Appendix A
Current Initiatives

There are a number recent studies in the area of higher education and the minerals industry, which merit some discussion in the context of this review. These are:

1. Review of Higher Education Financing and Policy;
2. Changing the Culture: Engineering Education into the Future;
3. Western Australia's Minerals and Energy Expertise: How can it be Optimised?
4. The Competitiveness of Australian Industry - Report No.3 The Minerals Industry; and
5. Towards 2005: A Prospectus for Research and Research Training in Australian Earth Sciences.

1.1. Review of Higher Education Financing and Policy - Learning for Life Discussion Paper

Reference: Committee for Review of Higher Education Financing and Policy (1997), '*Learning for Life - Review of Higher Education Financing and Policy, A Policy Discussion Paper*', Department of Employment, Education, Training and Youth Affairs, Commonwealth of Australia, Canberra, November.

The *Review of Higher Education Financing and Policy* is the first major review of the sector since the Dawkin's reforms of the late 1980s. Commissioned in early 1997 and will report in early 1998. The Review is often referred to as the *West Review* after its chair, Roderick West.

The West Committee has recently released an interim discussion paper. This report is intended to summarise the conclusions so far drawn during the review, and to propose a number of options for the way forward. The full interim discussion paper, entitled *Learning for Life*, can be accessed via the Internet at: http:\www.deetya.gov.au.

1.1.1. Conclusions

Current Situation

The philosophy underlying the review is that for Australians to prosper in the next century, they will depend on the quality of the education that they acquire. Prosperity *"embraces all dimensions of life, not only economic and social but cultural and spiritual as well."*

The central conclusion of the Review is that Australia's higher education policy framework is under stress.

"There is a feeling of unease in universities" and the "morale of academics is low". "Many believe that traditional intellectual values and sound scholarship are under threat". This comes about because of the public funding cutbacks of the last 15 years as well as a more general feeling that the contribution of academics to society is undervalued.

"There is also a feeling of unease [about] *universities in terms of their capacity to meet the needs of business and industry."* Many of the employer groups consulted during the course of the Review expressed the view that universities were not producing the kind of graduates that were needed for the 21st century.

Forces for Change

Compounding current problems is the fact that major change is already underway in the sector and that the Australian university is poorly equipped to deal with it. These forces for change are essentially driven by the digital revolution and the Internet. This will change higher education in a number of ways:

1. Geography will become less of a limiting factor in providing education. This will open the door for major overseas universities to challenge the traditional geographical dominance of Australian universities; and
2. The traditional view that higher education services and delivery methods will be swept aside as the Internet allows mass customisation of education and significant re-engineering of course design and delivery methods.

In the USA, the education software and services industry is growing rapidly, with the sector now having a capitalisation in excess of $5 billion.

The changes are also driven by the general societal move towards flexibility in all arrangements.

Adequacy of the Current Policy and Financing Framework

In the light of these changes, the Review Committee was particularly concerned to assess the adequacy of the current policy and financing framework.

The current framework does have significant strengths. It is open and accessible to most Australians, and compares well on this measure internationally. Part of its success in this is the fact that it provides well for those students who are unable to undertake study fulltime on a campus.

Australia is also "*extremely successful*" as an exporter of education. It has more foreign students per capita than the USA, UK or Canada.

Other strengths of the system are that institutions have a greater degree of autonomy than in most other publicly funded systems, and the universities have a strong research record.

The system, however, also has its weaknesses.

Firstly, there is a focus on institutions not students. Universities are not financially accountable to students. Instead, universities tend to respond to the central funding agency. This is because the amount of funding available to universities is centrally determined. "*The distribution of students among universities would undoubtedly be different if decisions about where to study were left to students and universities.*"

This funding framework is partly responsible for the homogeneity of the university system. While there is considerable diversity, "*far greater differentiation is possible and desirable.*" This uniformity is particularly problematic on the issue of tuition fees. These are the same for all universities regardless of quality of course.

This leads to a lack of incentive to pursue low cost course delivery options.

Another weakness is that, within the current framework, the incentives to undertake research activity are greater than those encouraging excellence in teaching. There are few, if any, rewards for gifted teachers.

The current financing policy has also contributed to institutions not managing themselves in a business-like manner. "*Incentives for cost reduction are weak*" and "*institutions do not appear to have good information on costs*." This is not to say that there is no emphasis on cost reduction. However, even where cost reduction is taken seriously, most institutions are using the domestic education market as the benchmark. This is not appropriate when the most competitive institutions are overseas.

Other weaknesses of the university policy framework are the continuing problems with equity and the increasingly problematic divide between VET (TAFE) education and the universities. Students from low socio-economic backgrounds continue to be under-represented in the university sector.

1.1.2. The Way Forward

The Review argues that a new financing framework is needed to overcome the weaknesses it has identified. The six basic principles of the new framework proposed by the Review are to:

1. encourage the expansion of a learning environment of quality for all students;
2. facilitate maximum flexibility for students both within the higher education sector and between the sector and the VET sector;
3. promote equity of opportunity and equity of access to public funds;
4. provide appropriate targeted support for equity groups;
5. maintain, and perhaps even increase, the level of public funding provided at present. However, it is difficult to determine an appropriate level of public funding on a 'per capita' basis because of questions surrounding the actual costs of providing education. Whatever the future, the government should remain a dominant provider of funding for higher education; and
6. incorporate a capacity to provide targeted support for high priority initiatives. This may include support for indigenous education or for a program of telecommunications infrastructure building.

The Review goes on to discuss in some more detail the particular funding framework issues that need to be addressed.

The three biggest issues related to funding are:

1. ensuring the primacy of student-centred funding, as opposed to university-centred funding;
2. encouraging and rewarding good teaching; and
3. achieving an appropriate balance between research and teaching funding.

The Review then proposes three financing models ranging from essentially a status quo approach with some finetuning to a radical, fully market-oriented model. The issues surrounding each of these models are to be clarified during the discussion period. This discussion period closed on December 19th, 1997.

1.2. Changing the Culture: Engineering Education into the Future

Reference: The Institution of Engineers, Australia (1996), '*Changing the Culture: Engineering Education into the Future*', Institution of Engineers Australia, Australian Council of Engineering Deans and Academy of Technological Sciences and Engineering, Canberra.

"*The Review of Engineering Education is recommending no less than a culture change in engineering education which must be more outward looking with the capacity to produce graduates to lead the engineering profession in its involvement with the great social, economic, environmental and cultural challenges of our time*."

– Professor Peter Johnson AO, Chairman, Steering Committee of the Review of Engineering Education, 1996.

Changing the Culture was the first far-reaching review of engineering education since the Williams review of 1988. It was published in June 1996.

The Review of Engineering Education (hereafter in this section referred to as 'The Review') was sponsored by the Institution of Engineers, Australia (IEAust), the Academy of Technological Sciences and Engineering (ATSE) and the Australian Council of Engineering Deans (ACED). Over a period of eighteen months during 1995 and 1996, the Review gathered information from a wide variety of sources within universities, industry and the general community. The objective was to obtain a comprehensive view of the key issues to be confronted by the engineering profession in Australia and possible pathways for achieving the required change.

Summary of Recommendations

The review makes 14 recommendations. All of these recommendations have implications for the reshaping of minerals tertiary education.

Changing the Culture: Engineering Education into the Future - Recommendation Headings

- Engineers must receive a broader education and be drawn from a wider range of backgrounds.
- Student intakes must be sufficient for Australian industry to remain internationally competitive.
- Engineering courses must have clearly stated goals and outcomes and equip graduates for lifelong learning.
- Professional accreditation systems must encourage innovation in course content and delivery.
- Each university should consider the viability of its engineering school.
- Internationally competitive Advanced Engineering Centres must be developed.
- Engineering schools must be prepared to form alliances and facilitate student mobility.
- An effective and independent National Centre for Engineering Policy must be established.
- School and community liaison must be enhanced so that more students choose engineering.

- The four-year full-time engineering course equivalent must remain the minimum requirement, but diversity must be encouraged.
- Staff profiles must balance teaching, research, professional practice and community skills.
- Engineering schools must be prepared to collaborate to produce innovative courseware.
- There must be greater collaboration between the engineering schools and industry.
- The sponsoring bodies must take immediate action to implement these recommendations.

The following text is a summary of key issues highlighted by the Review, which have a direct bearing on the recommendations for the National Tertiary Education Taskforce.

The Need for Change

The need for such a profound cultural change has come about because of the fundamental changes occurring in the business environment as we move towards the new millennium. Globalisation of the economy, an enormous increase in the rate of change in technology and changing community standards of social responsibility make it imperative for the engineering profession and engineers of all disciplines to have a better understanding of the social, political, and economic climate in which they operate.

While Australian engineering education has enjoyed a good reputation for producing flexible and adaptive engineers, the dramatic changes taking place in all aspects of society require parallel changes in our education system to maintain our position in an increasingly complex and demanding world. *"To ignore this necessity for change is to put at risk important elements of our national development and the future for our youth*".

According to the Review, engineers and engineering graduates of the future will require a new set of skills in addition to their traditional base of mathematics and engineering technology to enable them to operate effectively. These skills will include political and social awareness, general problem-solving ability, the ability to communicate across cultural boundaries and skills for self-directed, life-long learning.

In order to deliver these 'new age' engineers, courses and tertiary institutions themselves must have as their foundation objectives and goals that are focussed on achieving international best practice. Courses will need to deliver graduates who, not only possess the ability to apply their knowledge of science and engineering fundamentals, but who can also:

- undertake problem identification, formulation and solution;
- utilise a systems approach to design and operational performance;
- function effectively as individuals and as part of a multi-disciplinary team in roles of both leader and team member;
- understand and achieve their responsibilities socially and environmentally;
- apply the principles of sustainable design and development;
- commit to their professional and ethical responsibilities; and
- undertake life-long learning.

Student Numbers and Quality

One of the key drivers for the changes proposed by the Review is the alarming fact that, despite increases in the number of engineering students over the last decade, Australia continues to produce fewer engineering graduates per head of population than other developed countries. At present graduation rates "*it is unlikely that the manufacturing sector will have the human resources to increase its R&D activity to a level comparable with that of the average OECD member country*". The Review warns, if Australia is to remain technologically competitive with other developed nations, our engineering activity and, hence our need for engineers will have to increase.

However, it is important to note that substantial increases of engineers per head of population will only occur when the current culture within industry changes. There are two mechanisms for achieving an increase of engineers per head of population:

- government must develop a strong industry policy which encourages a growth in industry development within Australia; and
- a better appreciation by industry of the benefits of employing engineers leading industry to employ more engineers.

Creating a Representative Profession

Two particular concerns emerged from the Review. Firstly, the danger in assuming that traditional roles and practices will continue, and, secondly, the fact that the under-representation of women and other minority groups in the profession threatened the very survival of the profession into the 21st century. The review therefore recommended, as a first priority, action to transform the current engineering culture.

Despite considerable activity to address the issue of male dominance over the last decade, the engineering profession has failed to significantly improve the diversity of its membership and is consequently not truly representative of the society it serves. While the proportion of female engineering graduates has steadily increased from 7.4% in 1989 to 14.1% in 1995, considerable evidence supports the view that the culture of the engineering profession, neither acknowledges nor appreciates the differences in perspectives, values and skills that gender (and other cultures) can bring to engineering. As a result, the engineering profession is unable to understand or respond effectively to the concerns of at least half of the wider community.

Moreover, the Review acknowledges that it will not be possible for the profession to achieve its primary objective of improving the number and the quality of engineering graduates to international standards by continuing to exclude more than half of the eligible student population. Unfortunately, the supporting recommendations to address the homogeneity of the profession are not specific enough to clearly identify the required action, perhaps due to the fact that solutions to the problem are neither immediately obvious nor readily identified.

The Question of Specialisation

Over the last few years, there has been an increasing trend in course specialisation which has gone hand in hand with a proliferation of different undergraduate engineering degree programs. There are now 182 accredited engineering programs from 36 universities many of which focus on a very narrow range of engineering skills. This is despite the fact that one of the historical strengths of Australian-trained engineering graduates has been their broad foundation and their relative lack of early specialisation.

In addition to the fact engineers of the future will need a broader base of knowledge outside the technical aspects of their profession, the ability to attract quality students into the profession is becoming more and more difficult in the face of greater competition from other disciplines. This can only be made worse by fragmentation and increasing course proliferation, whereby engineering courses compete against each other for top students.

Yet another compelling argument against early specialisation is the fact that many of the specialist engineering courses produce graduates for a very narrow range of employment opportunities. In the current environment of youth unemployment, one of the major criteria influencing students' degree choices is the employment rate on graduation. Quality generalist degrees, producing students with a strong foundation of the fundamental engineering principles are much more robust in the face of fluctuations in the employment market.

Number, Size and Characteristics of Engineering Schools

Linked to the question of generalisation versus specialisation of engineering courses is the issue of the number, size and characteristics of the various engineering schools. There are convincing arguments both for, and against, having large numbers of small engineering schools, particularly in Australia where population centres are spread across such large distances. However, the most compelling argument against the current situation of many smaller schools is the inability to adequately resource a large number of small schools due, in the most part, to the relatively high costs of running engineering programmes. These costs make it difficult to maintain existing laboratory equipment or put in place new equipment to keep pace with rapidly changing technologies; and make it difficult to offer a range of undergraduate course options.

While rationalisation of the current situation seems inevitable, the process for that change needs to be managed through perceived advantage rather than forced closure. Innovative alternatives for the delivery of engineering courses should be considered, such as feeder programs, infrastructure sharing and sharing academic resources (via tele-conferencing). These make the most of the specialist expertise and academic resources already available within existing institutions.

Course Design and Delivery

Changes occurring within the tertiary education system and in the broader global community will undoubtedly impact on the design and delivery of engineering courses.

Despite the proliferation of five-year double degree courses, the four-year engineering degree will remain a good basis for an engineering career and for lifelong learning.

Work experience requirements for engineers are also likely to remain an essential component of the course. Such work experience is a valuable opportunity to increase the effectiveness of education by placing the concepts of the course into their social, environmental and industrial context. Indeed, employers demand such work experience. This, in turn, raises the issue of industry's contribution to undergraduate education. Industry has demands of university education but it is not always contributing as much as it should. Some consideration has been given to dropping the work experience requirement because the opportunities, in some cases, do not exist for students. Further, industry secondments to academia are a rarity and site visits more difficult than in the past.

The impact of information technology on course design and delivery in tertiary education is uncertain, but it is likely to be revolutionary. In time, the world's best coursework will be available on the internet. This will raise the question as to why a student should even attend a university campus. This could provide opportunities for academics to spend more time in 'quality face-to-face tutorials' instead of delivering set-piece lectures.

Information technology will put pressure on academics to relinquish their 'monopolistic approach'. No longer will it be feasible for a university department to develop and deliver all of the coursework for its particular degree. Instead, departments will develop and market coursework in their own area of expertise and will buy-in the rest. Undergraduate education will shift from being 'provider-driven' to being 'learner-driven'.

While recognising the need for a balance of skills and interests among academic staff, engineering departments will have to place more emphasis on the quality of teaching and the training of academics.

Community Perceptions and Attraction of Students

"*A survey of about twenty journalists has indicated that their knowledge of the work of engineers is limited. 'Engineers build road, bridges and buildings' is the popular answer to the question 'What do engineers do?'* "

One of the key problems facing the engineering profession is its virtual invisibility on the public stage. Of even greater concern is the perception among engineers themselves that the community does not value their contribution. This image problem is perceived to arise from the public misconception that engineering is a 'dirty' profession and that, rather than having a positive influence on the quality of peoples lives, it is seen as the cause of many of the world's ills, from pollution to stress.

The impact of these negative community perceptions on engineering education is best illustrated by the substantial drop in university entrance scores which have occurred over the last few years as engineering courses have battled for student numbers to keep courses viable. Largely, this problem can be attributed to a lack of knowledge among school students of what the engineering profession is about, and a decline in the attractiveness of engineering as a career option.

According to the American Society for Engineering Education Report, *Engineering Education for a Changing World*, (ASEE, 1994), Engineering programs must be relevant, attractive and connected to the community. In Australia, this 'connectedness' between the engineering profession and the community it serves, appears to be lacking and the need to develop these links has emerged as one of the most important issues in shaping the future of engineering education into the next century.

To improve the image of the profession, particularly among school students, the Review concluded that the engineering profession and engineering educators should develop and maintain positive relationships with schools, teachers, and school students. The goals should be to: improve student perceptions about the engineering profession and to influence the curricula of school programs, thereby increasing the number of students wanting to pursue engineering as a career. In particular, the teaching of mathematics and science should ensure that students have the necessary pre-requisite knowledge for engineering courses at the tertiary level.

The Relationship to Education for the Minerals Industry

The education of students for the minerals industry is heavily influenced by the wider issue of the education of engineers and scientists since mining engineers, metallurgists and geoscientists are drawn from the general engineering/science population. The health of engineering education in general is, therefore, of critical importance to the health of minerals-related courses. For these reasons, the previous discussion has identified the issues effecting engineering in general which are of particular significance for the minerals industry.

The minerals industry has recognised a need for change, which is driven by many of the same concerns driving the review of engineering education in general: rationalisation, falling student numbers, concerns about the quality of students and the need for greater diversity in the profession. The last of these involves identifying alternative paths for developing minerals professionals and recognises the value of a generalist engineering/science education. As is the case for the engineering profession in general, educators must face the difficult question of how best to provide the new ‘product’ demanded by the industry and deal with related issues such as the number and location of courses.

Underlying all of these issues is the recognition there is a real and immediate need to improve the community’s perception of the minerals industry by better marketing our current performance; by significantly refocussing some of our activities; and by demonstrating our relevance to the wider community on whose support our success and perhaps even our survival depends.

1.3 Western Australia’s Minerals and Energy Expertise: How can it be Optimised?

Reference: Algie S (1997), ‘*Western Australia’s Mineral and Energy Expertise: How can it be optimised*?’, Western Australian Technology & Industry Advisory Council, September.

The Discussion Paper released by the WA Chamber of Mines and Energy stimulated much discussion throughout Australia, particularly within the tertiary education sector. There have been two formal responses from Western Australia. The first was to establish the Western Node Committee, which is aimed at bringing together stakeholders within the WA minerals education. The second, outlined in this section, was the Technology and Industry Advisory Council (TIAC) paper, which describes the issues in the minerals research and education sector in WA and lays the foundation for policy development in this area.

This report was published in September 1997 by the Western Australian Technology & Industry Advisory Council and was intended to be a background paper (without conclusions or recommendations) to stimulate an informed debate on the topic of the expertise available to the Western Australian Minerals and Energy Industry.

The report is presented in three chapters:

1. The minerals and energy industry, its technical needs and suppliers;
2. The External Research Scene; and
3. The Current Education and Training System.

The last chapter is of most relevance to minerals tertiary education. It deals mostly with the university system but also devotes some space to the TAFE system. In summary:

1. The chapter starts with an overview of the State's universities and their funding. These financial realities have tended to discourage the universities from adopting some of the ideas for change that industry has suggested. This is taken up in the next two sections.
2. The second section expands on the industry view of the university system. This draws on the Discussion Paper published by the Tertiary Education Taskforce of the Chamber of Minerals and Energy of Western Australia in 1996. It does not, however, accept everything in this paper at face value.
3. The third section examines the view from the other side: how those in the universities see their role. This reveals an important cause of misunderstanding. The industry thinks that it is the customer for the universities' services. However, as far as the universities are concerned the student, not the industry, is the customer. The Chamber's vision of a rationalised system runs up against the reality that:

"*...the present regime of funding tertiary education works by competition for student enrolments. Under such conditions no institution is inclined voluntarily to withdraw from offering courses that students might find attractive*."

The section goes on to discuss how the different universities are going about the business of attracting students.

4. Following the publication of the Chamber's discussion paper, a succession of events has led to the establishment of a committee to progress the formation of the Western Node of a proposed National Centre of Excellence in Teaching and Research in Minerals and Petroleum. The fourth section describes current moves in the Western Australian university sector in relation to this development.
5. Many of the problems that occur between the industry and the education sector are tied up in the dynamics of recruitment. It takes a considerable time to train someone for the industry, but the industry is notoriously cyclic and graduate supply and demand are frequently out of step. The section goes on to consider the consequences and possible remedies.
6. The TAFE sector is covered in the sixth section. This sector seems poorly understood, and may be under-valued, by the minerals and energy industry, possibly because the system is quite complicated and in a process of change that has not yet entirely stabilised. The implications of other changes to funding and the move to competency-based training are only now beginning to become apparent to industry, and concerns are emerging about training at supervisory level.
7. The seventh section refers to prospects for growing the education industry.
8. The final section touches briefly on continuing professional development and distance education.

1.4 The Competitiveness of Australian Industry Report No. 3, The Minerals Industry

Reference: Australian Academy of Technological Science and Engineering (1997), '*The Competitiveness of Australian Industry Report No. 3: The Minerals Industry*', Parkville Victoria, July.

The Australian Academy of Technological Sciences and Engineering (AATSE) has identified the competitiveness of Australian Industry and the role of technology in enhancing competitiveness as being issues of national importance and has carried out studies in the following areas:

1. The Processed Food Industry;
2. Science and Technology Based Industries; and
3. The Minerals Industry.

The report develops a list of ten recommendations aimed at improving the competitiveness of the Australian minerals industry. Of the ten recommendations, two relate to minerals tertiary education.

Recommendation 9

The industry should continue to concentrate on the staff education and training so that management standards are equal to world best practice in order to cope with rapidly changing conditions.

Recommendation 10

Industry, public sector organisations (particularly CSIRO), universities and education and training authorities must cooperate to ensure that technological education is adequate to provide a continuing stream of management, operating and research staff for minerals companies, with special recognition being given to the geographical location of industry units.

To substantiate these recommendations the report discusses management and education, saying that "*the source of competitive advantage for Australian mining is no longer our ore bodies but our management and learning capabilities*"[1] *and that "while Australia's universities were as good as any in the world, Richmond (1996) notes the decline in the number of mining and metallurgy schools and feels it is now below the critical mass.*"

In a further section on the availability of technology the report summarises that "*it can, be said that the Australian minerals industry is not limited in the short term in its competitiveness by poor technology. In fact, it is quick to take up new ideas and apply them, particularly when the underlying companies have good ore reserves and are sufficiently profitable. The industry has competent technical staff and strong links with the teaching institutions and government and private research and service organisations. It is an exciting industry and is attractive to young technical people - the worry is that not enough of them will take up the challenge of living outside the urban society of the large coastal cities. In fact, the Chamber of Minerals and Energy WA recently raised concerns about the availability of suitably qualified people to meet the current wave of expansion. Nor can the industry recruit significant numbers of professionals from overseas as it has often done in the past. Many of the mining and mineral processing schools in overseas universities that were sources of graduates for the Australian industry have been shut. In Australian universities, it is becoming* *increasingly difficult for small schools such as mining and metallurgical engineering to survive. There is no doubt that these changes could adversely influence the competitiveness of the Australian industry over the next 10 years.*"

1.5 Towards 2005: A Prospectus for Research and Research Training in the Australian Earth Sciences

Reference: Australian Geoscience Council (1992), '*Towards 2005: A prospectus for research and research training in the Australian earth sciences*', Australian Research Council Discipline Research Strategies, National Board of Employment, Education and Training, Commonwealth of Australia, Canberra, August.

