.6
2011	62	22	**84**	51	14*	**65**	1:0.8

*Sources: (Wits University School of Mining Engineering, Annual Report 2011; Cruise, 2011; Webber-Youngman, 2012; Nel 2012; Knottenbelt, 2012). Note: *estimated.*

Are the South African universities enrolling and graduating adequate mining human capital needs for the industry, or specifically for the platinum industry? This question is difficult to answer as a number of other factors need to be taken into account. For example:

- In a developed economy the ideal ratio of engineers to technologists is a ratio of one engineer to four technologists, if the ratios of developed countries are taken as a guide. From Table II, it would appear that this ratio will be difficult to meet in the long-term strategic time frame, and it is more critical that the output of graduates from UNISA and UJ are propped up at a much higher rate than those from Wits and Tuks
- The global overall retirement rate will be 4 -5 per cent per annum over the period 2005-2015, resulting in a requirement for 225 mining engineers per annum just to replace those retiring (Phillips, 2005)
- Globally, only 75 per cent of mining graduates currently join the mining industry. In order to meet industry demands for 225 entrants, this would increase the required number of graduates to 300 per annum (Phillips, 2005)
- There is an ageing population of mining engineers in developed countries, particularly the USA, against a backdrop of declining students numbers (Phillips, 2005). This will encourage 'competitive poaching' between countries as already observed by Stacey, Hadjigeorgiou, and Potvin (2009)
- The 'competitive poaching' also occurs within the industry itself, allowing permeability of skills across all mineral commodities. Of note is the fact that the South African platinum mining industry drew some of its skills from the South African gold mining industry at a time when the gold mining sector was considered a sunset industry while the platinum sector was going through a period of rapid development.

The response by universities to the demand for more skills has been to increase enrolments in order to improve numbers graduating from the system, as seen in Table II. For example, the School of Mining Engineering at Wits has seen the undergraduate student body grow from 268 in 2005 to 531 in 2012. As noted by Cruise (2011), the growth in numbers has been accompanied by racial and gender transformation to a point where approximately 30 per cent of the mining engineering student body is female and 90 per cent is black. This transformation is in line with assisting mining companies with a pool of well-educated young engineers in future to meet their employment equity targets. Additionally, the mining schools have implemented further measures to ensure that those entering the system progress through the system in the minimum possible time and are not lost to leakage from the system. The following sections describe some of the examples of the initiatives undertaken by mining schools to improve the graduation rates of students entering their systems.

At the University of the Witwatersrand in the School of Mining Engineering, the following initiatives have recently been undertaken as part of a five-year strategic plan (Wits Mining, 2011):

- The School has made concerted efforts to attract new staff and reached full complement as of October 2011, for the first time in several years. This is in line with the goal of reducing student–to-staff ratios and improving the learning experiences of students to result in higher throughput. Additionally, extra staff were appointed in honorary positions to increase staff capacity in specific specializations, and this number has grown to 13 in 2012
- A donation from Gold Fields in 2010 in the form of a staff development scholarship was used to develop a junior staff member with the intention that once they have had a positive working experience in the School, they are likely to consider a future career in academia and so increase the pool of skills from which the School can tap from in the future
- Increasing the percentage of fully-sponsored deserving students considering that the School draws students from disadvantaged socio-economic backgrounds who are only able to attend the School on a fully-funded basis. The London Metal Exchange (LME) made a donation to the School in 2009 that benefited 14 first-year students, 11 of whom passed all subjects and now stand a chance of picking up a bursary from traditional mining companies. The funding has been renewed as a result of the initial success of the initiative. SRK Consulting Canada recognized the success of this programme and made a donation in 2012 for this purpose. The Dean of Engineering at Wits University secured sufficient funding from ESKOM to assist another 28 students repeating first-year subjects, while the Department of Mineral Resources (DMR) gave full bursaries to 14 first-year students
- Establishing a Wits Mining Advisory Council in 2010 to assist the School in keeping its programmes relevant to academic, professional, and industry needs
- Streamlining its postgraduate programme into 10 focussed MSc (50 per cent coursework and 50 per cent research) specializations in order to deliver specialists required by the mining industry and introducing Certificate Programmes in Mineral Resources Management (MRM) in 2001 and Mine Planning in 2011 (launched with the support of the Southern African Institute of Mining and Metallurgy) to cater for non-degreed but experienced practitioners planning to study further at MSc level. The throughput from the postgraduate programmes is indicated in Table III, which also shows a gradual increase in the numbers qualifying from postgraduate programmes for all degrees awarded by the university.

Table III-Graduate and certificate qualifications issued by Wits Mining from 2005-2011 (Source: Wits Mining 2011 Annual Information Report)

Year	GDE	MEng	MSc	PhD	Total PG	Certificate of Competency	MRM Certificates
2005	53	19	4	1	77	*	*
2006	26	22	10	2	60	*	*
2007	36	15	5	1	57	*	*
2008	43	14	4	2	63	*	5
2009	49	14	5	0	68	7	11
2010	55	24	16	2	97	40	10
2011	63	24	8	3	98	52	14

Note: GDE-Graduate Diploma in Engineering; MEng – Master of Science in Engineering (by advanced coursework only); MSc – Master of Science in Engineering (50 per cent coursework and 50 per cent research or 100 per cent research); PhD – Doctor of Philosophy; PG – Postgraduates; Certificate of Competency – certificate awarded to occasional student attending a single course and writing the examination for that course; MRM – Mineral Resources Management.