The Prospectus for Research and Research Training in the Australian Earth Sciences (hereafter referred to as 'The Prospectus') was undertaken by the Australian Geoscience Council (AGC) and encouraged by the Australian Research Council (ARC). Over a period of twenty-two months from October 1990 to August 1992, the AGC gathered information from a wide variety of sources within universities, industry and the general community to obtain a comprehensive view of the key issues to be confronted by the Australian earth sciences. Reviewing in particular:

- current activity in Australian earth sciences;
- how resources could be more concentrated. For example, should there be one department in each State undertaking research across the full range of the earth sciences, or a group of separate departments each specialising in different areas?
- the relationship between undergraduate teaching and postgraduate research, and means of retaining the energy of undergraduate programs without close contact with postgraduate research; and
- priorities for the future funding of earth science infrastructure.

The following sections are a summary of key issues highlighted by the Prospectus which have a direct bearing on the recommendations for the National Tertiary Education Taskforce. While the report was "*specifically aimed at research and research training in the earth sciences,[it] provides a great emphasis on the higher education sector because of the special role played by the ARC in supporting research and research training in the universities.*" A substantial amount of the discussion, conclusions and recommendations of this report are relevant in setting a context for minerals tertiary education issues.

Issues and Concerns relating to the Ability of Earth Science to Meet Industries Needs

AGC (1992) raises several issues of concern, relating to the capability of Australian earth science education to support the current and future needs of various Australian industries. Among the issues of concern are:

- the ability to maintain a high level of knowledge in all earth science disciplines;
- the continued development of a fundamental research base;

1. **Richmond M** (1996), '*Mining Technology Conference*', CRC for Mining Technology and Equipment, Fremantle, Sept. 1996.

- the cost effectiveness of the whole system as a result of the disparate organisational structures which have, in the past, produced duplication of effort and inhibited the efficient deployment of research facilities and personnel; and
- the level of funding of earth science departments, calculated on an EFTSU basis, is not considered to be appropriate for the earth sciences; and
- every department, even those in the same city, has tended to develop independently, leading to fragmentation of effort, overlap of research skills and duplication of equipment.

The issues identified by the Prospectus "*emphasised the need to establish earth science research structures and funding mechanisms that will promote effective coordination between existing organisations, reflect the need for a geographic spread of research facilities, and provide support for a number of sub-disciplines that are currently assessed as being major research weaknesses or inadequacies.*"

Models for Consideration

Based on the above issues the Prospectus gave "*careful consideration to [the following] models for earth science research organisation.*"

"*Maintain the status quo. There are currently some thirty tertiary departments of earth science in Australia, together with eleven government agencies. To maintain status quo would be (1) to encourage the belief that there is a need in Australia for thirty such departments at the university level; and (2) to argue that maintaining the historically accidental mix of government earth science agencies in Australia is more important than to improve the nation's performance of earth science research. Monies invested in the creation of research centres will yield much greater dividends than the same amount of money dispersed across the system to maintain the status quo.*"

"*The Oxburgh model. During the 1980's, earth science departments in the United Kingdom were completely reorganised following the recommendations of the Oxburgh (1987) report into Earth Science at university level. One underlying premise of the Oxburgh report was that effective research groupings have a minimum size of about twenty-five research personnel. Whilst the Working Party agrees partly with this - hence the recommendations for creation of larger centres in Australia - any implication that 'big is necessarily beautiful' in earth science research is rejected. Intuitive judgements, and such published data as are available (eg. Hicks & Skea 1989), rather suggest the opposite, ie. that much cost-effective science stems from small university departments or research groups. A second premise of the Oxburgh report - that not all university science faculties need maintain a department of geology - has been discussed in Sections 5.2.6-5.2.7 and is endorsed. It is noted that the Oxburgh changes were apparently intended as a cost-cutting exercise which, in the event, resulted in the expenditure of $40 million of new money. There is an increasing view, however, that the Oxburgh reforms have strengthened the earth sciences in the United Kingdom.*"

Model for Recommendation

The Prospectus discussed the above models, and as its primary recommendation, suggested a further model - the establishment of the National Earth Science and Technology Centre (NESTC).

"*The role [of the NESTC] is to undertake a coherent program of basic, strategic and applied research in the earth sciences in collaboration with government earth science agencies and industry. Together with research there would be a strong emphasis on research training. The NESTCs would complement and might eventually replace the existing program of Co-operative, Special Research and Key Centres. Each NESTC should be under the aegis of an existing department/school or faculty of a university, or involve a consortium from geographically related universities. It should involve government earth science institutions and, where appropriate, industry. Each NESTC is to accept responsibility for the development of research/research training in at least one of the following fields identified as research inadequacies. These fields will need to be developed as additional to existing, identified strengths of the lead institution(s)*:

- geophysics;
- regolith studies;
- marine geoscience;
- environmental engineering geology;
- hydro-geology;
- regional geology/geological mapping; and
- computer applications in earth sciences."

"*A number of these fields are interdisciplinary, and proposals should demonstrate the ability to bring together researchers from appropriate science and engineering faculties, and from Government and private industry research establishments*."

"*A NESTC would be established for five years in the first instance with a review after three years. It is envisaged that two or three NESTCs would be established in the first round with another two or three after five years. There would be an opportunity for first round NESTCs to continue for a second term of five years. The aim should be to have five NESTCs in operation by the year 2000*."

"*Each NESTC would be funded by government through the Department of Employment, Education and Training (DEET) on a recurrent basis at $1.5 to $2.0 million per year. An establishment grant of $2.0 million would be available for use in the first two years. Total annual costs when all were established would be up to $10 million with $10 million available as an additional one-off cost towards facilities and infrastructure. Additional funds from other external sources are expected but not prescribed at any particular level. Funds supplied by DEET could be used for equipment, staffing and other facilities.*"

"*DEET would establish a selection committee to review submissions, the committee to include representatives from industry and government earth science agencies.*"

Other Conclusions

Subsequent to the primary recommendation of the NESTCs the Prospectus made several other conclusions relevant to this review.

"*Each tertiary institution must decide whether it wishes to support a separate earth science department. However, the Working Party is of the view that Australia needs fewer departments, which offer a full undergraduate to postgraduate research program. More particularly the Working Party is advocating the establishment of a limited number of major research centres in earth science*."

"*There is a need to provide greater exposure to earth science education at the secondary school level. Earth science courses should also be provided at all tertiary institutions with science and/or environmental studies programs. However not all such institutions require a separate earths science department. Continuation of all of the existing thirty earths science departments in Australia's tertiary institutions is not supported*."

"*The level of funding of earth science departments, calculated on an EFTSU basis, is not considered to be appropriate for the earth sciences, given the relatively low student numbers, high costs associated with field investigations and training, and high laboratory equipment costs. A more appropriate basis needs to be determined according to the needs of a department in any given institution*."

"*Tertiary institutions are likely to find it increasingly difficult to hire suitably qualified academic staff in the earth sciences over the next ten - fifteen years. The provision of adequate research facilities and funding, payment of salaries more commensurate with those being offered by industry, maintenance of a proper balance between teaching, administration and research, and utilising the skills of researchers from the government and industry sectors would help to alleviate this problem*."

Summary

The issues outlined in these conclusions still exist in the earth science discipline within Australia. In 1992 there were 29 departments of geology or earth science and in 1997 there are 26. Little progress has been made on the recommendations. This is, no doubt, at least partly because the Federal government was nominated as the primary source of the funding which was intended to drive the change. The current more competitive climate in higher education may help the progress these recommendations, but this will take considerable time for a cost-effective system to be established.

Appendix B
A Changing Higher Education Sector

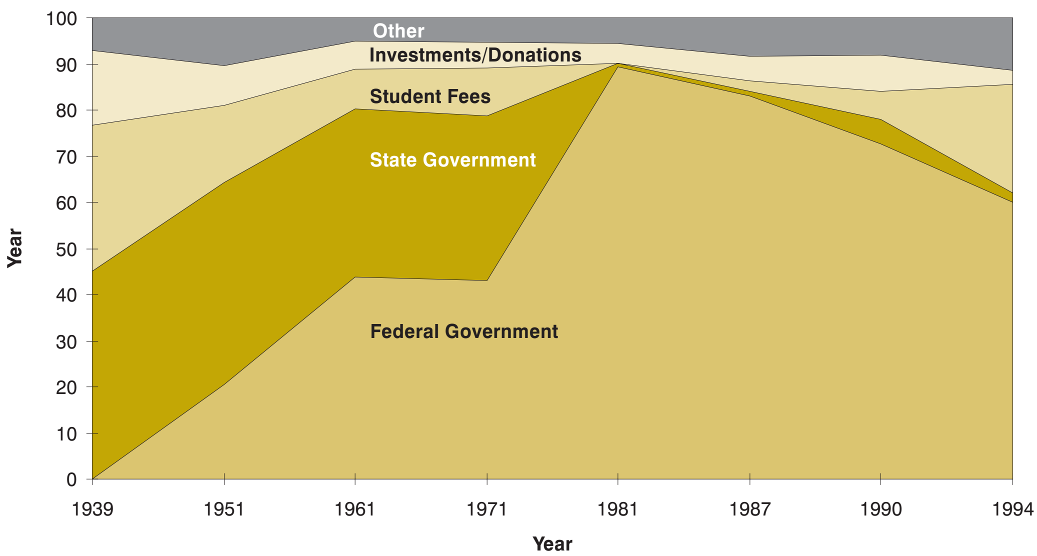
Australian higher education, like many other sectors of the Australian economy, has experienced a great deal of change over the last decade.

Changes over this period have been dominated by the impact of the so-called Dawkin's reforms. These reforms unified the Colleges of Advanced Education (CAE's) with the universities. At the same time, steps were taken to lighten the weight on the public purse of the tertiary education sector by introducing a user-pays system (HECS), thereby progressively reducing the proportion of Federal government funding in the total funding mix available to the universities. The last decade has also seen a continuation of the rapid growth in numbers of people studying at tertiary level.

Figure 1 and Figure 2 illustrate these two trends over the last 45 years. From Figure 1 it can be seen that public funding, as a proportion of the total funding mix, is at its lowest level since the 1950s. Similarly, the proportion of student contributions to the total funding mix is at its highest level since the 1950s. Figure 2 shows that the numbers of students in higher education has been on a steadily, even rapidly, rising trend since the 1950s.

The large changes in the 1972 to 1979 period were due to the Federal government assuming control of all funding to the higher education sector and phasing-out student fees.

Figure 1 Australian University Income by Source

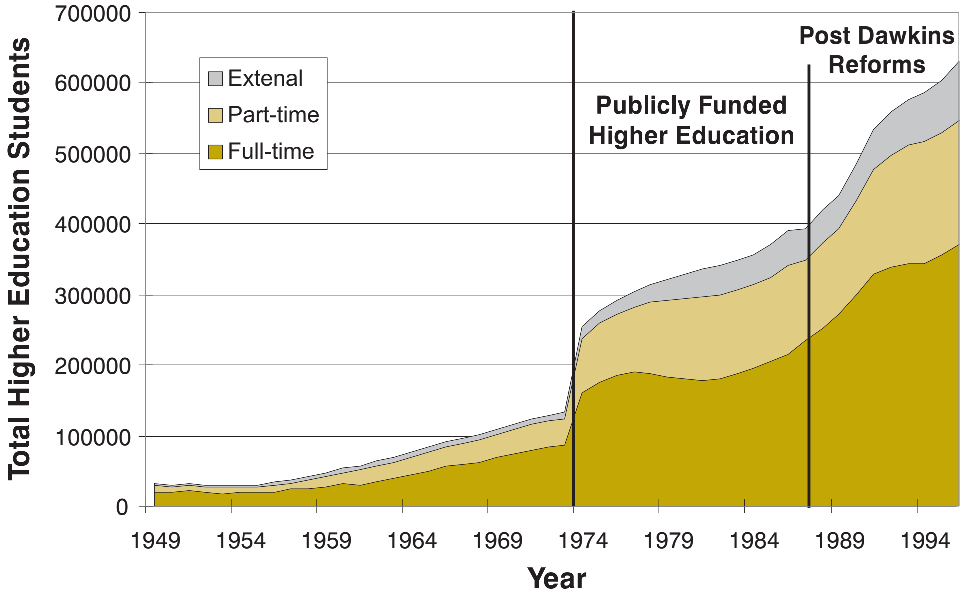


Note: 1994 Student fees include full-fee overseas students, fees paid for postgraduate courses and short courses, as well as HECS.

Source: Sharpham J & Harman G (1997) [1]

1. **Sharpham J & Harman G** (1997), '*Australia's Future Universities*', University of New England Press, Armidale,p246.

Figure 2 Total Higher Education Students by Mode of Attendance



Note: (a) Figures for 1949 to 1973 are for universities only. Comparable data for CAE's for years prior to 1974 are not available.
(b) Figures for 1974 to 1989 include universities and CAE's.
(c) Figures for 1990 to 1996 are for all higher education institutions.
Source: DEETYA (1996)[2]

A decade on, the Dawkin's reforms have resulted in at least five important shifts within universities:

1. the competition for funding dominates the activities of the system;
2. the system is now geared to large-scale production of graduates rather than focussed on a smaller elite;
3. many universities are reassessing their strategies and structures to remain viable as institutions;
4. the system is far more entrepreneurial and responsive to its customers - predominantly students as well as employers; and
5. many universities are rethinking their role as educators and the role of undergraduate education.

The following sections discuss these five shifts within universities.

1.1 Funding for Tertiary Education

The most visible sign of change in the tertiary education system is the way the universities are funded. This section outlines the funding framework within the higher education system.

1.1.1. Funding Sources

As a proportion of funding, Federal Government provision of 'taxpayers' money for tertiary education has been in steep decline since 1983. This has been the continuation of a trend which began in the late 1970s. Since the introduction of HECS the funding of tertiary education has became more oriented towards user-pays. The ability of universities to charge full fees to overseas students and for those seeking second degrees or graduate qualifications will intensify this user-pays trend.

The ratio of Federal funding to non-government funding changed little from 1993 and 1996, Table 1, with the commonwealth providing 56-57% of the funds. More recent funding policy has, however, seen further significant reductions in the contributions from the Federal government. The tertiary education sector will see a 12-15% cut in effective government funding over 1997-99. This reduction in 'taxpayers' contributions will be mostly made-up via increases in HECS fees ranging from 35-112%.[3]

The decline in public funding has led to an increase in private funding. The introduction of the HECS student-pays system is the best known of the new private sources of income. As Figure 3 shows, there are two other very important sources of private income.

The first of these is Fees and Charges. The primary sources of these appear to be overseas full fee-paying students and the fees levied on postgraduate coursework and second degrees. Postgraduate coursework study is almost entirely privately funded. The proportion of Fees and Charges in the total funding equation can be expected to increase, possibly dramatically. Recent Federal Government policy has allowed the introduction of up-front undergraduate fees for up to 25% of students per course. In the words of one commentator, 'after that, direct undergraduate fee-charging will probably spread quickly'.

The second of these is Other Sources. Where Fees and Charges are derived from the students (or their sponsors), Other Sources funding is derived directly from organisations and tends not to be specifically related to student numbers. Examples of this are funds from private companies and other organisations for research. Also included are private funding of scholarships, professorial chairs and the like.

Table 1 and Figure 3 show some broad statistics of funding sources and trends.

The funding sources are clearly an important factor driving change in tertiary education and is causing two significant changes. Firstly, a shift from public to private funding is driving a greater student awareness of, and focus on, the quality and outcomes of education. Students are also demanding a greater variety of options with regard to how they might structure their course (full-time, external etc).

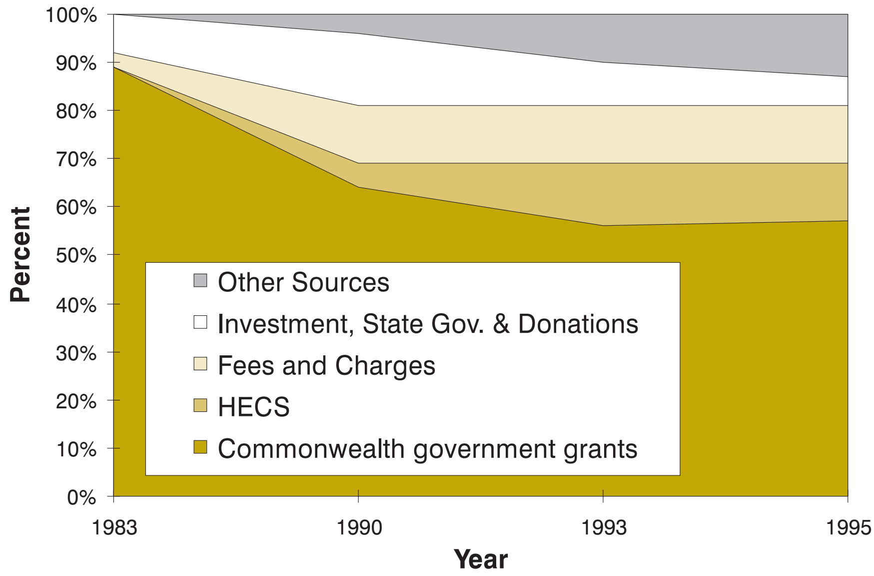
Table 1 Sources of Funds for University-Level Education

Funding Source	1983	1990	1993	1995
Commonwealth government grants	90%	63%	56%	57%
HECS	na	5%	13%	12%
Fees and Charges	3%	12%	12%	12%
Investment Income	4%	8%	3%	4%
State Government	1%	5%	4%	1%
Donations and Bequests	3%	2%	2%	1%
Other Sources	0%	4%	10%	13%

Source: Industry Commission (1997) [4]

2. **Department of Employment, Education, Training and Youth Affairs** (1996), '*Higher Education Students - Time Series Tables*', Higher Education Division, Commonwealth of Australia, October.
3. **Marginson S** (1997), '*Careers in a competitive environment - a perspective on higher education and client servicing in the Vanstone era*', Australian Journal of Career Development, Volume 6, No. 2, Winter 1997, p11.
4. **Industry Commission** (1997), '*Industry Commission Submission to the Review of Higher Education Financing and Policy*', Industry Commission, Canberra, July. http://www.indcom.gov.au/research/subs/highered/index.html

Figure 3 Sources of Funds for University-Level



Source: Industry Commission (1997)[4]

Secondly, decreasing government funds is putting more pressure on industry to contribute to higher education. In Vanstone (1996) the government has developed clear intentions of industry's involvement in the funding of higher education. *"The Government's objective [is to encourage] closer links between industry and universities in order to increase diversity and to assist universities broaden their financial base.* [5] *… Governments world wide are turning to private funds to ensure universities remain strong and vibrant*."[6] This is further reiterated by AVCC (1997)[7] which indicates that the community as well as government considers industry as a significant future contributor to the increasing proportion of private funds.

1.1.2. Funding Distribution

Before examining the actual dollar amounts of funding, some explanation is needed as to how funding of undergraduate education occurs.

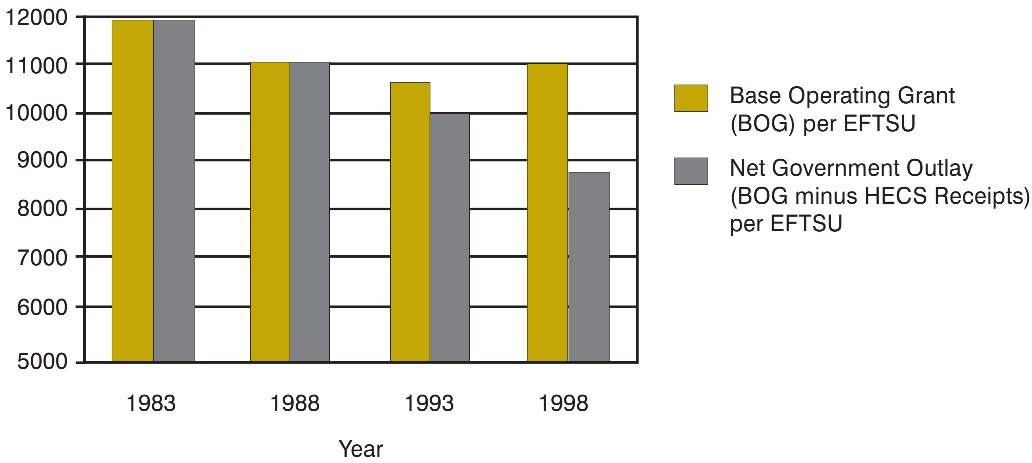
Excluding specific research and capital funding, the Federally-determined funding for universities comes in the form of an operating grant. This operating grant is a lump sum based on the number of approved student places offered by the university, and on the 'educational profile' of the university. The educational profile is intended to differentiate universities on the basis of the relative weight of the different kinds of courses offered by each university. The operating grant is higher for universities with a large component of the relatively more costly technically-oriented courses than for those where the emphasis is, say, on liberal arts or business studies.

The operating grant is funded from Federal government 'taxpayers' money and from HECS. As the operating grant is offered on the basis of student numbers, one of the critical measures in the university system is the Base Operating Grant (BOG) per Equivalent Full-time Student Unit (EFTSU) - in other words, government funding per student.

Without doubt, the base operating grant per EFTSU is the financial underpinning of the current university system at undergraduate level. The trend of this funding is, therefore, an important indication of the financial pressure, or otherwise, facing universities in offering undergraduate courses.

Figure 4 shows the trend in the base operating grant per EFTSU. Between 1983 and 1988, funding per student fell by about 7% in real terms. Between 1988 and 1993 there was a further fall of 3%. In total, this amounted to a 10% real reduction over the decade 1983 to 1993. There will be a slight increase between 1993 and 1998.

Figure 4 Government Base Operating Grant Funding per EFTSU, 1983-1998



Source: AVCC (1997)[7]

However, while the BOG has decreased over the period from 1983 to the present, Figure 5, shows that the total commonwealth funding per EFTSU (including HECS) has increased 4.2%,[8] in real terms, from 1983 to 1996.

The Base Operating Grant can be described as the non-competitive funding which is distributed to all universities and departments. BOG is predominantly based on student numbers and largely independent, at least in the short-term, of improvements in efficiency and quality. The difference between the '*total*' commonwealth funding and the Base Operating Grant consists primarily of performance-based funding for research and teaching purposes.

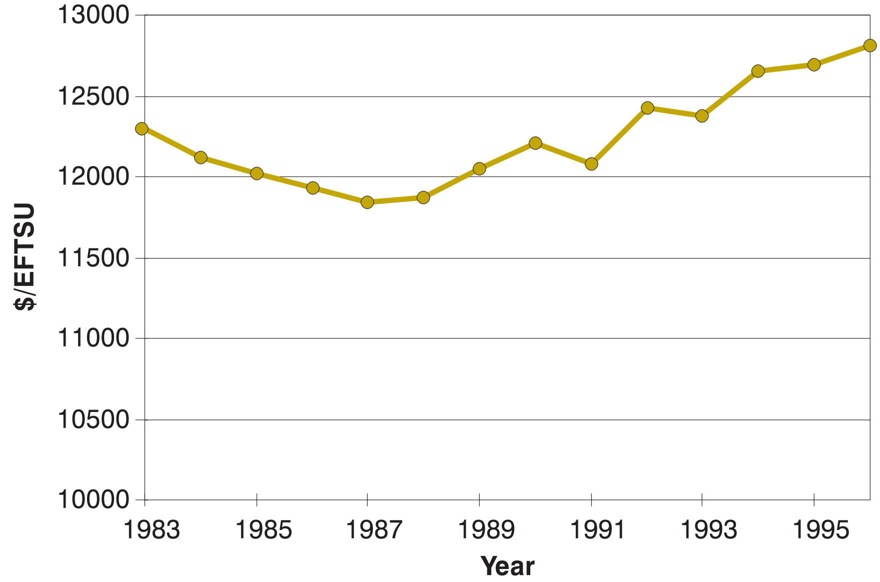
With a real decrease in the base operating grant per student and simultaneous real increase in the '*total*' commonwealth funding per student, it can be concluded:

- that '*total*' government funding is increasing in real terms; and
- competitive or performance based funding is increasing as proportion of total government funding.

The picture being painted by this funding data seems at odds with the universities own view that there is a funding crisis in the universities.

5. **Senator the Hon Amanda Vanstone** (1997), '*Tax Exemption for Educational Scholarships Assured*', Media Release, V119/97, 1 July 1997, DEETYA. http://www.deetya.gov.au/minwn/vanstone/v119_1797.htm
6. **Senator the Hon Amanda Vanstone** (1997), '*Blair Follows Vanstone Down the Private Contribution Path*', Media Release, V128/97, 21 June 1997, DEETYA.
7. **AVCC** (1997), '*Submission to the Review of Higher Education Financing and Policy*', http://www.deetya.gov.au/divisions/hed/hereview/submissions/A/AV-CC1.htm
8. **Department of Employment, Education, Training and Youth Affairs** (1996), '*Annual Report 1995-96*', Commonwealth of Australia, Australian Government Publishing Service, Canberra.

Figure 5 Commonwealth Funding per EFTSU: 1983-1996



Note: EFTSU - Effective Full-Time Student Unit and Dollars are in prices given in the Department's Higher Education Funding Report for the 1996-98 Triennium, (AGPS, Canberra, 1996)
Source: DEETYA (1996)[8]

Taking, first of all, the trend in the Base Operating Grant. While it is true that the BOG has dropped by 10% in real terms over the last decade and a half, this has been offset by an increase in enrolments by up to 50% over the same period. As universities have a high proportion of fixed costs, it would seem that a 10% reduction in 'unit cost' is not too much to ask during a time of 30% to 50% increase in 'throughput'. Certainly, among minerals companies, a 10% real reduction in unit costs over the 1983 to 1996 period is commonplace.

Furthermore, total funding per student has actually increased over the period. While this includes research funding, and therefore is not directly linked to student numbers, the question still arises as to how this sort of trend can be compatible with a funding crisis.

The answer seems to be that two changes have offset the apparent economies of scale in higher education.:

- individual institutions are absorbing more resources in trying to cover a wider field of activity in order to position themselves to be competitive, predominantly in the field of research. This is being driven by the increased importance of competitive funding in the total funding equation; and
- more recently, enterprise bargaining is driving up salaries which are now funded by individual universities[9].

The result is continued funding pressures which are creating a driver for education providers to either become more efficient, to attract more students, or to raise money from elsewhere to maintain high standards of education.

1.2 Participation in Tertiary Education

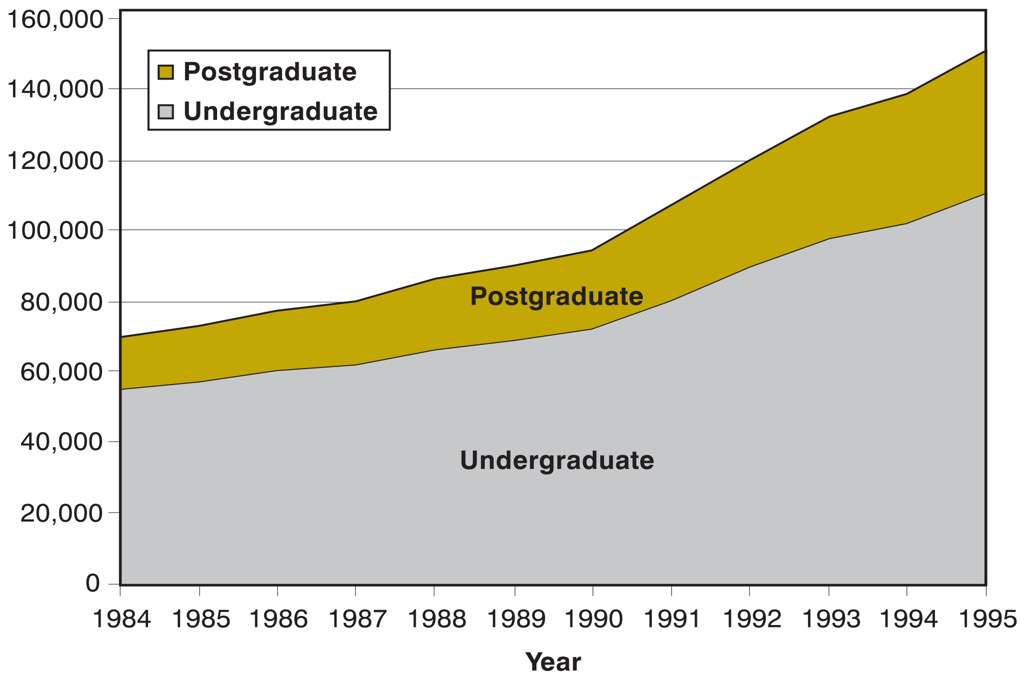
Since 1983, another of the major changes which has occurred in tertiary education is the growth in student numbers. Annual new enrolments in higher education have almost doubled over the period. Per head of population, the Industry Commission4 quotes a rise, between 1987 and 1996, from 31.7 to 46 people in tertiary education per thousand of the population.

This increase has occurred in both undergraduate and postgraduate courses. Between 1989 and 1996, the numbers of students in postgraduate studies has nearly doubled. In the same period, students enrolled in undergraduate studies has increased by about 30%, Figure 6.

The rise in postgraduate studies is significant. It can be interpreted as showing that undergraduate studies are increasingly being able to provide only a basic grounding in a particular field of knowledge. An undergraduate degree appears to be becoming for many professionals only the first step in a lifetime of tertiary education.

This trend can be compared to the situation of 20 years ago. At that time, education up to Year 10 was a commonly accepted educational preparation for a lifetime. These days, education to Year 12 is very often regarded as a minimum for any first-time job seeker.

Figure 6 Course Completions by Level in Higher Education: 1984 to 1995



Note: Original Sources: Higher Education Series, Report No.13, 1992 and Selected Higher Education Statistics 1995
1995 Figures projected.
Source: DEETYA (1996)[8]

However, there are signs that the growth in higher education enrolments is levelling-off. Indeed, some commentators argue for a deliberate policy of limiting enrolments. This argument is (at least superficially) supported by international comparisons. These comparisons show that Australia is second only to the USA among OECD countries in the proportion of its population which is studying at tertiary level.

9. Salaries and oncosts account for up to 70% of university operating costs -Appendix C

1.3 University Strategy and Structure

(a) Diversity

There are currently 37 universities in the Australian university system. They are a diverse collection. The first element of diversity is size. Universities range from an undergraduate student body of 3,000 up to 30,000. The total number of students ranges from 4,000 up to 40,000. The average is about 12,000 undergraduate students and 16,000 students in total. The second element of diversity is perhaps best described as longevity. Table 2 shows the foundation years for the first six Australian universities.

Table 2 Establishment Date Australia's First Six Universities

- Sydney 1851
- Melbourne 1853
- Adelaide 1874
- Tasmania 1890
- Queensland 1909
- Western Australia 1911

Source: Joint Working Party on Higher Education Indicators (1994) [10]

After the foundation of the University of Western Australia, there were no additions to the list until 1946 when the Australian National University was founded. By 1986, just prior to the Dawkin's reforms, there were 18 universities. The years following 1986 have seen the addition of a further 19.

(b) Identity and Strategic Position

While individual universities typically allow a great deal of internal autonomy, the notion of a 'university identity' is a real one. Indeed, it is an important influence shaping today's tertiary education sector. One way of characterising university identity is given in Table 3.

Whilst the situation is obviously more complex than this grouping suggests, the grouping does capture an important set of differences which exist between universities.

According to Marginson:

- *Sandstones* are best-placed because of their established positions as the leading institutions in their respective population centres. In a competitive world, these institutions benefit from people wishing to maximise the value of their education by benefiting from the 'crest on the graduation certificate'. They are also in the best position to benefit from alumni donations and from established links with the professional and corporate world.
- *Universities of Technology* are also in a strong position given their reputations as the pre-eminent vocationally-focussed universities with a strong track record with employers.
- *Sandstone Aspirants* are in the most difficult position because of the mismatch between their expectations and their likely future. In less competitive days, these universities were publicly-funded to provide a comprehensive range of teaching and research. In today's funding

environment, many will find it to difficult to maintain this range in the face of competition from the Sandstones, Universities of Technology and from overseas institutions.

- *New Universities* are a varied lot. Some have already targeted niche markets, others are aiming at establishing a comprehensive range of education and research. Many of these are likely to face 'serious problems' and 'some may close or fall back into a more TAFE-centred role'.

The established 'Sandstone' universities dominate the system by attracting the bulk of research funding and by carrying the greatest prestige, thereby attracting the best students and the bulk of the corporate donations. Indeed, it is estimated that 75% of all research funding is directed to the Sandstone universities. As for dominance in attracting students, in Western Australia, over 90% of the academic top 10% of school leavers go to University of Western Australia. This is despite there being four other universities in Perth.

Table 3 Characterising University 'Identity'

Sandstones	Universities of Technology	Sandstone Aspirants	New Universities
Sydney	UT, Sydney	New England	Western Sydney
NSW	RMIT	Macquarie	Charles Sturt
Melbourne	QUT	Newcastle	Southern Cross
Monash	Curtin	Wollongong	VUT
ANU	[South Australia]	La Trobe	Ballarat
Queensland		Deakin	Swinburne
WA		James Cook	Southern Qld
Adelaide		Griffith	Central Qld
[Tasmania]		Murdoch	Sunshine Coast
		Flinders	Edith Cowan
			Canberra
			Northern Territory
			Australian Catholic

Note: that [ ] indicates that the university has some but not all the characteristics of the category.
Source: Marginson (1997)[3]

(c) Competition and Strategic Positioning

Many of the comments made above refer to increasing competition. Genuine competition within the university sector is a recent phenomenon. The Dawkin's reforms threw the door open to competition by increasing the number of universities, reducing public funding and introducing student fees. This competition is not limited to competition between Australian universities. Information technology and the world-wide climate of deregulation in all areas of the economy is making international competition in education a reality.

In the words of Ziggy Switkowski: '*In education, the competitor no longer is the campus across town, but institutions around the world, many with assets beyond our capability to match and reputations reflecting centuries of investment*.'[11]

10. **Joint Working Party on Higher Education Indicators** (1994), '*Diversity in Australian Higher Education Institutions, 1994*', Higher Education Series, Report 26, Higher Education Division, Department of Employment, Education and Training, February. http://www.deetya.gov.au/divisions/hed/operations/jwphei/26intro.htm
11. **Switkowski Z** (1997), '*Global Battle for Education in On-Line Economy*', SciTech, Volume 17 No. 14, July 25.

In response to this, the Sandstones, the so-called group of eight, have been calling for a deliberate policy of fostering some (ie. the group of eight) universities as world class teaching and research institutions, and maintaining the others as basically higher education teaching establishments. The Deputy Vice Chancellor (Academic Affairs) at University of New South Wales has summed up this approach by calling for a '*strategic determination of teaching intensive and research/teaching intensive universities*'. These moves are one manifestation of the tensions arising from the increasing competition for funds and students within the university sector.

There is no doubt that there is a need for consolidation in the university system and a concentration of resources. Whether this should be done by government policy favouring some institutions over others is another question.

One thing seems certain. With or without a change in government policy, the current structure of the university sector will change. Universities will seek alliances and mergers and will pursue all manner of strategies. There will probably be an increase in the number of universities occupying educational niches, perhaps industry-based, and a greater degree of deliberate differentiation between the universities. In time, there may arise the 'multinational university'.

The very organisational structure of the university as we know it may become a thing of the past. Caution, however, should be exercised before making any dramatic prognostications. As Wicken puts it: "*Of the one hundred institutions founded in the 13th century which still survive in one form or another, some seventy are universities*."[12]

(d) Cost Structure

One area where change is likely to come is in the cost structure of universities. It is estimated that about 45% of the Base Operating Grant does not find its way to the teaching departmental level (see Section 1.1, Appendix C). Instead it is used to manage and fund a wide variety of university services. This review has not established any detailed understanding of the uses to which this funding is put. Nevertheless, this figure raises the question of the efficiency and effectiveness of the provision of university services and overheads. Competition within the sector may well see a great deal more innovation in the provision of these services.

1.4 Course Design and Delivery

One of the more striking changes in universities compared to 10 or 15 years ago is the degree to which they are focussed on the commercial aspects of tertiary education. An effective academic, particularly in a management position, must be a zealous salesman for the department and a zealous cost-cutter. Universities are in some ways coming to resemble other businesses.

As in many other businesses faced with a tougher competitive environment, it seems that, in universities, the initial response has been focussed on incremental improvement through reducing 'unit costs'. Thus, in the decade since the Dawkin's reforms, more emphasis has been put into cost-cutting than into coursework innovation designed to improve teaching (or 'product') quality. Some real change in course design and delivery has occurred but the fundamentals of most courses remain unchanged.

It appears, however, that such incremental cost-cutting cannot go too much further. Instead, the emphasis now is moving towards a more sweeping course redesign to improve quality, so as to attract more revenue, while containing and reducing costs. The following selected quotations from a recent speech by the Minister for

Employment, Education, Training and Youth Affairs express the reasons why: "*Students are already starting to 'shop around' - to think about issues like facilities, access to supervisors and the overall support systems that they are offered. They are beginning to think seriously about their options and making informed decisions about their education. They are recognising their power as consumers and can be expected to exercise their right as consumers to choose the best 'products*'."[13]

The introduction of full fees for a large proportion of local students will magnify this trend.

As a result, in recent years the tertiary education sector has developed a focus on monitoring 'quality assurance' in education. The Federal government introduced its quality assurance program in 1992 with the purpose of reviewing teaching practices and outcomes across the system. Additional funding was available to those universities which excelled in this area. This initiative was reinforced by the Federal government's Committee for Advancement of University Teaching (CAUT). This Committee was established to fund projects which are innovative and designed to improve teaching.

Publications like the Good Universities Guide, a comprehensive guide to the undergraduate and postgraduate education on offer in Australia, are facilitating this new consumer awareness. On the other hand, the apparent persistent refusal of students to travel interstate (or even across town) to attend another university, highlights the present limit of market forces in undergraduate education.

Despite the fact that there seems to be a long way to go in improving and changing the way teaching is done, the recent OECD review of tertiary education in Australia noted that there had been 'substantial achievements' in improving the quality of teaching right across the tertiary education sector.

In this new environment, genuine changes in modes of educational delivery and in course design seem likely.

One area which appears to have significant growth potential in this respect is the 'out-sourcing' of educational design and delivery. This recognises that the traditional approach of the 'in-house' designing and presenting all of the course-work for a particular degree is no longer necessary and may well be both inefficient and result in poorer quality courses. However, before this becomes a widespread practice a substantial cultural shift within academia remains to be made to allow such education to be seen as acceptable and desirable within a university.

There are many signs of this shift occurring. For example, in a recent paper, Galvin (1996) argues the case for a radical redesign of mining engineering undergraduate education. His model encompasses the delivery of some courses on-site at the Wyee Colliery and, he adds, "*It is expected that University of New South Wales will be both a provider and a receiver of teaching inputs and services to and from other institutions.*"[14] At least some of the teaching inputs are envisaged as being provided via telecommunications technology.

12. **Wicken AJ** (1997), '*Future trends in tertiary education*', Proceedings of the 1st International Underground Coal Conference, Sydney, 11-13 June.
13. **Senator the Hon Amanda Vanstone**, '*Business/Higher Education Round Table - Annual General Meeting*', 26 November 1996, DEETYA. http://www.deetya.gov.au/minwn/vs26_11.htm
14. **Galvin JM** (1996), '*UNSW Mining Engineering - Education for the 21st Century*', Address to the Annual General Meeting, Sydney Branch, The AusIMM, 21 October.

Another example is from the aptly named *Changing the Culture: Engineering Education into the Future*. In discussing issues of education delivery the review noted: "*rather than develop its own subject material for an entire range of degree courses, an engineering school may well develop and market modules in selected areas of interest and expertise, and source the remainder from other providers and from the Internet*."[15]

Developments in information technology are facilitating these changes in educational delivery and course design. Selected quotations from a speech by the Hon. Christopher Pyne MP sum up one view of these developments. "*Information technology developments will profoundly influence higher education over the next few years in particular and in coming decades. … Information systems already play an important part in the teaching and learning process. Traditional distance education providers in Australia were quick to adopt these new technologies. However, the real revolution is beginning where educational designers are starting to use information technologies to provide learning experiences that are qualitatively different from their predecessors*."[16]

Pyne goes on further to illustrate some examples of how new on-line information services have the potential to:

- expand the ability of students to interact with remote universities;
  - teachers and administrators;
  - fellow students;
  - course material; and
  - databases and libraries.
- students will be freed from constraints affecting where and when they learn;
- lecturers can interact with students more efficiently, by email and frequently asked question databases;
- students will increasingly be able to undertake more routine aspects of their coursework independently;
- researchers will more quickly identify problems and solutions, test their hypotheses and disseminate conclusions widely; and
- provide greater access to research articles and enable more comprehensive searches to be undertaken.

Pyne also claims that these developments may change the fundamental economics of higher education. For example:

- The cost structure of delivering a multimedia course via the Internet is going to be very different than that of delivering the same course through lectures and tutorials.
- To deal with these new cost structures institutions may need to collaborate more in developing and providing services such as multimedia courseware, to pool their development costs and spread them over a larger client base. That will fundamentally change the way that institutions interact with each other.

There is no doubt that effective coursework is being developed to take advantage of the possibilities offered by information technology. The leading exponent in this field in Australian tertiary education is Deakin University's Deakin Australia. This organisation is a significant player in Australia (and probably internationally) in developing and delivering distance education programs.

However, it is easy to overstate the extent to which things have changed to date. The dominant mode of undergraduate educational delivery is still, as it has long been, the set-piece lecture delivered to a classroom of students. This is likely to continue to be the case, especially at undergraduate level, for some time yet.

Widespread changes in educational delivery are most likely in the future. But, in this case, the future may not be long in arriving.

1.5 The Role of Undergraduate Education

The role of undergraduate education has long been a topic for debate. The available options tend to lie along a continuum: at the one end, a student may undertake focussed vocational training and, at the other end, a student may 'read' for a liberal arts broadly-based degree.

Many academics and universities are now re-appraising where their course or their university should sit on this continuum. The reappraisal is prompted by:

- changes in the nature of work and the nature of a working career;
- changes towards student-pays for undergraduate education and the consequent greater focus on getting value for money;
- the rapid increase in the rate of change, the complexity and the 'interconnectedness' of societal norms and structures; and
- the increase in the proportion of university funding which comes from employers.

The current debate is yet to crystallise into definite directions. The OECD report commented that the debate "*has yet to result in a searching analysis of ways in which the undergraduate curriculum might be reconceptualised and restructured to enable students to face the demands and challenges of contemporary life.*" [17]

There are notable exceptions to this. The recent restructure of the medicine degree at a few universities is perhaps the best known example. At these universities, the first three years of a degree in medicine can now be taken as a science degree.

Movement towards the other end of the continuum is seen in the proliferation of specialist engineering degrees - mechatronics and aeronautics - and their popularity among students.

In the engineering field, the *Changing the Culture* report advocated a much more broadly-based approach to undergraduate education. The report argues that "*the present emphasis placed on engineering science resulting in graduates with high technical capability, has often acted to limit their appreciation of the broader role of engineering professionals. Graduates must understand the social, economic and environmental consequences of their professional activities if the profession is fully to assume its expanding responsibilities. This will necessitate the increased use of postgraduate study to enable graduates to obtain the specialist skills needed for the particular needs of organisations or for individuals' career development.*"[15]

15. **The Institution of Engineers, Australia** (1996), '*Changing the Culture: Engineering Education into the Future*', Institution of Engineers Australia, Australian Council of Engineering Deans and Academy of Technological Sciences and Engineering, Canberra.
16. **Pyne C** (1996), '*Information, Innovation and Scholarly Communication*', Speech to the Australian Academy of Science, Canberra, DEETYA, http://www.deetya.gov.au/minwn/vanstone/vs21_01.htm
17. **Directorate for Education, Employment, Labour and Social Affairs OECD** (1997), '*Thematic review of the First Years of Tertiary Education Australia', OECD, Higher Education Division, Department of Employment, Education, Training and Youth Affairs, Commonwealth of Australia and the OECD February 1997*". http://www.deetya.gov.au/divisions/hed/operations/theme.htm

To balance this shift in thinking towards more broadly-based undergraduate education, is the general 'economic rationalist' view of education, summed up by Marginson (1997): "[the increases in] *HECS will impact directly on many more students and make those students more vocationally conscious from the day they enrol. … Students will demand a better employment-related performance from universities.*"[3]

Course design of the future will no doubt produce courses at all points along the continuum. Some universities will focus on vocationally-oriented courses, some on more broadly-based education. Perhaps the more interesting question is whether, in years to come, innovative course design can be such as to render irrelevant the current distinction between broad-based and vocational education.

Appendix C
Minerals Tertiary Education - Funding

The mechanisms for the distribution of funding to the tertiary education sector have been described in Section 1.1.2 of Appendix B. This appendix follows on from that section and discusses the funding and cost structure of minerals courses, and issues arising from this.

1.1 Funding Distribution to Individual Departments

Table 1 shows the average revenue and expense stream for all government funded universities in 1995. The way in which this revenue is distributed within the university is a matter for the management of the particular institution.

Table 1 Adjusted Operating Statement Averaged for all Institutions

Category	**1995 $ million**
Commonwealth Government Grants	108
HECS	23
State Government	3
Other Research Grants and Contracts	7
Investment Income	8
Fees and Charges	22
Other	15
Total Operating Revenue	**186**
Academic Activities	106
Libraries	9
Other Academic Support Services	9
Student Services	7
Public Services	3
Buildings and Grounds	10
Admin. & Other General Institution Services	26
Other	5
Total Operating Expenses before abnormals	**175**

Source: Joint Working Party on Higher Education Indicators (1994)[1].

After various deductions for research and for university services, Table 2, about 45-55%[2] of the university's revenues are made available for distribution to the faculties.

1. **Joint Working Party on Higher Education Indicators** (1994), *'Diversity in Australian Higher Education Institutions, 1994'*, Higher Education Series, Report 26, Higher Education Division, Department of Employment, Education and Training, February. http://www.deetya.gov.au/divisions/hed/operations/jwphei/26intro.htm
2. Private communication received during informal stakeholder consultations.

Table 2 Example Deductions for Central Services of the Universities

1. chancellery
2. libraries
3. buildings
4. maintenance
5. power
6. parking
7. student facilities; and
8. etc

Source: Private communication received during informal stakeholder consultations.

The Taskforce has not established any detailed understanding of the uses to which this funding is put, nevertheless, the magnitude of this percentage raises the question of the efficiency and effectiveness of the provision of university services and overheads.

The allocation of funds to the faculties is done using a pre-determined formula. About 85% of the funds are distributed on the basis of student numbers, about 15% on the basis of research carried out by the faculty.