At the University of Pretoria the following interventions have recently been undertaken by the Department of Mining Engineering and resulted in increased pass rates (Webber-Youngman and Callaghan, 2011):

- The School employed an instructional designer, sponsored by the South African Collieries Managers Association (SACMA), to design all mining modules into a format that enhances the one-dimensional script by including picture illustrations, animations of difficult mining concepts, and video material of mining concepts
- The Herman Brain Dominance Instrument (HBDI) and Shadowmatch tools were introduced to assist students with their personal professional development (PDP)
- Final-year students, in their respective mine design teams, now spend an in-depth mentorship and coaching weekend as part of their preparation for undertaking the final-year mine design project

- The department now has its own computer laboratory funded through the support of the METF, the Faculty's Dean, and other industry contributions.
- A radio-based Inter-write Personal Response System (PRS) in which students interact with lecturers during a lecture by means of 'clickers', was introduced in 2010 and has enabled early identification of shortcomings in courses.

At the University of Johannesburg, the following initiatives have recently been undertaken (Knottenbelt, 2012):

- Tutoring
- Use of Personal Response System (PRS) for active interactive learning in large classes
- Use of communication through the 'EDULINK' submission and assessment of assignments
- Greater access to computer facilities
- Improving lecture materials
- Encouraging students to work within study groups for improved understanding and fostering ability to work within a group.

The UNISA Department of Mining Engineering recognized that UNISA's mining student numbers are quite high but throughput is very low for a number of reasons (Nel, 2012). Firstly, it takes most students at least twice as long to complete a programme by means of distance learning, especially those that study while working. As such, much can happen during such a long period of time, resulting in students dropping out. This problem is also attributable partly to the lack of direct contact with students on a day-today basis to understand the challenges they are experiencing and assist the students timeously. Secondly, distance learning is often the second choice of some students. They will leave UNISA as soon as they can get placement with UJ or a bursary from a mining company to study at Wits or Tuks. UNISA is therefore looking at ways to reduce the drop-out rate and so improve throughput (Nel, 2012).

Outlook for the future

At both the University of the Witwatersrand and the University of Pretoria, student numbers show an increasing trend in the past five years. The expectation is that there will be over 100 mining graduates (over 65 at University of Witwatersrand and over 35 at University of Pretoria) being produced in 2012 increasing to a total of about 150 graduates (100 at University of Witwatersrand and 50 at University of Pretoria) in 2014. However, the question still remains are these never-attained-before numbers of mining graduates sufficient for the South African mining industry or are the mining schools over-flooding the industry? If universities graduate more than industry's needs, there is a propensity that excess graduates will come back into the education system and further their studies by undertaking postgraduate research.

This is beneficial to the industry in the long term, as they ultimately obtain more useful graduates with deepened specializations that assist in solving complex problems faced by the industry.

However, in the view of the authors of this paper, numbers of 150 per year are still not sufficient if one considers the following factors:

- There is an expectation that 'competitive poaching' by English-speaking countries will continue in order for them to replace the natural attrition of their mining engineers, whose demographics are skewed towards an aging population
- Natural attrition of South African population of mining engineers will continue into the future
- The historical attrition of mining graduates to other sectors of the South African economy, such as banking, will continue, considering that young graduates of current generations tend to be techno-savvy, while mechanization of mining operations continues to occur at a slow pace
- As mines in South Africa continue to mine at greater depths and attempt to push for zero harm, there will be a growing need for technical skills in specialized areas of mining other than the mining production career path
- An expected increase in demand for professional engineers in production as mines become deeper and more mechanized, and hence more complex to operate
- Likelihood of the proposed Identification of Engineering Work (IDoEW) becoming a statutory requirement in future, which will require engineering work to be undertaken by registered engineers only.

If the output of degreed mining engineers is not sufficient to meet demand, then the plight of mining technologists and technicians output is even more dire if one considers that in the developed world there are four technicians for every engineer and South Africa plans to become a knowledge-intensive economy by 2030.

Conclusion

In this paper it has been demonstrated that the education and training in mining skills is a pipeline system. The numbers leaving the system cannot exceed the total numbers entering the system, including those that enter at different points along the pipeline. The response by mining schools to the skills shortage therefore goes beyond merely increasing numbers through higher enrolments, but also entails plugging the system to stem undue leakages and facilitating flow through the system without compromising on the quality of the output.

To improve utilization of mining graduates, the universities offer postgraduate courses to allow graduates with industry experience to hone their skills in specific areas of specialization and graduate with a Master' qualification in that specific field. It has also been demonstrated that the education and training of mining engineers is more successful when there are strong partnerships between universities and the mining industry, which the universities and industry should continue to strengthen.

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