In allocating funds to faculties on the basis of student numbers, one critical measure is the Equivalent Full-Time Student Unit (EFTSU). The EFTSU is the basic measure of how many students are studying in the faculty. However, not all students are equal when it comes to funding.

Two weightings are used. Firstly, a postgraduate student is usually given a higher weighting than an undergraduate student (about 2:1). Secondly, departments with higher costs (such as engineering or medicine) receive more money per student than low-cost courses. This weighting is known as the funding index.

One example of the funding index is:

Faculty	Index
Business, Economics, Law	0.6
Engineering, Science	1.3
Health Services	1.6

Source: Private communication received during informal stakeholder consultations.

The funding index is multiplied by the EFTSU to arrive at the Weighted EFTSU, which forms the basis for funds allocation.

The faculty then allocates its funding to its various departments according to its own formula. Again, the principal issue in allocation is the degree to which different weighting should be given to different areas. In the main, postgraduate EFTSU's are given higher weighting than undergraduate. This has disadvantages for courses where the emphasis is on undergraduate teaching.

1.2 Impact of Funding Mechanisms

For minerals departments, it is not only the overall level of funding for tertiary education which is important, it is also the way in which the funding is distributed. The three most important issues arising from the method of distribution are:

1. there is little or no incentive for cooperation between universities or departments;
2. the distribution mechanism determined within a university can greatly alter the viability of a particular course; and
3. the considerable fixed costs of providing courses provides a strong incentive to lower entrance and assessment standards in order to boost student numbers.

1.2.1. Cooperation

As was discussed in Appendix B, government funding for tertiary education is driven by student numbers. The more ‘sharing’ of students with other departments that is done by a department the less is the funding which flows directly to that department. An example is the first two years of a common engineering degree. The first two years share many common courses - chemistry, mathematics and so on. They also share a number of more applied courses. The funding for these courses is directed to the department which provides them. As these common courses generally attract large numbers of students, the large departments are in a better financial position not just by virtue of their ‘core’ class sizes but also because of the many other students doing general courses. Smaller courses, with limited appeal to the wider range of students, are thus disadvantaged and have little incentive to share courses in the interest of efficiency and a broader education.

This sort of difficulty can be overcome at the faculty level where some degree of management direction and a common approach can be achieved. Between universities, there is much less commonality of purpose. As a result, under the present funding arrangements, there is very little cooperation between universities at undergraduate departmental level. This is especially so given that about 55% (central services funding) of the funding per student does not reach the academic department but is used by the university for other purposes, as a result departments will only be sharing 45% of the student’s available revenue.

For postgraduate coursework studies, the issues are less difficult to deal with. This is because postgraduate students are very often full fee-paying and also more aware of the quality of course they want. There is, as a result, more working together on postgraduate coursework between universities. A good example of this is the Centre for Oil and Gas in Perth. This Centre offers a postgraduate program drawing on the academic programs of the University of Western Australia, Curtin University and Murdoch University.

1.2.2. Distributing the Base Operating Grant

The way in which the Base Operating Grant (BOG) is distributed is of vital importance to the viability of any course. The distribution of the Base Operating Grant is for the individual university and the individual faculty to decide. This is done, as explained above, on the basis of a Funding Index and weighting of different type of postgraduate instruction versus undergraduate.

In the case of engineering and science programs, the Funding Index can vary from 1.2 to about 1.8, depending on the university. The viability of a minerals course is as much determined by the Funding Index as by the student numbers it attracts. To a large extent, the commitment of any particular university to the engineering and science disciplines can be gauged by the Funding Index accorded these disciplines.

1.2.3. Quality of Students

Educational quality and outcomes are not a factor in determining student-based funding except in the longer-term when students become more discriminating and have more access to information on course quality and outcomes. As a result, in the shorter-term at least, the incentive is there to both lower entrance standards to attract more students and to relax assessment standards to graduate more students. This incentive, at least superficially, is particularly strong for smaller departments (eg. minerals departments) which are subject to large fluctuations in numbers.

The following extract from Barratt (1995) gives one view of the potential effect of student-based funding on assessment standards. *"To be frank, I have the gravest doubts that this situation can be obtained under the present system of per capita funding. Per capita funding is a powerful financial signal to both the institution and the individual staff member that they have a strong interest in passing as many students as possible. This signal is, I understand, reinforced by a Federal Department of Employment, Education and Training which tells universities that they should pass a certain proportion of students in each course. This is an environment in which it is impossible to maintain standards - one in which the standards are set by the students, not the staff. … I know that some institutions do hold out against this system quite fearlessly. The problem is that they are apt to be financially punished for maintaining their standards, with the result that there is a net transfer of funds to institutions that do not apply the same rigour. How this is in the public interest I cannot imagine."*[3]

The Taskforce identified minor occurrences of the 'lowering of standards' in minerals courses. However, there has been some movement the other way in recent years with record enrolments.

1.3 Balancing the Revenues and Costs of Minerals Courses

A striking feature of academia is how low its total costs are. The operating cost of the Mining Engineering program at the University of Queensland, one of the largest mining engineering departments in the world, is not much more than $1.1 million per year.

Table 3 Departmental Expenditure

Category	% of Expenditure
Academic staff	60-70%
General staff	15-20%
Materials, consumables and equipment	15-20%

Source: Private communication received during informal stakeholder consultations.

A rough estimate for the total annual cost of the undergraduate education for all minerals graduates in Australia would come to $35-40 million.[4]

The costs of running such a course can be split into three areas, Table 3. As this table shows, academic salaries and salary loading amount to between 60% and 70% of a typical minerals course.

Figure 1 below shows in more detail how these costs are typically apportioned.

Figure 1 Cash Flow Model - Mining Engineering Department

Funding Model for Mining Engineering Department within a wider Faculty of Engineering

Note: Less Abnormals (eg. one off grants and major infrastructure expenditure)
No Non-Government income
No Academics Salary Supplementation
No Maintenance of Students Facilities - eg. Computer Laboratories

EFTSU

	Enrolments (a)	Mining Engineering EFTSU (b)	EFTSU Weighting (c)	WEFTSU (b) * (c)
Year 1	40	0	2	0
Year 2	40	0	2	0
Year 3	40	40	2	80
Year 4	40	40	2	80
Postgraduates	20	20	4	80
Total	180			240

Income

Unit Income of EFTSU at Departmental Level	$	3,000	(1)	
WEFTSU		240	(2)	
Enrolement Income	$	**720,000**	(3)	(1) * (2)
Research Quantum	$	**75,000**	(4)	
Departmental Income	$	**795,000**	(5)	(3) + (4)

Expenses

Salaries (oncosted @25%)					
	Academic	Professor	$	101,087	
		Professor	$	101,087	
		Associate Professor	$	83,261	
		Senior Lecturer	$	68,692	
		Senior Lecturer	$	68,692	
		Lecturer	$	56,851	
	General	Business Manager	$	75,000	
		Admin Assistant	$	40,000	
		General Assistant	$	35,000	
		Lab Technician 1	$	45,000	
		Lab Technician 2	$	45,000	
Salaries Sub Total			$	**719,671**	(6)
Other	Student Exc				
	Telephone & Fax				
	Laboratories				
	Computing				
	Officer Refurbishment				
	Travel				
	etc				
Sub Total Other @ (10% of salaries)			$	**71,967**	(7)
Departmental Expenses			$	**791,638**	(8) (6) + (7)
Cash Flow			$	**3,362**	(5) - (8)

Source: Private communication received during informal stakeholder consultations.

As for any business, to be economically sustainable a minerals department must bring in enough revenue to cover its costs. In the next section, the student numbers needed to sustain a minerals department (under current typical cost structures) will be examined. The analysis will lead to the conclusion that there are too many minerals departments to be economically sustainable.

In subsequent sections, we will examine how minerals departments deal with this problem by making cost savings which tend to weaken the quality of the course they are able to offer.

3. **Barratt P** (1996), '*What Business Expects from the Universities'*, Business Council of Australia, Business Council Bulletin, January.
4. Assuming cost to fee paying students of $58,000 for 4 year and $43,500 for 3 year engineering and science degrees and that 50% of geology and metallurgy will be 3 years with the remainder being 4 years. Fees are referenced from: **Senator the Hon Amanda Vanstone** (1997), '*University Fees Highlight the Bargain to HECS Students*', Media Release V55/97, 13 April 1997, DEETYA. http://www.deetys.gov.au/minwn/vanstone/v5513497.htm

1.3.1. Sustainable Size of a Minerals Department

The question this section will seek to answer is at what level of student numbers does a minerals course become sustainable on an economic basis.

A minerals course, like all other courses offered by universities, carries a high proportion of fixed costs and a variable revenue stream (based on student numbers).

Variable Revenue - More than most courses, the revenue stream of a minerals course is variable. Figure 3 and Figure 4 illustrate the variability in two large departments in different disciplines. These diagrams also show an estimation of the range of student numbers (or enrolments) needed before the course is economically sustainable.

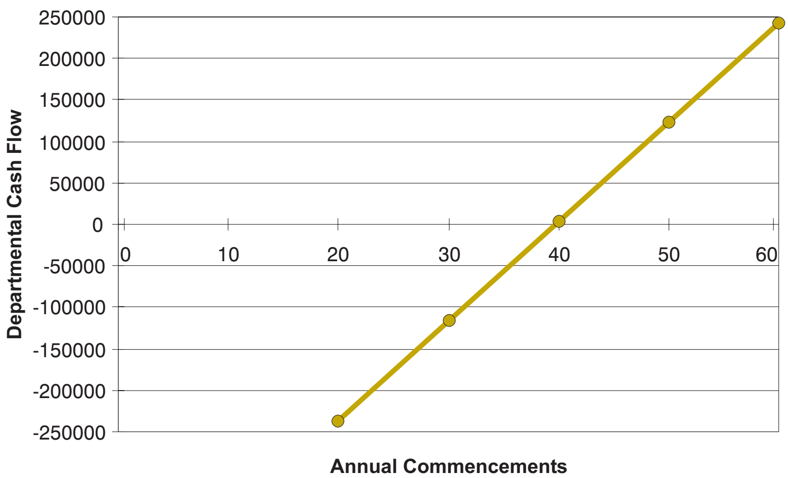
Cost Structure - The cost structure is largely fixed. This is because any worthwhile course must be able to offer a range of subjects, and these subjects cannot all be well-taught by two or three people. It is estimated that the minimum staff size for a mining engineering department is six and metallurgical engineering is seven. For a geoscience department, with its broad range of sub-disciplines, the minimum is about ten.

Figure 2 illustrates how the financial health of a typical minerals course varies with student numbers. The curve is based on assumptions in Figure 1 and the minimum number of academics needed for a particular course and on assumptions about university distribution of funds.

Figure 2 also shows the estimated break-even point for a mining engineering course under current funding arrangements is somewhere between 35 and 45. It is worth repeating that the breakeven point is heavily dependent on university funding distribution arrangements as well as on student numbers. It should also be said that this is a very generalised view and departments will vary in their particular circumstances.

Nevertheless, the point remains that breakeven numbers of annual enrolments are, at minimum, about 35 and by historical standards such numbers are very high in minerals courses.

Figure 2 Departmental Cash Flow Versus Annual Commencements



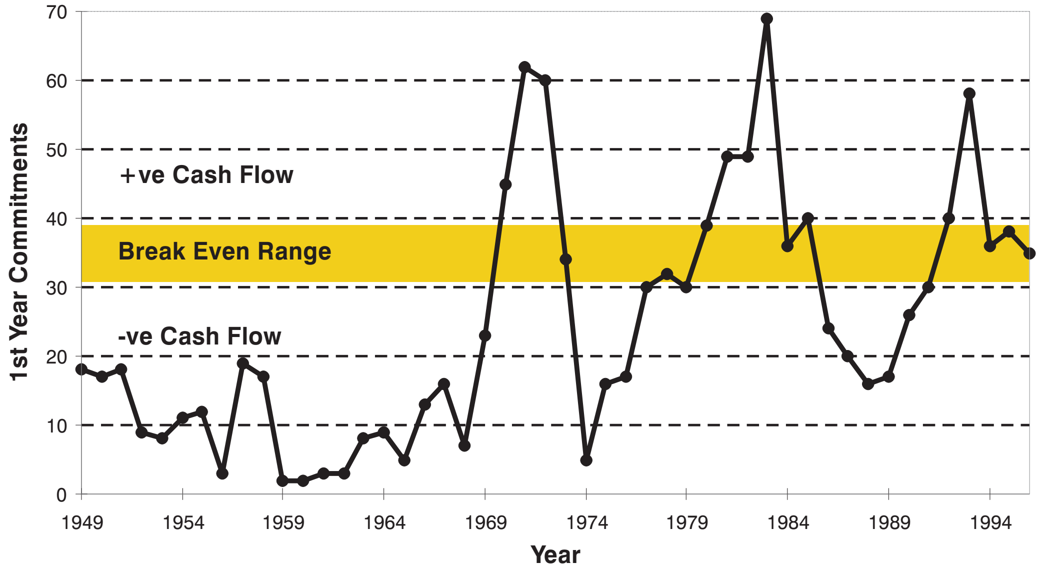
Source: Private communication received during informal stakeholder consultations.

Having established a minimum economic class size, it is worthwhile to look at current actual class sizes in the minerals course around the country.

Table 4, illustrates the current student numbers in the various mining engineering, metallurgical and geoscience courses across Australia.

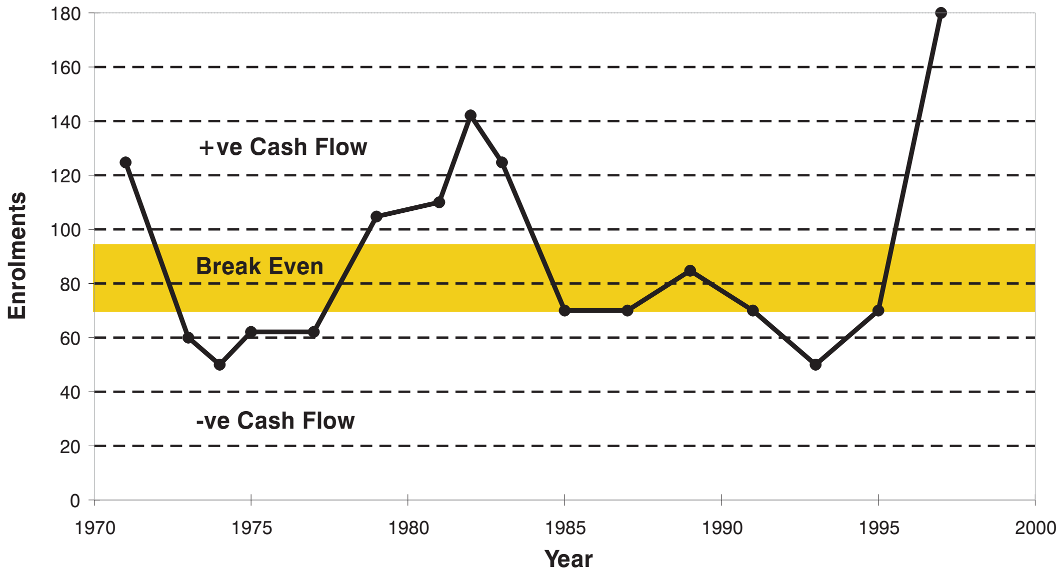
While care obviously must be taken with generalising from this analysis, Table 4 shows that none of the departments in Australia is comfortably in the sustainable range.

Figure 3 UWA Geoscience Total Enrolments



Note: Data is Total Enrolments, divide by 2.5 to 3.5 for estimation of annual commencements.
Source: Enrolments data from University of Western Australia Geoscience Department.[5]

Figure 4 UNSW Mining Engineering 1st Year Enrolments



Note: Data is annual commencements. The break-even range is not relevant for earlier period from 1949 to about 1974, due to different funding arrangements.
Source: Commencement data from Galvin (1996) [6]

5. Private communication received during informal stakeholder consultations.
6. **Galvin JM** (1996), '*UNSW Mining Engineering - Education for the 21st Century*', Address to the Annual General Meeting, Sydney Branch, The AusIMM, 21 October.

Table 4 Mining Engineering Average Annual Graduation of Students per Department

State	Metallurgy/ Materials Average Students per Department	Geoscience Average Students per Department	Mining Engineering Average Students per Department
Queensland	15	23	35
NSW & ACT	25	14	16
Victoria	20	23	13
Tasmania	0	15	0
South Australia	8	27	9
Northern Territory 0	17	0	
Western Australia	15	23	25
Total	17	20	19

Source: Lawson (1997) [7]

Assuming that the demand for mining engineers roughly meets supply and the current graduating number is around 160, it could be reasoned that this number of graduates only supports three to four mining engineering departments (160 divided by break even enrolments 35 to 45). Similar cash flow models as Figure 1 for geoscience indicates that about 13 to 16 departments of geology is economically sustainable. For metallurgy, this logic leads to the conclusion that 3 to 4 departments is an economically sustainable number.

However, in recent times higher education funding continues to support 6 mining, 9 metallurgy and 26 geoscience departments - all operating more or less independently.

There is a strong case for reducing the number of minerals departments and, in the process, strengthening those which remain.

1.3.2. Academic Staffing Numbers

One impact of having too many minerals departments is that each department has insufficient academics to offer a truly first class course.

It is difficult to derive from 'first principles' the number of academic staff required to achieve teaching excellence in a minerals course. The best that can be done is to look at class sizes and evaluate these in terms of past experience, the judgement of those working in the field and at international comparisons.

One estimate is that, for a 'world class' mining engineering course, there should be 8 full-time academics for class sizes of 30. This estimate is raised to 10 academics if there are class sizes of 50. Under current funding arrangements and current cost structure, this would mean a world-class course would run at a deficit of $400,000 to $600,000 per year. The University of Queensland currently has class sizes of 50, now with seven academics carrying the teaching load. It operates at a small financial surplus.

In this discussion, it is important to remember that class sizes of 50 in mining engineering are an historical rarity and have never been sustained for very long. Mining engineering average class sizes in the major departments over the last three years have been less than 30. The same observation can be made for all minerals disciplines. Estimates of academic staff based on the current student numbers must be treated with caution.

The shortage of academics can, superficially, be attributed to the large number of small departments. As Table 4 shows, class sizes over the last three years for mining engineering have been 19. The average number of academics has been 5. With half the number of departments, class sizes would be 34 (assuming the same number of students were captured by the rationalised departments) and academic numbers could be raised to 10 - well within 'world class' standards.

However, a reduction in the number of departments, while necessary, is not the whole answer. More often than not, particularly in the absence of a deliberately managed process, such reductions in departments merely amount to closures. Transfer of students and academics to the surviving courses is the exception rather than the rule. The reason for this is that student choice (as discussed in Appendix E, Attraction) seems to be generally influenced by a preference for a location and university, not solely by the preference of a course of study. Student transfer from one minerals course to another at a different university is, therefore, very far from being guaranteed. Understandably, universities will be reluctant to fund the transfer of academics until there is proof that the student numbers will be there to justify the transfer.

1.3.3. Academic Salaries

A second impact of too many departments is that academic salaries, as much as academic numbers, must be kept low. While this is a result of the wider issue of the academic salary structure within universities, the thinly spread resources in minerals education further inhibit addressing this issue.

Table 5 Academic Salaries - 1996

Academics Level	Range of Gross Salary
Associate Lecturer	$30,500 - $41,400
Lecturer	$43,600 - $51,800
Senior Lecturer	$53,400 - $61,600
Associate Professor	$64,300 - $75,800
Professor	$82,000

Source: Private communication received during informal stakeholder consultations.

Twenty-five years ago, salaries of professors and heads of departments enjoyed salaries reasonably equivalent to similar positions of maturity and experience in industry. During this period, base salaries of academics and industry salaries in the minerals professions have significantly diverged by as much as 100% of academics salaries. Minerals academics salaries have remained tied to the wage system within universities and industry salaries have grown greater than the norm, (although some universities provide a 'market-related loading' to partly offset the disparity). Table 5 illustrates current academic salaries.

A shortage of quality academics is becoming evident. Industry and academic salary disparity is discouraging highly capable professionals from choosing to pursue academic careers, along with a declining status for the academic profession within society. Minerals courses have limited room to move on this issue given that academics salaries constitute 60-70% of departmental costs, and given that most departments are already in marginal financial situations.

7. **Lawson F** (1997), '*The Education of Professional Specialists for the Minerals Industry into the Next Century*', Proceedings of The AusIMM Annual Conference, Ballarat, 12-15 March, p315-319.

Given the importance of salary levels in the departmental budget, it is easy to see why the recent salary increases of 10-15% are causing so much concern in academia. These salary increases are unfunded by the government and will further increase the required minimum student enrolments to break even.

There are ways and means of augmenting salaries under the current system. For example, it is not unusual for academics to earn money through consulting. Indeed, this is a good way of ensuring that skills and knowledge are kept relevant. However, over-reliance on such 'salary augmentation' will inevitably reduce the focus on the quality of academic teaching.

1.3.4. Infrastructure Costs

The following sections deal with two components of infrastructure costs:

- the inability of the current funding framework to adequately resource minerals education infrastructure costs; and
- examples illustrating the level of infrastructure costs that are required.

(a) Limitations of Present Capital Funding System

Infrastructure funding is provided through three mechanisms within the institutional operation grants:

1. teaching component of BOG, minor capital and non-salary items associated with teaching;
2. capital 'roll-in' of BOG; and 3. Research Infrastructure (Equipment and Facilities) Program (RIEFP).

The first two mechanisms are part of the per student funding from the BOG that filters through to the department level. As illustrated in the cash flow analysis in Figure 1, there is little or nothing of this income left available for basic departmental expenditure on capital. The share of total funds represented by capital funding and research funding has increased at the expense of base operating grants. Academics salaries have continued to be the priority of BOG funding and as a consequence, the expenditure of the minor capital and capital roll in components of the base operating grant have been starved.

The third mechanism, RIEFP, is a competitive grant designed to encourage universities to develop cooperative arrangements for the purchase and use of large items of equipment and other research infrastructure. The capital infrastructure purchased, while primarily for research, can be used for undergraduates teaching. Collaborative arrangements are generally suitable for research infrastructure - it is relatively easy to temporarily move researchers from one institution to another to use the facility - but not for undergraduate teaching. While the desired outcome of this program is not for undergraduate education, there does not appear to be any other significant programs for undergraduate teaching infrastructure expenditure. With the current level of competitiveness within universities, home institutions will always have the advantage in access to facilities. The significant teaching focus of mineral courses limits the mineral tertiary education from accessing these research funds. Similarly, mineral courses are geographically diverse with limited incentives or opportunities for universities to collaborate for undergraduate education equipment funding.

In summary, the base operating grant funding for capital which mineral courses once had ready access to, has been continually reducing over the last 14 years. This is being replaced with competitive funding, of which mineral industry courses are considerably disadvantaged to compete for as a result of small student numbers and a fragmented system of providers.

For the Government to improve the focus of teaching excellence, one alternative for consideration, is to adapt the RIEFP to an undergraduate teaching level. It is also the Taskforce's view that the establishment of a coordinated network of mineral tertiary education institutions will enhance the systems ability to identify and collaborate for the justification of capital funding from industry and government.

(b) Level of Capital Funding for Improvement

No systematic assessment has been made of the equipment needs and the condition of that equipment across the minerals departments. Most of the departments appear to have equipment which ranges from 'obsolete but serviceable' to state-of-the-art. There is certainly a need for upgrading in some areas. One of the significant areas requiring funding and the most difficult to gauge is the condition of, and need for, is information technology equipment. If courses are to be designed for the use of information technology, then there is considerable upgrading required. Generally, only some departments seem to be reasonably well-provided for. However, technical advances in this equipment are such that future costs are difficult to estimate.

During its review of Australian geoscience research, the AGC (1992) developed a study of equipment condition and requirements in each of the geoscience departments across Australia. The conclusion was that "*the capital equipment costs of establishing a basic earth science department approach $1 million. … the implication [is] that annual equipment grants respectively of $75,000 … are needed merely for the maintenance and replacement of this equipment, sums which greatly exceed the funds typically available to earth science departments at present. (Though detailed country wide figures are not available, the indications are that - other than the Research School of Earth Sciences - the majority of departments receive on average between $30,000 and $60,000 per year for equipment.)*"[8]

Similar concerns have been quantified from some mining engineering departments within Australia, "*the annual investment of $150,000 is regarded as the amount required to maintain an upgrade program starting from a condition of installed state-of-the-art equipment*". AGC (1992) went on to comment that "*a significant number of respondents to the survey expressed concern about the approaching obsolescence of equipment in current operation, and the difficulty of identifying funds for its replacement. Given that the survey indicates that country-wide only a few departments are equipped at the well-founded research level, it is clear that cost-effective measures are needed in order to improve and update earth science equipment holdings.*"

Comments made to the Taskforce gave the impression that funding allocations for equipment upgrades were very often a function of the persuasive capabilities of the academics within the department. Normal funding channels are such that a department will submit an application for funds to the university administration. Depending on the strength of the case, no doubt also depending on how well it is expressed and presented, the application will stand or fall.

8. **Australian Geoscience Council** (1992), '*Towards 2005: A prospectus for research and research training in the Australian earth sciences*', Australian Research Council Discipline Research Strategies, National Board of Employment, Education and Training, Commonwealth of Australia, Canberra, August.

It is the view of the Taskforce that routine external (eg. industry) funding for such equipment upgrades would only serve to take the pressure off the university administration and the departments in this area. However, there does seem to be a case for making some extra funding available given the generally difficult funding circumstances prevailing in recent years. Such funding should only be made available where there is a corresponding commitment from the university.

1.4 Conclusion

The conclusions of this broad analysis are:

1. there are too many minerals course providers in Australia; and
2. of necessity, these courses employ fewer academics than they should and are paying them less than is desirable; and they have limited funding for equipment and infrastructure - if world class standards are to be achieved.

What is to be done?

One option is to allow rationalisation to take its course. However, rationalisation within the higher education system does not occur quickly. The current funding framework does not develop substantial market forces, allowing university interventions to supply medium term life support to failing departments. As a result the decline of some education providers drags on for a period of time absorbing valuable resources. It could be concluded that through the current funding framework the universities as a group, inefficiently uses government funding to subsidise departments which are questionably economic.

The Taskforce believes that this process should be accelerated and that some financial incentives will be necessary to assist this.

To address the academic salaries issue, one approach worthy of consideration is for industry to establish salary supplementation for teaching excellence in the mineral field. These could be split into two areas - teaching for students undertaking minerals undergraduate courses and teaching of service courses to other undergraduate disciplines. A second part of the approach to addressing the salary issue is for the funding of ‘chairs’ which have an associated salary designed to attract the suitable candidates. The establishment of ‘chairs’ has been used within the minerals industry and university departments. Measures such as these have been used and will be required in the future to address issues involving the development of new curriculum items over and above the current content, for example improved mine safety education.

Finally, the Taskforce believes that there are significant examples of inadequate equipment and infrastructure in minerals education and there is a need for additional funding to develop these facilities to standards which are capable of supporting world class education.

Appendix D
Minerals Tertiary Education - A Snapshot

In this Appendix, the current state of minerals education in Australia, and the factors influencing it, is described. The description will focus on:

1. the numbers of graduates and the factors affecting this; and
2. the diversity within the minerals education sector.

1. *Supply and Demand Balance of Minerals Professionals: A Cyclical Phenomenon*

Three essential 'system-wide' characteristics determine the supply and demand balance of minerals professionals in Australia:

1. the minerals industry dominates the employment of mining, metallurgy and geoscience graduates;
2. the industry is cyclical in its expenditure and is consequently cyclical in its employment of minerals professionals; and
3. in the past, shortages of professionals have been met from a ready overseas supply.

The following sections individually discuss and substantiate these characteristics. Taken together, these characteristics have led to a system, which will always struggle to maintain a balance between graduate supply and demand balance within Australia.

1.1. *Who Employs Minerals Graduates?*

This section presents a brief analysis of employment statistics for 1996 for minerals graduates. The data for these statistics is sourced from the Graduate Careers Council of Australia (GCCA) and the Department of Employment, Education, Training and Youth Affairs (DEETYA).

The following points summarise the data:

- Geology: 90% of the total respondents were in Full-Time (FT) employment. 62% of the total respondents were employed by a minerals or minerals service company;
- Metallurgy: 97% of the total respondents were in Full-Time (FT) employment. 55% of the total respondents were employed by a minerals or minerals service company; and
- Mining: 98% of the total respondents were in Full-Time (FT) employment. 75% of the total respondents were employed by a minerals or minerals service company.

For the purposes of analysis, employers were categorised as follows:

MCA Member	minerals & minerals service companies that are members of the Minerals Council of Australia
MCA Contractor	minerals contracting companies that are members of the Minerals Council of Australia
Minerals	minerals & minerals service companies that are not members of the Minerals Council of Australia
Contractor	minerals contracting companies that are not members of the Minerals Council of Australia
Other	non- minerals industries, eg. tourism, manufacturing etc.
Government	Government Departments, AGSO etc.
Research	private and public research eg. ACIRL, CSIRO & universities, etc.
Company unknown	categorisation not possible

Table 1 and Figure 1 to Figure 4 show the breakdown of the employment 'destinations' of the survey respondents. (It is important to note that the percentages shown are based on the number of people who responded to the survey and are only indicative of the total picture.)

Table 1 GCCA Graduate Employment Statistics, Graduates 1996

	GCCA Surveyed Graduates				Percentage of GCCA Surveyed Graduates			
Employer	Geology	Metallurgy	Mining Engineering	**Total**	Geology	Metallurgy	Mining Engineering	**Total**
MCA Minerals	65	50	67	182	27%	50%	51%	38%
MCA Contractors	3	0	8	11	1%	0%	6%	2%
MCA Sub Total	**68**	**50**	**75**	**193**	**28%**	**50%**	**57%**	**41%**
Minerals	81	6	21	108	33%	6%	16%	23%
Contractors	1	0	2	3	0%	0%	2%	1%
Other Minerals Su	**82**	**6**	**23**	**111**	**34%**	**6%**	**18%**	**23%**
MCA & Other Mine	**150**	**56**	**98**	**304**	**62%**	**55%**	**75%**	**64%**
Other	31	23	12	66	13%	23%	9%	14%
Government	20	5	3	28	8%	5%	2%	6%
Research	17	11	8	36	7%	11%	6%	8%
Company Unknown	24	6	10	40	10%	6%	8%	8%
Other Sub Total	**92**	**45**	**33**	**170**	**38%**	**45%**	**25%**	**36%**
Total	**242**	**101**	**131**	**474**				

Note: (a) Respondents as a percentage of Total Graduates

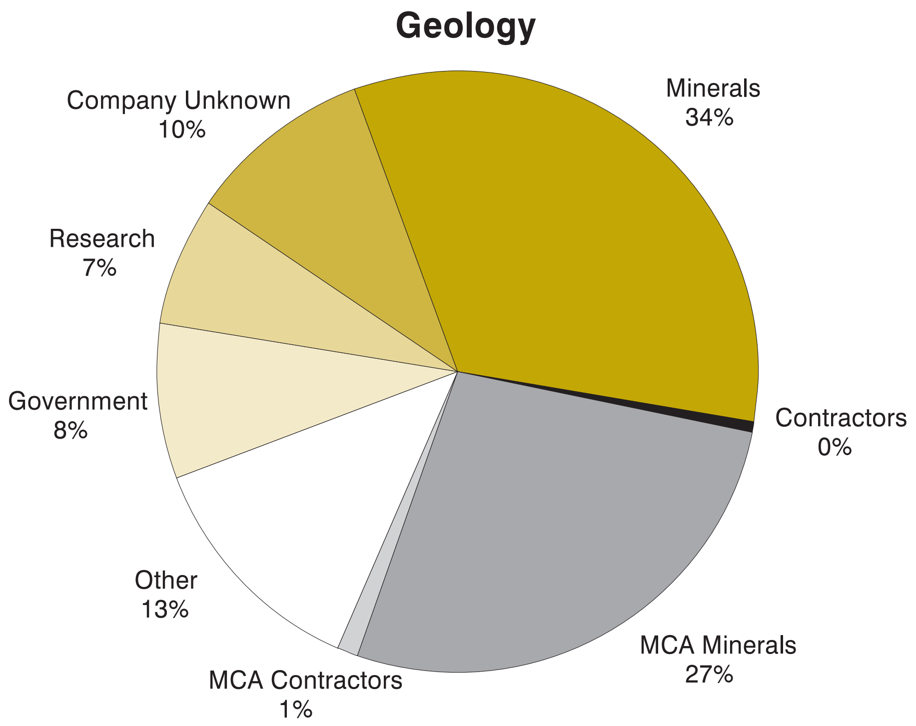
Geology	71%
Metallurgy	92%
Mining Engineering	68%

(b) The Western Australian Tertiary Education Taskforce Discussion Paper indicated that only 20% of 1994 geology graduates entered the minerals industry as compared to 62% in the 1996 survey. Anecdotal evidence indicates the figure of 62% is somewhat higher than general perceptions within the industry and universities. However, in assessing the validity of these figures it is important to note that during 1990-1995 the GCCA employment rates 3 months after completion of a geology degree ranged from 26% to 39% and in 1996 the figure for the same survey was 85.2%.

(c) the following points Classification of companies based on names only 20 characters long, GCCA limitation. All degree types from graduate diploma to PhD are included. Part-time and full-time employees included. Internal external and multimodal graduates included. Overseas and non overseas included. An overall total, independent of degree type and institution, has been used as discrepancies in the numbers of graduates by degrees type and university exit within the data. This is thought to be the result of other course graduates being employed in the roles of minerals professionals.

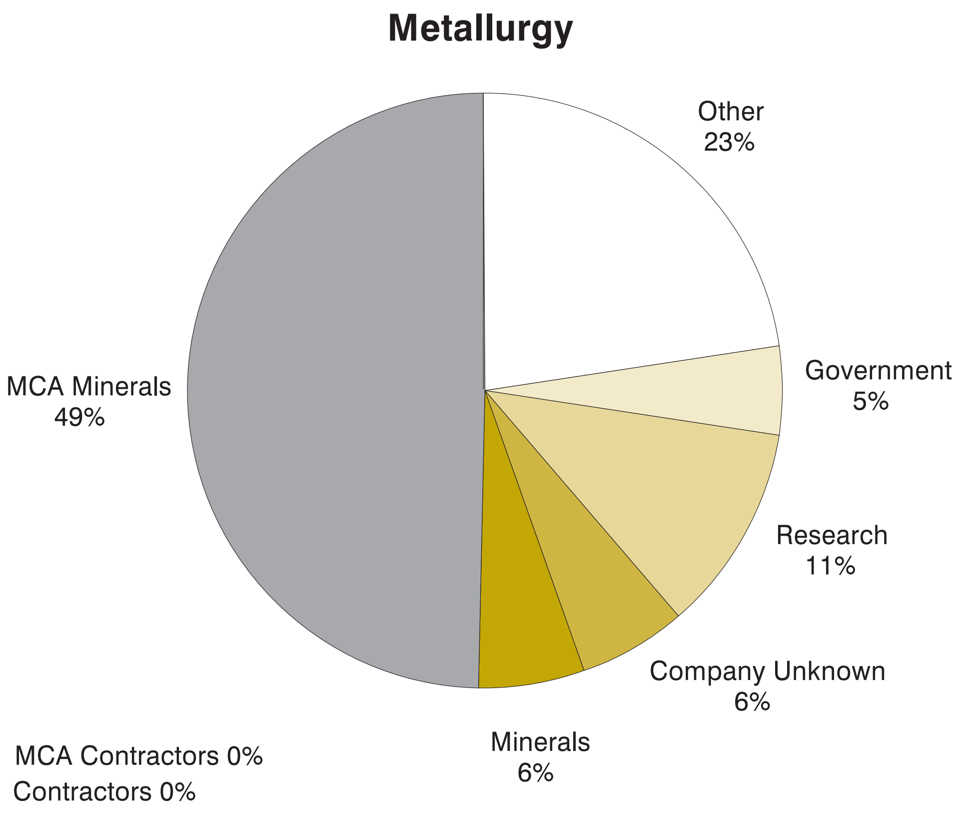
Source:GCCA and DEETYA Data.

Figure 1 Geology Graduate Employers by Type, 1996



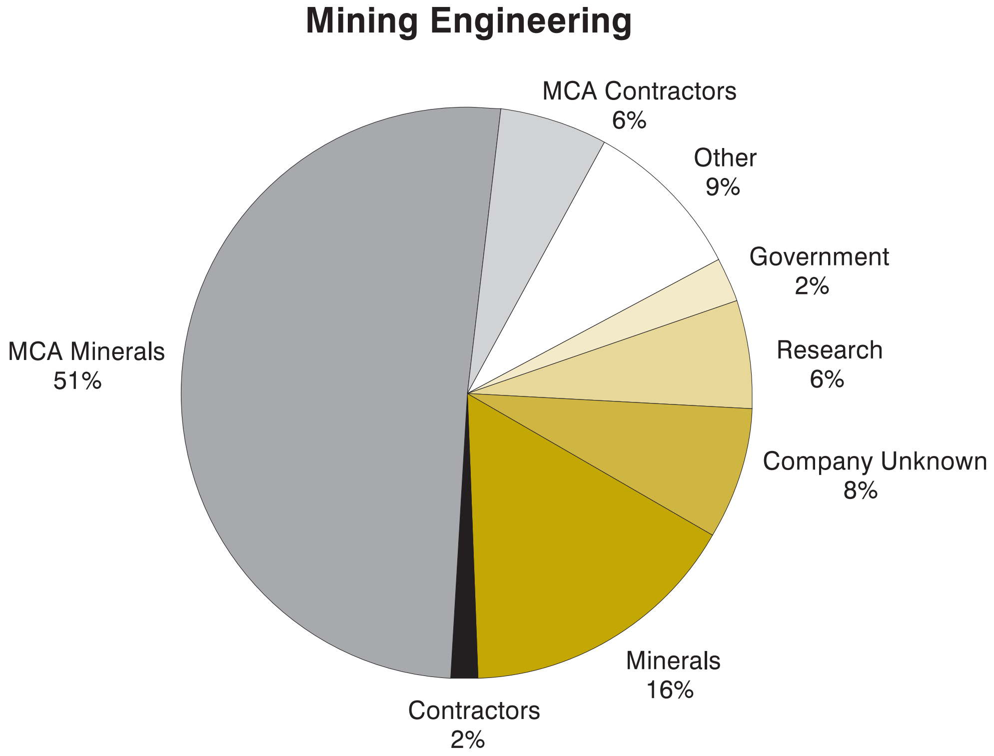
Source: GCCA Data.

Figure 2 Metallurgy Graduate Employers by Type, 1996



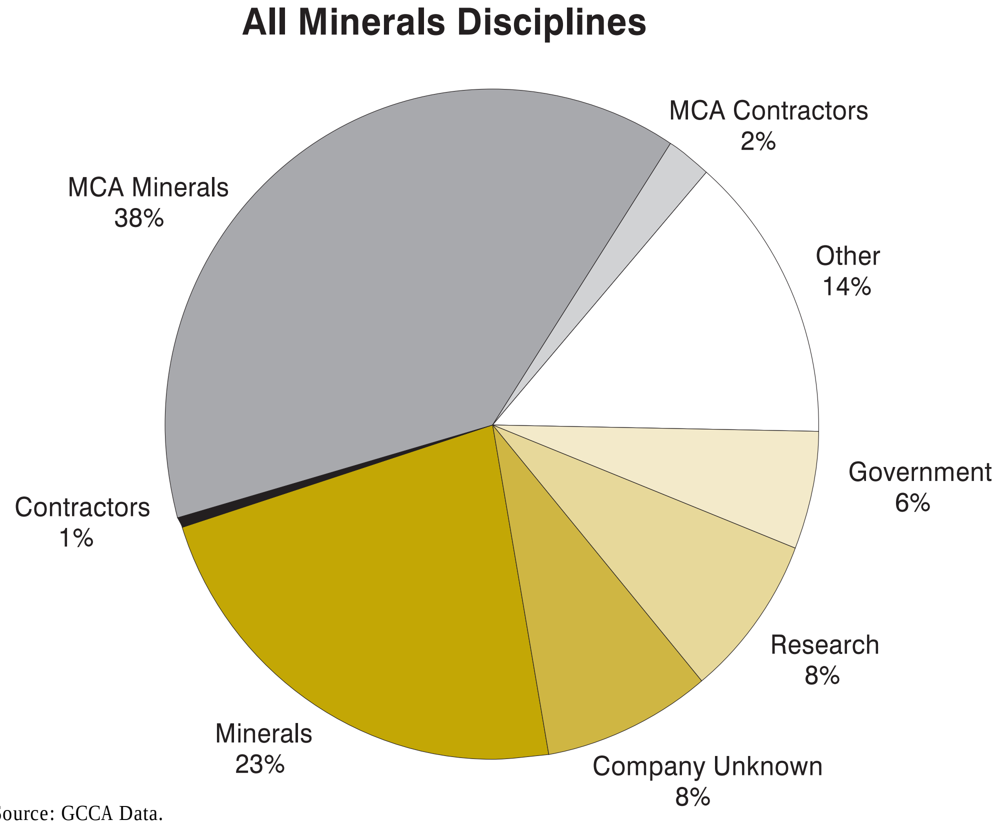
Source: GCCA Data.

Figure 3 Mining Engineering Graduate Employers by Type, 1996



Source: GCCA Data.

Figure 4 All Minerals Graduate Employers by Type, 1996



Source: GCCA Data.

These statistics show that the minerals industry dominates the employment of professionals in each of the three 'core' minerals disciplines. Note that while the owner/operator companies dominate mining and metallurgy (as indicated by the dominant percentage employed by minerals companies who are members of the Minerals Council of Australia), geoscience is dominated by minerals and minerals service companies who are not members of the Minerals Council. This may be due to a higher proportion of non-owner/operator or minerals service companies employing geoscience graduates as, for example, geological consultants.

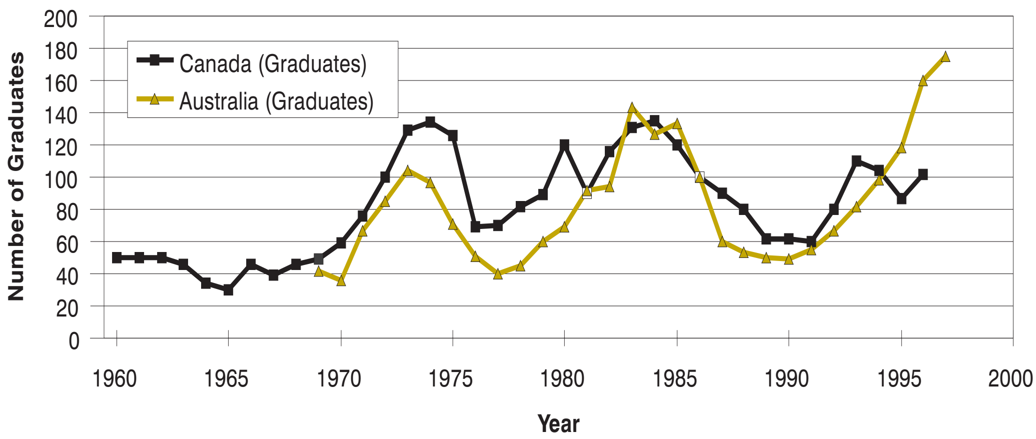
1.2 Cyclical Nature of Graduate Numbers

Note: The following section generally uses data for mining engineering graduates to infer general trends within all three of the minerals disciplines. Mining engineering graduation data was the only reliable data obtainable by the Taskforce that represented a nationally complete set over a substantial period.

If the health of minerals education is measured by the numbers of graduates, then minerals education is in the best health that it has been in for years. Numbers of graduates in all the core disciplines have been growing since 1988.

Over the last 20 years the trend in the numbers of minerals graduates has been one of steady, even rapid, growth characterised by significant peaks and troughs (Figure 5 and Figure 6). If other cycles are any guide, the number of graduates has more or less peaked and will begin to decline over the next few years. Obviously, only the future can prove this observation.

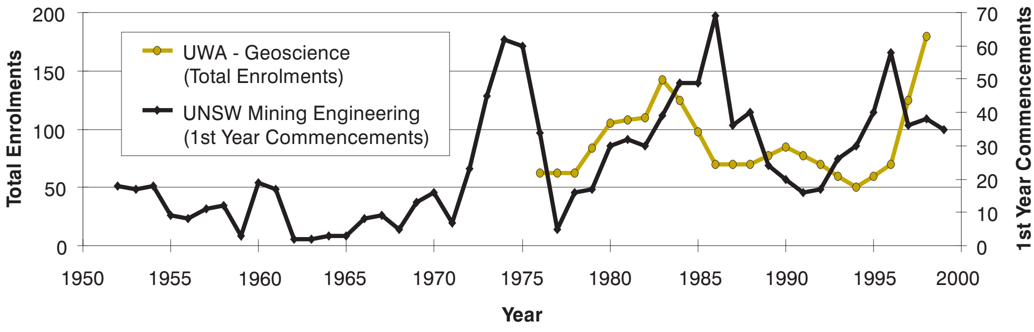
Figure 5 Mining Engineering Graduates - At a National Level



Source: Sen (1991)[1], and Brady (1997)[2]

1. **Sen GC** (1991), '*In Preparation for High Technology*', Proceedings Reliability, Production and Control in Coal Mines, The AusIMM, Wollongong, 2-6 September, p323-325.
2. Appendix F.

Figure 6 Cyclicality at the Departmental Level within Australia



Source: UWA[3] and Galvin (1996)[4].

Figure 5 and Figure 6 further imply that cyclicality is:

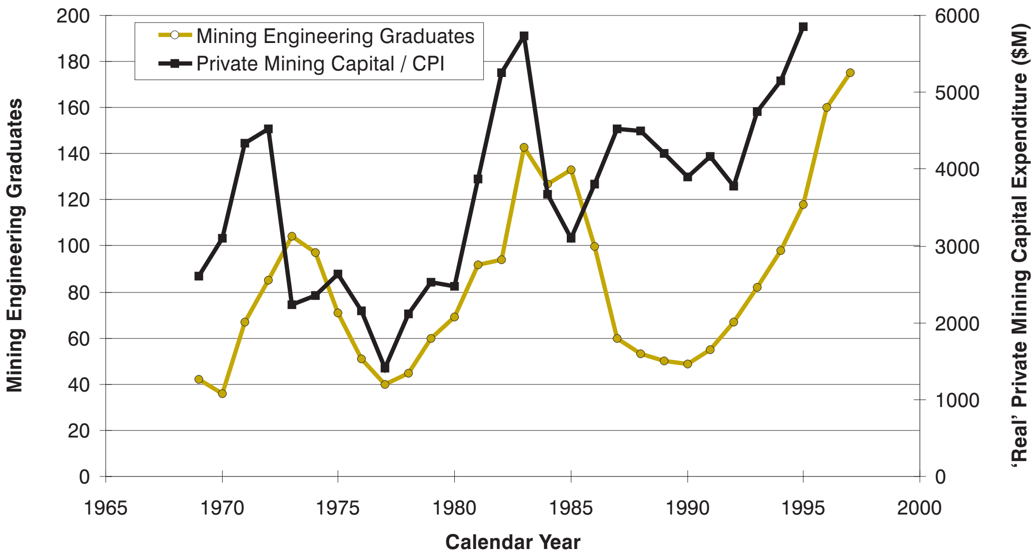
1. a characteristic of all minerals disciplines;
2. an international phenomenon; and
3. a long term characteristic going back to at least the 1960s.

What drives this cyclicality?

The key influence seems to be the industry's demand for graduates. In turn this is driven by the worldwide commodity investment cycle. This conclusion is supported by:

1. anecdotal evidence;
2. by the strength of the correlation between the industry's capital investment cycles and the numbers of mining engineering graduates (Figure 7) and
3. lastly, by the close correlation between the Australian and Canadian graduate outputs.

Figure 7 Australian Mining Engineering Graduates[5]



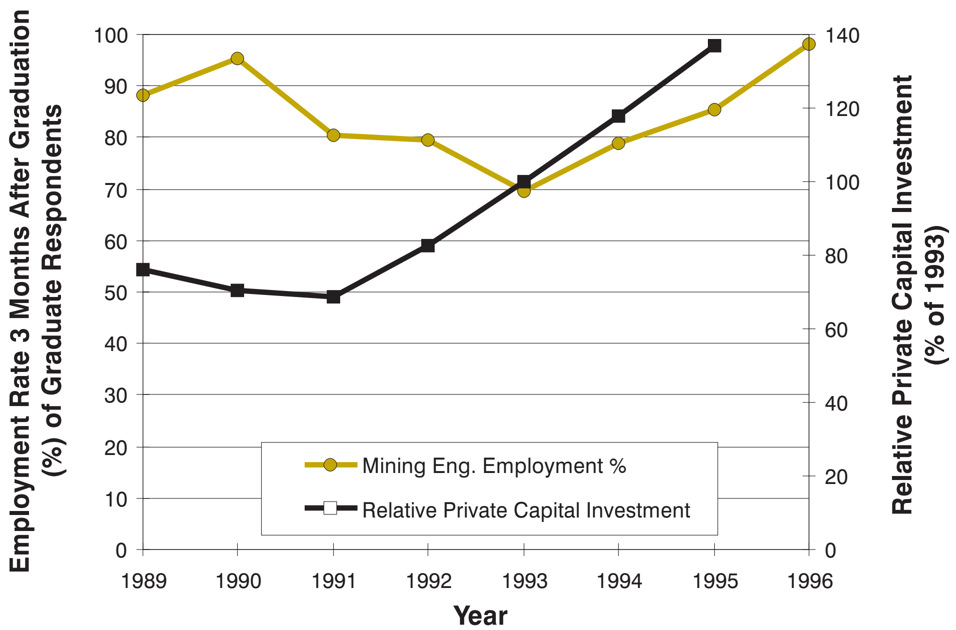
Note: Private Mining Capital Expenditure is divided by CPI to develop expenditure in 'real' terms
CPI reference value of 100 in 1990[6]

Source: ABARE (1996)[6], Sen (199)[1] & Lawson (1997)[7]

Whilst 'actual' demand appears to be the important driver of cyclicality, this does not fully explain the cycles. A second influence is probably 'perceived' demand. This would help explain the large slump in graduate numbers in the period 1986 to 1990 when minerals investment was, after a drop in 1986, fairly buoyant. The continued low graduate output during this period was despite a relatively strong demand for these graduates. The trend in employment rates of graduates (from 1989 to 1995) illustrates this. Figure 8 shows that employment rates in 1989 (the bottom of the slump in graduate numbers) were higher than in following years when the industry investment cycle was turning sharply upwards.

This suggests a frequent mismatch between real industry demand and supply of graduates, which is driven by students' perceptions of employment prospects. Figure 8 illustrates recent evidence, which points to an overestimation of demand for mining engineers. This evidence puts into question the industry mythology that there is always a shortage of minerals graduates.

Figure 8 Mining Engineers Employed (3 months after graduation) Versus Private Capital Investment



Source: GCCA Data and ABARE (1996)[6]

1.3 Decrease in the Overseas Supply of Minerals Professionals

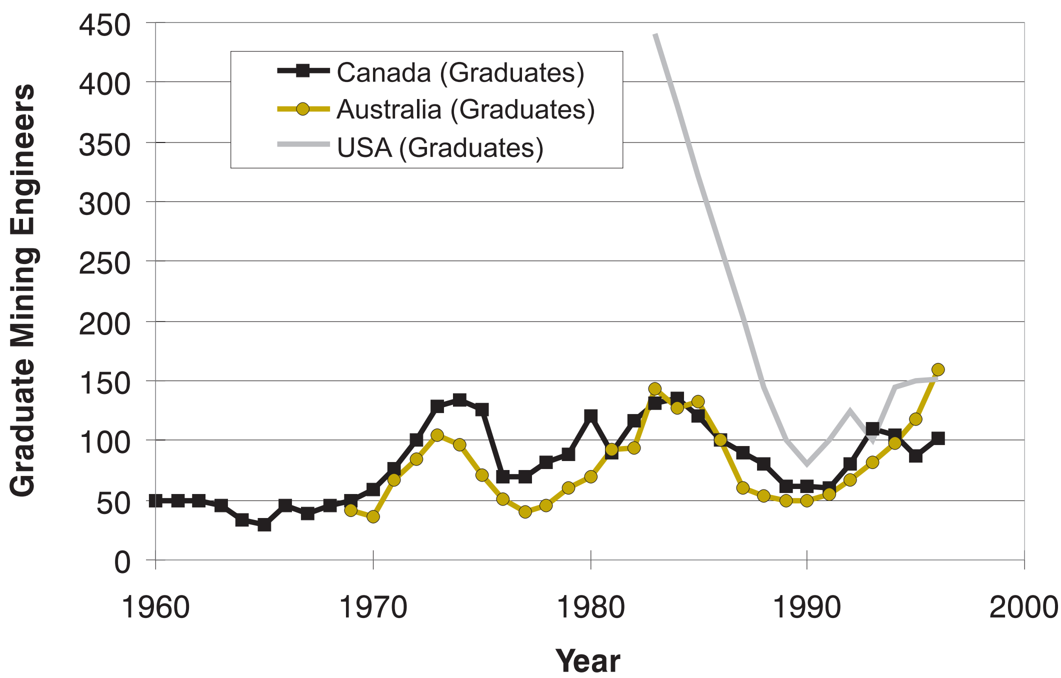
The cyclicality of the supply and demand for minerals professionals has led to periods of considerable undersupply and oversupply. At present, the case is one of undersupply and employment rates for mining engineers are at virtually 100%. In years past, such undersupply in times of high demand has typically been met from overseas. In recent years, this source of supply has become much less reliable. Figure 9 shows the extent of decline in the numbers of mining engineers graduating each year in the USA.

3. Personal communication received during informal stakeholder consultations.
4. **Galvin JM** (1996), '*UNSW Mining Engineering - Education for the 21st Century*', Address to the Annual General Meeting, Sydney Branch, The AusIMM, 21 October. [Need to check that this is the right Galvin Paper]
5. Derived from **Sen GC** (1991), **Lawson F**(1997) and **ABARE** (1996)
6. **ABARE** (1996), '*Australian Commodity Statistics 1996*', Australian Bureau of Agricultural and Resource Economics, Canberra.
7. **Lawson F** (1997), '*The Education of Professional Specialists for the Minerals Industry into the Next Century*', Proceedings of The AusIMM Annual Conference, Ballarat, 12-15 March, p315-319.

These observations are reinforced by Brady (1997) in Appendix F and Lawson (1997)[7] who states that "*there are real indications that the industry is being faced with a shortage of mining engineers and metallurgists now and that this will continue over the next few years, and possibly into the next century. In the past, Australian minerals companies have looked to the UK, New Zealand and South Africa to fill the gaps. All countries seem to be having the same difficulties in attracting good young people into minerals related courses, so this source of trained staff appears to be no longer available*". [2]

Whilst Lawson is no doubt correct about the decline in overseas supply, the prediction of a continuing shortage of mining engineers and metallurgists remains to be seen.

Figure 9 Mining Engineering graduates from the US, Canada & Australian Universities (partly from Hall, 1994)



Source: Brady (1997)[2]

2. Diversity of Minerals Education

What has emerged from the Taskforce's review of minerals education in Australia is a picture of a very diverse education sector, which comprises many centres of educational excellence. The diversity of minerals education in Australia is characterised by three elements:

1. size and coverage of minerals disciplines and the geographical spread;
2. the educational approach to the minerals disciplines; and
3. the linkages between minerals education stakeholders.

The first element of this diversity is in the size and coverage of minerals disciplines within the various universities. The large mining departments such as at the University of Queensland, the University of New South Wales and Curtin University dominate the minerals education scene in Australia. These departments produce large numbers of graduates in all three minerals disciplines. Nevertheless, there are many other centres, which are smaller and more limited in their educational scope. They include the many departments of geology (26 universities have such departments) and also, among many others, the minerals science course at Murdoch University and the metallurgical engineering course at Royal Melbourne Institute of Technology.

In addition to the diversity in the size of individual departments, there is also a geographical spread of minerals education within Australia. Every capital city in Australia (except Darwin) has a significant presence in at least one of the three minerals disciplines. They can lay claim to being the home of at least one, and usually several, excellent centres in minerals education. Brisbane, Sydney and Adelaide are home to mining departments as also is the regional centre of Kalgoorlie. Another regional centre, Townsville, with its Department of Geoscience at James Cook University, is an important contributor to the minerals education sector. The University of Tasmania in Hobart has one of the strongest minerals geoscience schools in Australia. Perth and Melbourne, despite not having a School of Mines, are both home to very strong metallurgical and geoscience schools.

The second element of diversity is in the educational approach and direction of the different universities. Geographical location and proximity to particular mining centres drive some of this diversity. In other ways, different centres of minerals education are influenced by particular industry relationships and by a variety of different commercial strategies. This in turn has led to the development of diverse strategies - some centres are focussing on vocational education, others on postgraduate education and still others on research and specialised technical education.

Despite this diversity, it is still true to say that universities covering all three disciplines dominate minerals education in Australia. This is, in part, because of the numbers of graduates they produce. Perhaps more importantly, they are the only centres which produce mining engineers. In a very real way, and even despite its narrow definition, many people identify ‘minerals education’ with the single discipline of mining engineering.

To illustrate these elements of diversity the following three sections summarise details describing the minerals education system of today. These descriptions are somewhat subjective and are not meant to be complete or representative of importance, they simply illustrate the diversity of minerals education in Australia.

2.1. Size and Geographical Diversity of Undergraduate Minerals Education

When considering the current state of tertiary education for the minerals industry, the situation varies significantly even between the three disciplines with which we are concerned. The following sections use statistics gathered for undergraduate education in the three disciplines to illustrate the significant size and geographical diversity within the minerals education system.

(a) Mining Engineering

There are currently six universities in Australia which offer the degree of Bachelor of Engineering (BE) (Mining) Table 2.

In addition, there are several civil engineering courses, which consciously offer ‘mining majors’. Most notable among these are the University of Sydney and the University of Melbourne. The University of Western Australia has recently introduced a degree in resources engineering which will produce graduates holding a ‘major’ in mining engineering.

Table 2 Mining Engineering Graduation and Full-Time Academic Staff Numbers

State	Annual Graduation No. Last 3 Yrs	No. of Dept.	Current F/T Academic Staff	Avg. Staff Per Dept.
Queensland	35	1	5	5.0
NSW and ACT	22	2	9	4.5
Victoria	13	1	3	3.0
Tasmania	0	0	0	0.0
South Australia	9	1	3	3.0
Northern Territory	0	0	0	0.0
Western Australia	25	1	10	10.0
Total	104	6	30	5.0

Note: the figure for 10 academics in Western Australia (at the Western Australian School of Mines) is due to the fact that, unlike the other courses, these academics teach the full four years of the engineering degree. Most other departments are effectively teaching only the last two or two and a half years.

Source: Lawson (1997)[7]

(b) Metallurgical Engineering

There are currently nine universities in Australia, which offer the degree of metallurgy or materials, Table 3.

Table 3 Metallurgy/Materials Graduation and Full-Time Academic Staff Numbers

State	Annual Graduation No. Last 3 Yrs	No. of Dept.	Current F/T Academic Staff	Avg. Staff Per Dept.
Queensland	15	1	**2	2.0
NSW and ACT	*~49	2	19	9.5
Victoria	59	3	23	7.6
Tasmania	0	0	0	0.0
South Australia	8	1	6	6.0
Northern Territory	0	0	0	0.0
Western Australia	29	2	11	5.5
Total	~160	9	61	6.7

* No data were obtained from Wollongong.

** This number may be the extractive metallurgy staff only. Once again, six departments have six or fewer full-time academic staff to mount the course. Six staff with minerals/metallurgy specialisation are necessary to give an adequate coverage and to undertake graduate level teaching and research.

Source: Lawson (1997)[7]

In addition, there are several chemical engineering courses, which consciously offer 'metallurgy majors'. Most notables among these are the University of Newcastle, the University of Sydney and the University of Melbourne. As discussed earlier, the University of Western Australia has recently introduced a degree in resources engineering which will produce graduates holding a 'major' in metallurgical engineering.

(c) Geology

There are currently around 26 (of 37) universities in Australia offering degrees in geology and related disciplines, Table 4 illustrates statistics on 23 of these departments.

Table 4 Geoscience Graduation and Full-Time Academic Staff Numbers

State	Annual Graduation No. Last 3 Yrs	No. of Dept.	Current F/T Academic Staff	Avg. Staff Per Dept.
Queensland	70	3	32	10.6
NSW and ACT*	~ 95	7	~58	8.2
Victoria	116	5	56	11.2
Tasmania	15	1	21	21.0
South Australia	82	3	26	8.6
Northern Territory	**17	1	3	3.0
Western Australia	68	3	24	8.0
Total	~463	23	~220	9.6

* Data not obtained from Sydney or Wollongong
** Only two years of graduates
Source: Lawson (1997)[7]

2.2. Educational Approach to Minerals Courses

The different 'educational approaches' adopted by different institutions are described by considering separately:

1. undergraduate education;
2. postgraduate education; and
3. TAFE

2.2.1. Undergraduate Education

This section describes the range of course structures for the three disciplines of mining engineering, metallurgical engineering and geological sciences. It is worth noting here that both mining and metallurgical disciplines predominantly require a four year Bachelor of Engineering degree qualification - West Australian School of Mines and Murdoch University are the main exceptions. Geological qualifications are different in that they are science degrees and therefore require a three year undergraduate degree and an optional fourth year honours degree. The main exception to this is the BE (Mining Geology) offered at West Australian School of Mines.

It is also worth noting that, increasingly, double degrees are available in conjunction with all minerals courses. Double degrees range from Arts/Engineering to Science/ Engineering. They typically require five years undergraduate study.

The course structures described below have been developed in a number of ways. History plays a significant part in setting the basis for a course structure. As in any institution, there is ongoing evolution in the course structure - even so, by implication, the historical starting point for the course is very important. Equally important in determining course structure is the philosophical and industrial environment in which the course operates. Some courses will focus on more 'fundamental' subjects others will focus on more vocational subjects. This can be a reflection of the university itself, the history of the course, the influence of the surrounding industry or of particular individuals. A similar situation applies when it comes to strengths in particular subject matter. One metallurgical engineering course may be strong in minerals treatment by leaching, another course strong in minerals treatment by flotation, yet another may have a particular strength in pyrometallurgy.

A general observation is that all course structures have established compromises because of the difficulty of covering all relevant subject matter equally well. The larger the course, the easier it is to offer a wide range of well-presented subjects.

(a) Mining Engineering

There are a number of models for mining engineering undergraduate courses, which provide distinctive approaches. We will describe five of these:

1. University of Queensland;
2. Curtin University (West Australian School of Mines);
3. University of Western Australia - Resources Engineering;
4. University of Sydney - Civil Engineering; and 5. University of South Australia.

All of these courses are four years full-time.

University of Queensland

Year 1: all subjects are common to all engineering disciplines in the university. Students select their engineering discipline prior to Year 2.

Year 2: coursework remains mostly general and includes subjects which are not directly related to minerals. There is a mining field trip in the second semester.

Year 3: mining-specific subjects are offered such as ventilation and mining geomechanics. Students must also take a number of minerals processing subjects.

Year 4: subjects continue to be mining specific and include mining economics and design. There is a compulsory thesis. Subjects in mining management and environment are part of the curriculum.

The mining engineering course is very closely allied to the metallurgical engineering course so the mining students are given the opportunity to understand the metallurgical field. Geological subjects are not offered much beyond Year 2.

Curtin University (West Australian School of Mines)

Curtin differs from Queensland in a number of ways. Firstly, it offers a Bachelor of Science (BSc) (Mining). This is a 3-year degree. The BE (Mining) degree requires another year on top of this degree. Curtin also differs from Queensland in emphasis. There are more prescribed courses which cover a wider range of subjects, with a greater focus on general management content. The metallurgical emphasis is reduced in comparison to Queensland.

University of Western Australia

In 1998, the University of Western Australia plans to offer a course in Resources Engineering. This allows a mining major to be taken. It remains to be confirmed whether this mining major would be recognised as an appropriate qualification for a first class certificate of competency under the WA Mines Act (indications are that it will be). Resources Engineering will provide majors in mining, minerals processing, oil and gas, process engineering and offshore engineering.

Those students pursuing the mining major will emerge as ‘project engineers’ for the mining environment. The final three semesters include mining-specific subjects such as geomechanics, mine design and ventilation. A thesis is required for an honours degree.

University of Sydney

Until the late 1980s, the University of Sydney offered a BE (Mining). This was discontinued following a decline in interest and financial pressure. The Civil Engineering course now offers 'majors' in environmental engineering and geomechanics. Core courses contain a good coverage of structural engineering subjects. Subjects specific to underground mining - such as ventilation - are absent and there is no exposure to the metallurgical processing area.

University of South Australia

Recently the University of South Australia has moved from having a highly specialised BE (Mining) to a more general degree. The subjects offered in the first two years of the degree are common with a number other engineering degrees offered by the University. The sorts of subjects offered are similar to the University of Queensland but with a stronger emphasis on the geosciences.

(b) Metallurgical Engineering

As for mining engineering, there are a range of distinct models for metallurgical engineering undergraduate courses. Most of the courses offer grounding in both primary and secondary metallurgical engineering although the emphasis in most courses tends to be on primary metallurgy. Four course models are described below:

1. University of New South Wales;
2. Murdoch University;
3. University of Melbourne; and
4. Royal Melbourne Institute of Technology.

University of New South Wales

The BE (Metallurgy) is offered through the School of Materials Science and Engineering. It is a four-year full-time course although it can be done via a six year part-time program. The first two years are common to the ceramics and materials engineering courses and include a range of fundamental subjects in the engineering and materials science disciplines. In third year the students must choose between process metallurgy (primary metallurgy) or physical metallurgy (smelting etc). The course requires a fourth year thesis.

Murdoch University

Murdoch University offers a BSc (Minerals Science). This is a three year degree course, with Honours as an optional fourth year. The three year degree has a bias towards 'analytical science' as opposed to 'engineering' subjects and is focussed on primary metallurgy. There is an emphasis on chemistry throughout the course. The course may be completed externally. The Honours year is dominated by a field-based research thesis (usually related to an aspect of chemistry-based metallurgical extraction).

University of Melbourne

The University of Melbourne offers a BE (Chemical) which is typical of such courses throughout Australia. The course focuses very strongly on general process engineering and chemical principles producing graduates suitable for a wide range of different processing industries - eg. petrochemicals, food, pharmaceutical and minerals processing. The course requires a fourth year thesis. Apart from one subject - Minerals Engineering - there is very little specific focus on minerals processing other than that which the student chooses. Graduates from such chemical engineering courses effectively have formal grounding only in primary metallurgy techniques.

Royal Melbourne Institute of Technology

Royal Melbourne Institute of Technology offers a BE (Metallurgical Engineering). This course has a strong focus on chemistry in the first year with the following three years covering a range of primary and secondary metallurgical engineering courses. Royal Melbourne Institute of Technology has a stronger coverage of pyrometallurgy than any other metallurgy course in Australia. The course has a stronger bias towards practical experience than some others - in the third and fourth years, students are required to do industrial experience reports and a range of business management topics are offered.

(c) Geological Sciences

In contrast to the mining and metallurgical disciplines, there is a wide range of specialisations available within most undergraduate courses in geological science. In contrast, also, is the fact that whereas mining and metallurgical have substitutes in the civil and chemical engineering disciplines, there is no such substitute for geological sciences.

Because of this range of specialisations and the lack of a substitute discipline, the structure of geological sciences courses tend to cater for a wide range of undergraduate specialisations. In this section, we will describe three models for undergraduate courses - two of these exist side by side at Curtin University.

Curtin University - West Australian School of Mines

The West Australian School of Mines offers a BE (Mining Geology) and a BSc (Mining Geology). This course is very much focussed on covering a broad range of subjects, which will give a geologist a good grounding across all the various specialisations. Exploration, geophysics and tectonics are all covered as are geological mapping, economic geology and analytical methods. The subjects are mostly prescribed throughout the course.

Curtin University - Bentley campus

The Curtin School of Applied Geology offers a BSc(Applied Geology). This course is structured into four main streams - Economic Geology, Petroleum Geology, Hydrogeology and Special Topics in Geology (palaeontology etc). Students tend to specialise only in their third (and fourth) years. The course is characterised by an emphasis on field work and laboratory work. The Honours year is dominated by a field-based research project.

University of Tasmania

The Geology Department at the University of Tasmania is structured into six main streams. Students can select one of these streams virtually from Year 1 although it is only in Year 3 that selection of a stream will make much difference to coursework. The streams are Geology (a general course covering all other specialisations but in less depth), Economic Geology, Environmental Geology, Geophysics, Geochemistry and Geological Engineering (this is BSc/BE double degree course which allows the student wide latitude in selecting geology and civil engineering-based subjects over a five year degree).

The general structure of the course is a broad coverage of basic principles in the first two years followed by a specialisation in the third year. The Honours year focuses on a field-based research project.

2.2.2. Postgraduate Education

In this section, the range of postgraduate coursework that is available in the areas of mining engineering, metallurgical engineering, and the geological sciences is briefly described.

Table 5 Estimate of Postgraduate Graduate Completions (1996)

Course Type	Geoscience	Mining	Metallurgy
Masters/Diploma completions	50	17	21
PhD completions	59	4	27

Source: Dorricott (1996)[8]

These numbers suggest that a minimum of about 10% of graduates from any particular course will continue on to study for a higher degree.

Postgraduate education can have different purposes:

1. conversion courses for non-minerals graduates, this will focus mostly on basic minerals content and concepts;
2. specialist coursework designed to instil deep knowledge of a specialist area; and
3. short courses designed to give minerals professionals additional specialist knowledge in a particular area.

As discussed below the domain of short course provision lies predominantly with the AMF. Coursework to achieve a formal degree qualification, either for discipline conversion or specialisation, is still largely the preserve of individual universities. Most university minerals departments offer such postgraduate coursework, as do some research centres. It is worth noting that research centres tend not to become involved in non-research postgraduate education. Increasingly, universities are offering minerals-related postgraduate coursework through campus-based centres.

Anecdotal evidence suggests that there is an increasing trend for graduates to return to university and undertake further studies while they are employed.

(a) Providers of Postgraduate Education

Postgraduate minerals education is offered by:

- university departments;
- university- based research centres; and
- the Australian Minerals Foundation.

Minerals disciplines in most universities offer Masters and PhD's by research. A range of universities also offer masters degrees, which focus on professional development rather than research. This is a growing aspect of university education primarily because of industry's needs and the general social change to undertake general education and develop specialist skills later whilst employed.

8. **Dorricott M** (1996), '*Mining Engineering: An Overview*', Australian Journal of Mining, June, p36-38.

The various research centres also offer supervision for research based Masters and PhD's. At this level, there is greater collaboration between providers than at the undergraduate level. The motivation behind this is primarily the benefits that can be gained from cooperative research.

The Australian Minerals Foundation is the main provider of short course work in Australia.

The AMF was founded in 1970 in response to a perceived need for a national program of continuing professional development coursework for the resources industry (including the minerals and petroleum sectors). The reason behind the establishment of the AMF is summarised by Pollard (1993) "*Very few opportunities existed at that time for professionals in industry to participate in short courses or seminars. .. The major objective of the AMF was to 'provide training and refresher courses to professional and other staff' in the minerals and petroleum sectors.*"[9]

Industry support was crucial in setting-up the AMF.

The AMF's role in the petroleum sector is principally in the geoscience area.

There are over 87 corporate members of the AMF. This does not include membership from their various subsidiary companies.

The AMF focuses on providing short courses, ranging in length from one day up to one week. These are generally offered in capital cities or major mining centres. The coursework is often offered by or in conjunction with a university or university staff. However, the course development and presentation is equally often done by resources industry consultants and occasionally by practitioners.

The Vision for the AMF is: "*The Australian Minerals Foundation will be the premier provider of professional development programs, and scientific, technical and business information to the Australian and international minerals and petroleum industries.*"

The AMF sees itself doing this, in part, by identifying, designing and delivering continuing education programs. Whilst not carrying out these functions itself, the AMF plays the role of driving and facilitating this process.

In more recent years, the AMF has structured development pathways for the roles of geoscientist, mining engineer and metallurgist in the minerals industry.

Some examples of postgraduate coursework are given below. These examples are intended to provide some indication of the sorts of activities undertaken at different universities.

(a) Mining Engineering

Key Centre for Mines - University of NSW

The Key Centre for Mines at the University of New South Wales offers a Masters and Graduate Diploma in Mining Management. The Department of Mining Engineering at the University of New South Wales offers a Master of Applied Science which is linked with the Masters and Graduate Diploma courses offered in the Key Centre for Mines.

Western Australian School of Mines

Curtin University's Western Australian School of Mines offers a variety of masters programs for people in the mining industry. It offers a:

- Master in Mining Geomechanics;
- Graduate Certificate in Mining Geomechanics;
- Master in Minerals Economics;
- Graduate Certificate in Minerals Economics;
- Graduate Diploma in Mining;
- Graduate Certificate in Mining;
- Post Graduate Diploma in Mining & Minerals Technology; and
- Post Graduate Diploma in Metallurgy.

In addition Western Australian School of Mines offers Masters and PhD by research in Mining, Metallurgy, and Geology.

(b) Metallurgical Science & Engineering

GK Williams Cooperative Research Centre for Extractive Metallurgy

The GK Williams Cooperative Research Centre is one of a number of Centres in which staff from the Department of Chemical & Metallurgical Engineering are involved. Its postgraduate degrees include Graduate Diplomas, Masters by research or coursework, and PhD's. The main research interests at the GK Williams Centre are minerals processing, extractive metallurgy, and secondary metallurgy, base metal flotation, surface engineering of metals and ceramics, and metal fabrication.

Ian Wark Research Institute - University of South Australia

The Ian Wark Research Institute has as one of its focuses on particle and material surfaces as well as the application of chemistry and chemical engineering in the area of minerals processing. In conjunction with a number of companies the Institute has been developing a Master of Applied Science that allows employees to work on research based projects in their work place. This program also caters for full-time students who wish to do Masters or PhD's by research.

(c) Geological Sciences

W H Bryan Mining Geology Research Centre

The W H Bryan Mining Geology Research Centre's aims include enhancing the links between the University of Queensland and the mining industry through high quality collaborative research and education. The W H Bryan Centre also has programs for postgraduate fellows and graduates. It offers a number of postdoctoral research fellowships. At the PhD and MSc level, the Centre offers study in the areas of geostatistics, mine planning and design, geophysics, GIS and resource assessment and Minerals Economics.

Centre for Ore Deposit Exploration Studies

The Centre for Ore Deposit Exploration Studies based at the University of Tasmania offers studies at masters and PhD level. The Centre has a Graduate Diploma in Economic Geology, a Master of Economic Geology and a Master of Exploration Geoscience. These courses are taught in an extended short-course format over a period of two weeks by academics and industry leaders. In addition the Centre offers a Master of Science (Economic Geology) and PhD's in Geology or Economic Geology by research.

9. **Pollard DM** (1993), '*Continuing Education in the Australian Minerals Industry*', Monograph 19, The AusIMM, Melbourne.

Key Centre for Teaching and Research in Strategic Minerals Deposits

The University of Western Australia's Key Centre for Teaching and Research in Strategic Minerals Deposits offers masters and PhD's by research. In addition it also offers a part-time Master of Science in Ore Deposit Geology and Evaluation which is directed at people working in industry. For those students who have not completed a BSc with Honours, an MSc Preliminary is available to provide the skills and knowledge to enable them to undertake the MSc course.

2.2.3. TAFE

This review has not dealt with the TAFE system. However, there is no doubt that the TAFE sector is a vital part of minerals higher education. Indeed, the issue of the administrative and funding linkages between the TAFE system and the university system is becoming more critical and would seem likely to change in the coming years. It remains to be seen whether this change takes the form of amalgamating the two sectors, as per the CAE/university amalgamations of 1988.

Many universities have already developed formal linkages with various TAFE's and this no doubt will continue.

In this section, a selective overview of the sector is offered.

TAFEs in five states offer courses which are aimed at training technical support staff for minerals and petroleum sectors. Courses cover both geoscience and mining. New South Wales and Queensland are strong in the areas of mining whereas South Australia and Western Australia seem to focus more on the geosciences. The South West Regional College of TAFE does offer a Diploma of Engineering and Mine Surveying which is aligned with the mining and general engineering sectors. In addition TAFE's in all states offer the business sector the opportunity to develop training programs that fit in with its particular workplace needs. A number of students that complete their TAFE qualifications find their way into universities. This is facilitated by the credit transfer system between TAFE and the Universities. The view among TAFE staff is that the traditional body of students that once enrolled at TAFE now tend to go to the universities because of the massive increase in the number of places that universities have available.

Below is a summary of the sorts of courses offered by TAFE's in several states.

TAFE South Australia

Onkaparinga Institute takes about 20 students into its Associate Diploma course in Geoscience and Land Information Management Systems. In 1998 it will change its offering to a Certificate (6 months) and an Associate Diploma (18 months) in Geoscience.

The Certificate in Geoscience Field Practices covers a range of topics, which include things like first aid, 4x4 driver training, drilling, and sampling, computing, geochemical sampling techniques, geophysical instrument operation, and field camp operations. The Associate Diploma covers issues specifically to do with petroleum, specific geology/ mine software, basic geology subjects and mathematics.

The Certificate and Associate Diploma in Land Information Management Systems is a more general area of study with students covering mine surveying techniques that include on-site training.

A small number of students (about 6%) have gone on to do a University degree.

Over the last few years the Onkaparinga Institute has experienced a drop in the quality of school leaver students enrolling in its courses. This, they see as a direct result of the drop in the entrance level by Universities. Nevertheless, half of their students are mature aged trades people who are looking for a career change. At this stage they have no trouble filling the places they have available.

TAFE Queensland

TAFE Queensland offers a wide range of courses for people working in or interested in working in the minerals industry. Qualifications range from Advanced Certificate and Associated Diploma course to Certificate courses. Areas covered include:

- Mining Electric's;
- Underground Mining;
- Engineering (Surface or Underground Mining);
- Metalliferous Mining; and
- Explosives and Blasting.

TAFE's in Western Australia and Australian Capital Territory

These offer courses equivalent to those offered in South Australia, with similar numbers of students being enrolled.

TAFE New South Wales

TAFE's in New South Wales also offers a range of qualifications from Advanced Certificates and Diplomas through to Certificates and Statements of Attainment. Qualifications can be attained in the areas of geoscience and mining. They include:

- Geotechnical Field Operations;
- Coal Mining (Deputy, Undermanager, Manager);
- Coal Mining Induction;
- Coal Mining, Open-cut (Manager);
- Drilling Operations;
- Mining Explosives;
- Mining Studies;
- Mining, Small Scale; and
- Quarry Management.

TAFE and the Minerals Industry

The courses are primarily directed to the needs of non-professional staff that are currently working in the minerals industry and it is not clear how many go on and do further study at university level. Clearly TAFE is providing good training for support staff, thus providing the sort of resources that enable professional staff to focus more on more advanced work rather than routine work. Furthermore, they could play a stronger role in the provision of highly skilled technical assistants to various aspects of the minerals industry.

2.3 Linkages

The list of universities given in the previous section, gives some indication of the existing diversity of tertiary education for the minerals sector. It however, does not, give any indication of the linkages between these universities and these disciplines. Understanding these linkages is essential to understanding how the minerals tertiary education system currently 'hangs together'.

The linkages and 'clustering' take three main forms:

1. within universities. These linkages typically take the form of a 'school of mines' or a 'faculty of minerals'. The linkages can also be via Centres and Institutes. All such structures provide coordinating umbrellas to bring together different departments and fields of study;
2. between universities. These are typically initiatives involving sharing, between universities, techniques and resources for teaching and research. Mostly these are between individuals and are informal partnerings although there are some more formal arrangements; and
3. between universities and industry. The catalyst for many of the university/ industry linkages have been the CRC and Key Centre programs of the Federal Government. There exist many other individual company linkages to specific universities.

A recent report entitled 'Knowledge-based Cooperation: University-Industry Linkages in Australia',[10] has highlighted the rapid growth since the 1980s in all the various linkages described above. The driving forces identified by the report are a combination of government funding incentives, financial pressures and the move towards a research environment which is focussed on particular industries or technology groups and is crossing previously well-demarcated scientific boundaries. As the report points out, this trend has received a lot of encouragement from the Federal Government. Government funding is now provided to encourage a wide range of cooperative ventures. The CRC program, Key Centres and ARC collaborative grants are examples. This trend is typical across the spectrum of university activity - and the minerals disciplines are no exception.

The sections below describe in a little more detail some of the existing linkages.

2.3.1. Within Universities

Most universities are structured into between 8 and 12 'Faculties' (or sometimes 'Divisions'). Faculties consist mostly of 'Departments' (or sometimes 'Schools' and 'Departments'). This structure is based on an approach to organisational structure based around separately focussing on the fundamental intellectual disciplines. In minerals terms, this may mean that, at any particular university, mining engineering may come under the 'Engineering' faculty because it is a discipline which focuses on the application of a range of disciplines in an engineering environment. Geology, on the other hand, may reside in the 'Applied Science' faculty because it comprises a more fundamental scientific body of knowledge which has applications in many areas.

This 'fundamental discipline' approach to structuring universities has necessarily become less rigid as technology and scientific understanding have developed and university research has moved from 'fundamental' to industry-focussed. This is because what used to be separate bodies of knowledge (eg. geology, physics and electrical engineering) are now becoming increasingly interlinked especially in applied research directed at industrial applications.

While most universities have modified, and continue to modify, their structures to reflect these developments, there remains a continual need to establish 'Centres'. These Centres exist to create formal and managed linkages between 3 or 4 separate departments which must combine in order to deal with a common set of technical, theoretical or, as is often the case, commercial issues. Over time, a Centre may become a new Department (or Faculty) or it may be replaced by yet another set of linkages.

The commercial reasons for establishing a Centre is to develop an effective means of providing a 'one stop shop' for an industry group. These Centres often have as one of their primary reasons for existence the role of coordinating the activities of several Departments in providing consulting and professional development for an industry group.

As a result of this, at first glance, a university's structure can look like a mess. Once an understanding is gained of the reasons for the structure, it becomes apparent that in an academic environment such complexity is inevitable if intellectual life is to avoid becoming too narrowly focussed and commercial relationships are to be effectively managed.

Minerals-related examples of these linkages for teaching, research and consulting within universities are:

Sir James Foots Institute of Minerals Resources - University of Queensland.

Founded in 1990, this provides the formal linkages between the Department of Mining, Minerals and Materials Engineering, the JKMRC and the Department of Earth Sciences.

Faculty of Minerals and Petroleum - Curtin University.

This is a very recent (1997), and slightly different, approach in that Curtin has changed their basic organisational structure to create a separate Faculty for minerals and petroleum-related activities within the university. This Faculty will formally draw together the West Australian School of Mines, the School of Applied Geology and the University's involvement in resources-related CRC's and other Centres. It represents a departure from the 'fundamental discipline' approach to university organisational structuring.

2.3.2. Between Universities

There are relatively few formal linkages designed to coordinate teaching and postgraduate research activities, other than in the research area (where CRC's have provided a clear incentive). There is no doubt many reasons for this. One reason is the way in which universities are funded by the Federal Government. This funding is based on student numbers. The more 'full-time equivalents' that a course can attract, the more money comes into the university and the relevant Faculty (funding section Appendix B and C). Cooperative agreements regarding undergraduate teaching often mean some agreement on the sharing of 'full-time equivalents'. This has traditionally created difficulties. Another reason for this absence of closer working relationships is common to many areas - relinquishing control (in the absence of a higher coordinating authority as exists within universities) requires good relationships and those relationships are often not in place between universities. This is, of course, a situation not unique to universities. Lastly, there is the more practical problem of working out exactly how universities can go about working together to create a higher quality and more efficient teaching and research environment.

Nevertheless, there are examples of working relationships between universities. A few are described below:

10. **Turpin T, Aylward D, Garrett-Jones S, Johnston R** (1996), '*Knowledge-based Cooperation: University-Industry Linkages in Australia*', Evaluations and Investigations Program 96/17, Higher Education Division, Department of Employment, Education, Training and Youth Affairs, Commonwealth of Australia, 1996. http://www.deetya.gov.au/divisions/hed/highered/eippubs.htm

University of New South Wales and Newcastle University.

Those studying for BE (Mining) at Newcastle University complete the first two years of their degree at Newcastle before transferring to University of New South Wales to complete their degree.

University of Western Australia, University of Tasmania, James Cook University, University of Adelaide and Monash.

There is significant interaction between the geology-related disciplines of these universities. This interaction takes the form of encouraging honours students to consider doing postgraduate work at other universities, exchanging expertise for MSc courses and student supervision. University of Western Australia and Curtin are considering establishing a joint industry advisory board for their geological disciplines.

2.3.3. Between Universities and Industry

Several programs funded by the Federal Government have greatly encouraged the development of linkages between universities, CSIRO and industry. Of these, probably the most important is the Cooperative Research Centre (CRC) program. Another is the Key Centre program.

The CRC program has provided a financial incentive for joint research between universities, industry and CSIRO. Continuing financial support under the scheme is dependent on relevant, high quality research being undertaken and being financially supported by industry.

The program has led to research cooperatives being formed across the country. Some examples are: CRC for Australian Minerals Exploration Technologies. This involves the School of Earth Sciences at Macquarie University and the Department of Exploration Geophysics at Curtin. Other members of the cooperative are AMIRA and CSIRO; AJ Parker CRC for Hydrometallurgy. This involves Murdoch and Curtin Universities as well as CSIRO and the WA Department of Minerals and Energy; and CRC for Black Coal Utilisation. This involves the University of Newcastle, University of New South Wales and University of Queensland as well as CSIRO, BHP, Peabody Resources, Coal and Allied, ARCO and other mining concerns.

There are 9 CRC's in the resources sector, some of them involving only one university. AMIRA plays the main industry role in some of these.

The Key Centre program has a different intent and structure. The Key Centres are formed in order to promote industry and universities working together on educational and work experience programs at the tertiary level as well as on research projects. Key Centres generally only formally operate between single universities and industry supporters, with funding dependent on continued industry support as well as on their quality of teaching and research.

There are many other interactions between university and industry - some are formal, some are informal. The opportunity exists at all levels for the establishment of industry advisory boards, similar to those used by some universities. At the individual level, there are company sponsorships, scholarships, vacation work programs and so on. One of these programs is the University of Sydney's Industry Scholarships in Engineering. Under a new initiative, scholarship holders in chemical engineering will spend the first semester of their fourth year working with the scholarship provider doing work to contribute to their final year thesis. Other programs have been set-up by individual companies with individual universities. MIM, for example, has had a very long association with the University of Queensland minerals teaching and research areas.

Appendix E
Minerals Tertiary Education - Attraction

Attracting highly capable people into the industry will be an essential success factor for the minerals industry in the years to come. This appendix discusses issues associated with the attraction of people into minerals education.

What, in fact, are the decisive influences on a student's choice of course? This is an area where identifying the influences is difficult. The main influences, in no particular order, are:

1. parents, and friends, preferences and advice;
2. career interests and academic strengths of the individual;
3. employment and remuneration prospects and working conditions;
4. the proximity of the university to the individual's home;
5. the prestige of the university and the course;
6. the attractiveness of the industry; and
7. the ease of entry and the cost of the course.

These are not mutually exclusive influences and, in a later sections, some of these will be discussed in more detail.

Before doing this, however, minerals courses should be put into their context within the university system as a whole.

1.1. Minerals Courses Within the Wider System

There are about 244,000 student commencements every year within the Australian university system. Of these, perhaps 800 are in the minerals disciplines of geoscience, mining engineering and metallurgical engineering.

Table 1 shows the total and percentage of course commencements for the broad course categories for the years 1985 and 1995:

From Table 1 it can be seen that the engineering courses enrol about 6.4% of graduates - or 15,000 graduates per year. Physical sciences enrol about 34,000 graduates per year.

Physical science and engineering commencements show a slight or no increase in proportion to the total over the period. The main movements have been towards the health-related and commerce-related studies and away from education and arts. (The graduate numbers in the health area have been boosted by the fact that nursing is now a degree qualification.)

Table 1 Percentage of Higher Education Course Commencements, by Field of Study

Field of Study	1985 Commece-ments	1985 % of Total Commencements	1995 Commence - ments	1995 % of Total Commencements	1995-1985 Difference in %
Agriculture	2,675	1.9%	4,636	1.9%	0.0%
Architecture	2,311	1.7%	4,781	2.0%	0.3%
Arts	35,657	25.6%	57,183	23.4%	-2.3%
Business	25,158	18.1%	53,814	22.0%	3.9%
Education	30,209	21.7%	32,346	13.2%	-8.5%
Engineering	8,907	6.4%	15,557	6.4%	0.0%
Health	8,223	5.9%	27,984	11.4%	5.5%
Law	3,047	2.2%	8,978	3.7%	1.5%
Science	20,035	14.4%	33,965	13.9%	-0.5%
Vet Science	361	0.3%	445	0.2%	-0.1%
Non Award	2,568	1.8%	5,113	2.1%	0.2%
Total	139,151	100.0%	244,802	100.0%	

Source: DEETYA (1996)

Within the engineering field, minerals graduates comprise about 5% of engineering. In the physical sciences field, geoscience graduates comprise about 4% of physical science.

Minerals courses are, therefore, small fish in a big pond. This has two implications for attraction of students into minerals courses:

1. minerals courses will be very much influenced by broader trends within tertiary education; and
2. minerals courses have a plenty of opportunity to adopt niche strategies for attracting the best students.

1.2. Broad Trends Within Tertiary Education

Some of the broad trends within tertiary education which are of importance in attracting students into minerals courses are:

1. the competition for students is increasing amongst all universities and departments;
2. fewer students seem to be attracted to studying physical sciences and engineering;
3. women, in particular, seem to avoid physical sciences and engineering; and
4. students from a rural background are less likely to undertake tertiary studies than are students from an urban background.

1.2.1. Increasing Competition for Students

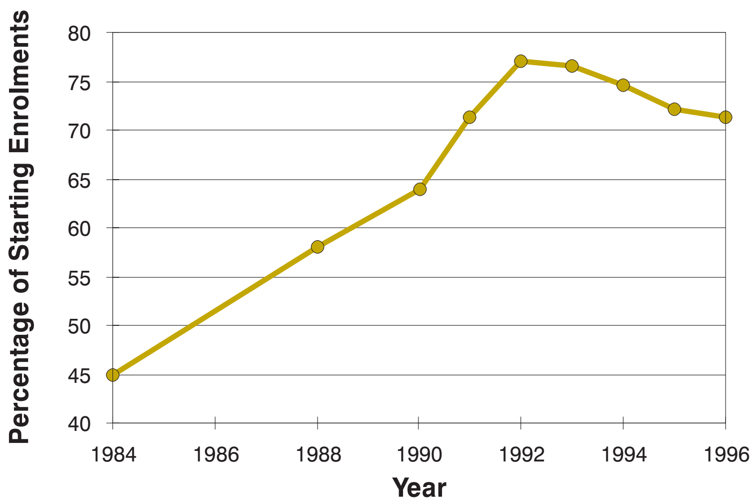
The last decade has seen the number (and diversity) of opportunities for grade 12 students almost double from around 150,000 places in 1986 to just short of 300,000 places in 1996. Current predictions indicate that this number will continue to grow, albeit at a slower rate, as we approach the new millennium[2]. Undergraduate student load targets (places within tertiary institutions) grew by approximately 6,000 places in 1997, and will grow by a further 4,000 places in 1998 and another 3,000 places in 1999. This represents an increase of around 3.7% (or 13,000 places) between 1996 and 1999.[2]

Against this background of an increasing number of university places, demand for higher education, as indicated by applications to tertiary institutions, has fallen for the last three consecutive years and the eligible university student population is also declining.[2]

According to information produced by the Australian Bureau of Statistics,[3] the number of births and deaths (and hence the number of school-aged children) in Australia has remained relatively constant for the last fifteen years. Given that 70 percent of undergraduate students are drawn from the 17-24 year old population, projections based on birth and death rates suggest that there will be a 3% decline in the number of university-aged people between 1996 and 1999[2] and that the number of university-aged people (17 to 64) will continue to decline into the twenty-first century Lawson, Table 2.

Retention rates for grade 12 secondary school students have also been declining over the last three years, Figure 1. After strong growth during the last decade, which saw retention rates improve from 45% of the secondary school population in 1984 to more than 75% in 1992, the proportion of students continuing to grade 12 has decreased by almost 4% to 71.3% between 1993 and 1996.

Figure 1 Retention Rates of Year 12 Secondary Students



Source: ABS (1997)[4] and AVCC (1997)[5]

1. **Department of Employment, Education, Training and Youth Affairs** (1996), '*Higher Education Students - Time Series Tables*', Higher Education Division, Commonwealth of Australia, October.
2. **Department of Employment, Education, Training and Youth Affairs** (1997), '*Higher Education Funding Report for the 1997-99 Triennium*', Commonwealth of Australia, March.
3. **Australian Bureau of Statistics** (1996), '*Year Book Australia*', Number 78, Canberra.
4. **Australian Bureau of Statistics** (1997), '*Schools Australia*', ABS Catalogue No. 4221.0, Commonwealth of Australia, Canberra.
5. **AVCC** (1997), '*Submission to the Review of Higher Education Financing and Policy*', http://www.deetya.gov.au/divisions/hed/hereview/submissions/A/AV-CC1.htm

Table 2 Projected Number of University Aged Persons, Lawson (1997)

Year	Total	Male	Female
2000	1,776,550	913,550	863,000
2004	1,770,200	911,600	858,600

Note: This data is corrected for the number of estimated deaths in the various age groups.
Source: Lawson F (1997)[6]

Combined with the steady birth rate, these trends in the secondary student population would seem to indicate the tertiary education sector can expect a steady or slightly declining supply of eligible students for a slightly increasing number of student places in the immediate future. The implications of this trend in a market-driven environment are obvious.

With an ever increasing number (and diversity) of alternatives for school leavers, it will become more and more difficult for 'unpopular' courses to attract the best students, a situation which is already a concern for many courses. This factor is summarised by Richardson (1997): *"As 'massification' of higher education proceeds, an important part of the summer ritual is the bewailing of falling standards as universities drop the cut-off TER score for entry to their less popular high-volume courses."*[7]

In dealing with this issue it is important to note that an inter-institution and inter-discipline competition for highly capable students certainly exists. The secondary school system has kept pace with providing the quantity of students needed for the rapid expansion of the higher education system. However, competition for highly capable students has been exacerbated by the secondary school system's inability to develop an increasing quantity of students genuinely capable of achieving high standards in tertiary education. The quality issues that are arising from the massification of tertiary education are, in part, a result of the quality issues in secondary schooling that have developed from the rapid increase in the retention rates to year 12 (1984 to 1992).

The Taskforce believes that the government should consider the role and relationship of secondary schooling to tertiary education and initiatives be considered that continually increase the percentage of students leaving secondary school that are adequately prepared to enter tertiary education and are capable of high standards in their professional education.

While the above suggestions will help the system at a fundamental level the minerals industry must consider solutions within the current framework. If the minerals industry expects a higher quality of people to enter courses suitable and capable of minerals industry careers, the industry must compete with other disciplines and improve the attractiveness of a minerals career. The implications and mechanisms for dealing with attracting students are discussed in later sections of this appendix.

1.2.2. The Low and Declining Appeal of Physical Sciences and Engineering

The attraction of students into the minerals industry is heavily influenced by the wider issue of attracting students into engineering and science since most students for these courses are drawn from the wider engineering and science populations. The health of general engineering education is, therefore, of critical importance to the health of minerals-related courses. For more than a decade, employers within the engineering professions have been concerned about the declining proportion of engineering graduates per head of population. The Review of Engineering Education *Changing the Culture* states that"*…by comparison with other developed countries Australia* *produces fewer engineering graduates per head of population. ... It is clear that for Australia to maintain a position among the world's most developed countries, its engineering activity must increase in terms of both quantity and level of technology*."[8] In response to these concerns, the 1988 Williams Committee[9] adopted the target of raising the number of engineers to 1% of the work force by the year 2000 and recommended interim enrolment targets for each year to achieve this objective. To date, it appears that new enrolments in engineering courses have been approaching and in fact exceeded these targets. Nevertheless, Australia's international ranking in terms of engineering graduates per head of population remains at 13th behind such countries as Taiwan and South Korea, who have almost three times the proportion of engineers, Germany, Finland and Denmark, who have more than twice the proportion, and the United Kingdom and Ireland.

"*Current predictions indicate that the Australian population will have increased by 15% by the year 2000. Unless the current rate of enrolments in engineering also increases dramatically, our international ranking will be even worse than the current poor level.*"[10]

The current imbalance which exists between the high demand for students and the over-supply of university places affects many courses across most disciplines of study. However, the engineering disciplines suffer an additional problem - that of a generally negative public perception. A 1996 survey of young peoples' attitudes towards science and technology found that technology was seen as "*alienating people, causing stress and dehumanisation*"[11] . These 'anti-technology' perceptions have had a significant impact on the number of school students electing to study pre-requisite subjects for a career in science or engineering. While the numbers of students continuing to grade 12 is much higher than it was a decade ago, the proportion of those students studying chemistry and physics at the grade 12 level has been steadily declining, from a 'high' of around 5.5% in 1986 to the current low levels of around 4% in 1996 Figure 2.

As might be expected, science applications to universities have also fallen over these years, Table 3. According to Lawson6, this trend is likely to continue, unless active measures are taken to change the views of secondary school teachers and students.

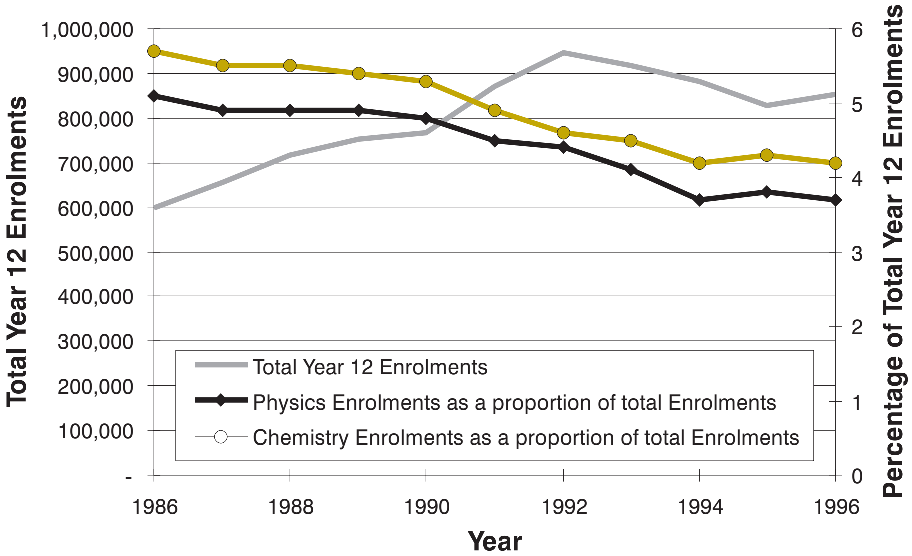
Table 3 Science Applications to Universities

Year	Percentage Drop in Science Applications to Universities
1993-1994	5.13%
1994-1995	2.81%
1995-1996	2.61%

Source: Senator the Hon Amanda Vanstone (1997)[12]

6. **Lawson F** (1997), '*The Education of Professional Specialists for the Minerals Industry into the Next Century*', Proceedings of The AusIMM Annual Conference, Ballarat, 12-15 March, p315-319.
7. **Richardson J** (1997), '*Must the TER get Vanstoned?*', Newspaper Article, 7 August 1997, The Australian.
8. **The Institution of Engineers, Australia** (1996), '*Changing the Culture: Engineering Education into the Future*', Institution of Engineers Australia, Australian Council of Engineering Deans and Academy of Technological Sciences and Engineering, Canberra.
9. **Caldwell G, Johnson R, Anderson DS, Milligan B and Young C** (1994), '*Report on the Impact of Discipline Review of Engineering*', Evaluations and Investigations Program, Department of Employment, Education and Training, Commonwealth of Australia, Canberra.
10. **Rice** (1996), '*Submission to the IEAust Review: Changing the Culture*', quoted from 'Changing the Culture' Reference 9.
11. **ASTEC** (1996), quoted from '*Changing the Culture*' Reference 9.
12. **Senator the Hon Amanda Vanstone** (1997), '*Lower Science Applications Reflect Continuing Trend*', Media Release, V7/97, 19 January 1997, DEETYA, http://www.deetya.gov.au/minwn/vanstone/v719197.htm

Figure 2 Enrolments in Physics and Chemistry as a proportion of total Year 12 Enrolments in all Courses



Note: Total enrolments data is for subjects (not students).
Source: ABS Data requested by the Minerals Council of Australia.

Clearly the ability for science and engineering to compete among other disciplines for quality students affects the quality of students entering minerals science and engineering courses. However, the minerals industry is not the only party responsible for improving community perceptions of science and engineering professions. It is, however, essential for the minerals companies to improve the perceptions of these professions within the minerals industry.

To achieve this the minerals industry must continue to support and increase the level of support to broad engineering and science initiatives such as the Changing the Culture: Engineering Education into the Future's recommendation:

"School and community liaison must be enhanced so that more students choose engineering.

That IEAust, ACED and ATSE with industry assistance, in parallel with changes to engineering education, develop strategies to increase the number of school students seeking a career in engineering, such strategies to include:

- *setting up engineering-related networks in high schools for students and parents;*
- *contributing to school curriculum committees and education boards;*
- *reviewing the resources for, and positively influencing the teaching of mathematics, science and technology in primary and secondary schools so that students are better prepared for, and are more predisposed towards science and engineering careers;*
- *providing more work experience opportunities for school students;*
- *developing and supporting the production of relevant informative material in printed and electronic format; and*
- *developing communication with school teachers and career counsellors and those who are being educated for these occupations."*[8]

To a significant degree the minerals industry has programs in place that achieve this recommendation. These programs relate primarily to attraction of students into the minerals disciplines and are discussed in the later sections of this appendix.

1.2.3. Decline in Rural Versus Urban Retention Rates of Secondary Students

Australia is essentially an urban society; almost two thirds of our population live in capital cities, and more than half of those live in Sydney and Melbourne alone. The location of mines outside urban centres means that the majority of school students have little or no exposure to the minerals industry which makes it unlikely that they will even consider a career in the minerals industry, let alone rate minerals courses as desirable options.

Remote Australia has for many years been a successful source of students for the industry. Many students studying minerals-related courses have grown up in remote locations, either in farming communities or in mining regions. It is, therefore, a major concern that the growth in retention rates to grade 12 for secondary students in rural and remote communities has been considerably lower than for students from urban areas, Table 4.

Given the industry's reliance on students who are familiar with, and have a preference for, remote lifestyles it is an imperative for industry initiatives to improve our attractiveness as employers by addressing the declining participation of rural and remotely-based students. One of the significant concerns preventing more rural and remote secondary students from entering minerals tertiary courses is the financial pressure of firstly paying for tertiary education and secondly paying for relocation, accommodation and living expenses to attend a university providing a minerals course. To address these issues the minerals industry must increase its level of funding for student support, given that these financial pressures are a dominating factor in the immobility of Australian students.

Similarly, it should be an imperative of Government to address the equity issues resulting from the imbalance of retention rates for year 12 students by developing student support services that encourage the mobility of Australian students.

This is not to suggest, however, that the industry should ignore the, as yet mostly untapped, supply of urban students who might be encouraged to consider careers in the minerals sector. Given these students make up almost two thirds of the student population, the industry severely limits the number of available students by failing to adequately market opportunities to this group. Over the last few years, efforts to increase awareness of career opportunities amongst this group have achieved some success, as is discussed later in this appendix.

Table 4 Year 12 Retention and Completion Rates: 1989 to 1995

	Estimated Completion %						
Location	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Urban	62	63	71	70	71	71	69
Rural	60	60	68	67	67	64	61
Remote	47	47	57	58	58	58	52
All students	60	61	69	69	69	68	67

Source: DEETYA (1996)[13]

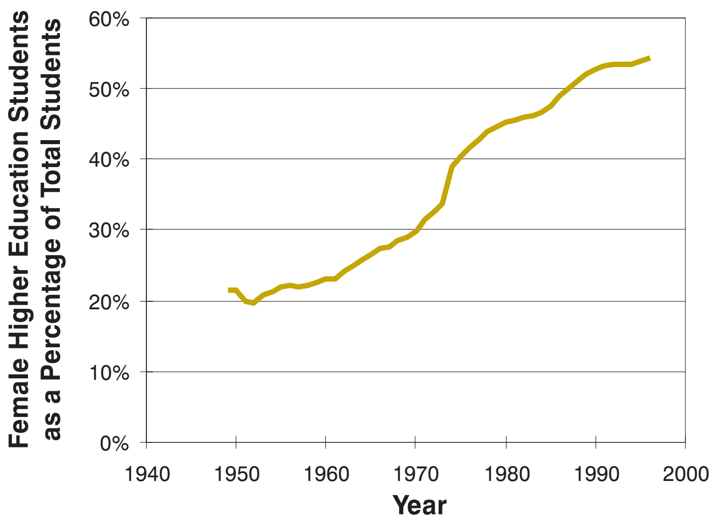
1.2.4. The Lack of Appeal to Women of Physical Sciences and Engineering

The retention rate of young women to grade 12 has been steadily increasing over the last decade. Proportionally more young women than young men are continuing their education to grade 12. In 1995, approximately 78% of young women continued to grade 12 as opposed to only 67% of young men. Moreover, young women now make up more than half (52.3%) of the tertiary education population, Figure 3.

Despite these significant increases in their participation in higher education, women presently make up less than 5% of the professional engineering work force, which stands in stark contrast to their increased participation in almost all other professions. In 1988, the Williams Review of engineering warned industry of the danger of continuing to ignore the low participation rates of women: "*The engineering profession is impoverished by this failure to attract females*"[9]

The Williams Review recommended many initiatives aimed at improving the participation of women in engineering education and set a target of 20% participation for 1997. While there has been some improvement in the numbers of women enrolling in engineering education, Table 5, at the current rate of progress, the targets set by the Williams committee are unlikely to be achieved.

Figure 3 Female Higher Education Students as a Percentage of Total Students



Source: DEETYA (1996)[1]

It should be noted at this point that the aggregate data presented in Table 5, does not show the wide variations in female enrolments which exist across universities and between disciplines. Chemical and environmental engineering, for example, attract a much larger number of female students than do mining or mechanical engineering. Nevertheless, given that women now constitute an increasing proportion of the tertiary sector, the engineering profession and the minerals industry can no longer afford to ignore the barriers preventing their participation in the industry.

Table 5 Proportion of Female Student Enrolments in Engineering

Year	1989	1990	1991	1992	1993	1994	1995
% Female enrolements	10.1	12.0	12.3	14.6	13.0	13.6	13.3

Source: DEETYA.

The minerals industry needs to actively support Recommendation 1 of the *Changing the Culture: Engineering Education into the Future*, in particular section 1.2 of this recommendation.

"Engineers must receive a broader education and be drawn from a wider range of backgrounds.

1.1 That in consideration of the major changes taking place in all aspects of society and requiring urgent attention, the increasingly critical responsibilities facing the engineering profession, and that expectations of governments and the community, engineering schools ensure that engineering graduates are equipped to:

- *understand the social, economic and environmental consequences of their professional activities;*
- *communicate effectively to government and the community on engineering issues and take a leadership role; and*
- *contribute as effective members of multi-disciplinary teams.*

1.2 That engineering educators address the serious social imbalance in students seeking to enter the engineering profession, in particular the low proportion of women, by:

- *recognising and valuing the alternative outlooks that women and minority groups may bring to engineering through different interests, background knowledge and work and family roles;*
- *developing education programs that recognise and are connected to community needs and issues; and*
- *supporting an understanding that engineering is interesting and relevant to a wider section of the community and to a diverse range of potential students."*[8]

13. **Department of Employment, Education, Training and Youth Affairs** (1996), '*Annual Report 1995-96*', Commonwealth of Australia, Australian Government Publishing Service, Canberra.

In supporting this Recommendation, one of the main initiatives of this Discussion Paper recommends the resourcing and development of new and innovative course design and delivery for a network of undergraduate centres, flexible pathways and postgraduate coursework. In the process of developing this coursework, consideration should be given to ensure that the course material is conducive to addressing the social imbalance of students seeking to enter the minerals professions. Following from this initiative, minerals companies need to develop recruitment processes that are representative of the community and ensure fair selection, independent of gender and culture.

1.3 Implications for the Minerals Industry and Minerals Education

There is not too much that the minerals industry or those involved in minerals education can do to reverse or influence these broader trends. As the discussion has highlighted, these trends are the outcomes of much wider social and policy issues. What is important is that the industry and educators understand these trends and work with them.

Given the size of the minerals sector, a huge increase in minerals enrolments can be achieved by changing the preferences of only a small percentage of the total number of students.

The Taskforce believes that the main influences to focus on are:

1. achieving truly world’s best educational standards and creating exciting and challenging jobs for graduates. This is the best means of attracting the best students;
2. bringing the course to the attention of the best students. This means raising the profile of minerals courses in the main student population and competing for students. The ability of the parent university to attract highly capable students is critical in this respect;
3. fostering a better understanding of the minerals industry within the wider community; and
4. redesigning entrance criteria so as to attract those students for whom minerals careers will be most suitable.

1.3.1. Achieving Educational Excellence

There is little doubt about the ability of Harvard University to attract a large number of highly capable students. This simple fact should be the initial focus for improving the attraction of the best students into the minerals industry. This, of course, must go hand-in-hand with an industry which is able to challange and to satisfy the ambitions of the best graduates.

The first step, then, in attracting more and better graduates, is to achieve world class educational standards and exciting job prospects for the graduates. Lack of progress in these areas will mean that, over time, all other initiatives become window dressing.

1.3.2. Fostering a Better Understanding of the Minerals Industry

The attraction of the best students is influenced by numerous factors affecting perception on the minerals industry:

- cyclical employment opportunities;
- narrow career options among other industries;
- remote locations;
- environmental; and
- etc.

Fundamental issues associated with minerals education such as the cyclical nature of employment combined with the narrow career options are dealt with elsewhere in this report.

The remaining perceptions are based on the way the companies within the minerals industry operate. Some examples are the environment, which is continually being addressed by improving the mining operations and remote locations, which will remain an unchangeable mode of operation for mines. To address the issues arising from these community and student perceptions requires a better informed community.

Research conducted by Roper Research on the perception of industries in the United States of America indicated that, in the early 1990s, the minerals industry had the least favourable public perception of any industry polled. These included, in decreasing order of favourability, Retail, Food, Telephone, Automotive, Life Insurance, Pharmaceutical, Oil and Gas, Chemicals, Liquor, and Tobacco.

This would seem to be a desperately low position from which to be making improvements. However, the same study also found that, when researchers excluded those polled who didn't know anything about mining, the industry's favourability improved to 67% (from around 25%). The 'don't knows' represented almost half of all respondents and were the largest group of 'don't knows' for any industry.[14] These results, although based on a North American population, provide encouraging evidence that efforts to improve community awareness in general, and student awareness in particular, will result in more favourable perceptions of the minerals industry.

Student Perceptions of the Minerals Industry

It is widely accepted that minerals courses are considered by the general student population to be 'unpopular'. To a large extent, this perception has arisen from the indisputable fact that relatively few students (less than 1% annually of the total student population) elect to study a minerals-related courses. While there is little empirical evidence of the perceptions that high school or university students hold of minerals industry professions specifically, a fairly strong body of anecdotal evidence suggests that students, particularly at the high school level, are either unaware of the existence of opportunities in the industry, or hold very dim views about the industry.

In the words of one commentator, the minerals industry is seen as "*a despoiler of the environment, a group who take aboriginal land and which is situated in inhospitable areas*." [8]

14. **Prager S** (1997), '*Changing North America's Mind Set about Mining*', Engineering & Mining Journal, February.

In addition to evidence extrapolated from the Roper research, there is considerable evidence from within minerals courses in Australian universities and from other industry-sponsored programs, that increasing student exposure to the minerals industry not only improves student awareness of the opportunities available within the industry, but also encourages greater participation in minerals-related courses. Three initiatives, each targeting students at different stages of their education, are worth particular attention.

(a) Minerals Council of Australia - National Education Program (NEP)

The National Education Program, which began in February 1996, is a long term industry-education partnership designed to raise the level of understanding of the Australian minerals industry among school students. One aspect of the program targets educators at the primary and secondary levels and aims to equip them with the necessary information to incorporate minerals related topics within their classroom teaching. This is largely achieved by tours of mining and minerals processing sites, geoscience short courses, seminars and workshops.

Student activities are dominated by the highly successful in-schools program whereby specially trained teachers employed by the Councils and Chambers, deliver a range of curriculum focussed presentations to class groups upon request. These presentations provide the basis for further follow-up work on the topic by the classroom teacher.

(b) Industry-sponsored summer schools - Australian Student Mineral Venture

The Australian Student Mineral Venture (ASMV) is an Australia-wide initiative of the AusIMM Education Endowment Fund designed to market professional careers in the minerals industry to senior high school students and to assist them in their career decision-making. Funding for the venture is provided by the AusIMM Education Endowment Fund and is supported by substantial contributions from employers in the industry as well as fees from participating students.

The ASMV exposes students from Grades 10, 11 and 12 to an intensive program of mine and plant visits, lectures, hands-on exercises and interaction with industry professionals during a 12 day summer program. Although the program has only been running for two years, early indications suggest that the ASMV is encouraging Grade 12 students to enrol in minerals industry courses.

(c) Department Marketing Initiatives - University of New South Wales

Students and lecturers from the University of New South Wales' mining department participate in an extensive program of school visits, open days and other career-oriented functions, the purpose of which is to market minerals industry opportunities to secondary school students. In conjunction with the university's Student Recruitment Centre, the AusIMM and the Minerals Council, the department promotes the course through a coordinated program of events, both at the university and in schools throughout NSW. As part of the program, students visit their own and other high schools to talk about career opportunities in mining and their own experiences of the course, and lecturers make regular school visits, to talk with teachers and students.

Most university departments participate in similar programs, however, the success of this program, which has seen new student enrolments grow from around 28 in 1995, to more than 60 in 1997, has been largely attributed to the enthusiastic involvement of the students themselves in promoting the course. This personal approach appears to have been particularly successful with young women, who made more than half of all enquires to the department at this year's university open day.

1.3.3. Creating Access to the Best Students

Creating access to the best students means offering scholarships and other student support, ensuring that the course is given a high profile within the university and ensuring that the university attracts the best students.

(a) The Role of Scholarships

In an environment of greater competition for quality students, courses that can offer financial incentives, in the form of HECS reimbursement, scholarships and student support will have an advantage in attracting students. While financial incentives are generally not a key determining factor for career choice, they can be a deciding factor. If the minerals industry is going to compete with other industries for quality students, attraction mechanisms such as these will be required.

Scholarships in one form or another have historically played a significant role in the attraction of students for the minerals industry, especially in the years prior to 1973, when students were required to pay for their education. The philosophy regarding scholarships changed quite significantly after the advent of a predominantly government-funded education in 1973 when financial pressures on students were significantly reduced, and changes in the employment climate began to undermine the notion of a ‘job for life’. Where once an employer could be confident of a return for the investment in a student, the benefits of offering scholarships were much less reliable, and far less tangible. Consequently, the purpose and value of scholarships changed from an essential source of student funding to a token amount of money awarded for outstanding academic performance.

With the re-introduction of students fees, in the form of HECS, the level of student contributions is reaching its highest levels since the 1950’s. The introduction of HECS, the gradual increases in HECS contribution and the implementation of differential HECS are all returning the system of student contributions to the pre-1970’s. However, the deferred nature of the HECS system has not seen employers return to the level of scholarship participation that existed prior to the 1970’s.

With some exceptions, scholarships today are used as a marketing tool by individual employers to raise student awareness about their company and to attract the best graduates at the completion of their degrees. These scholarships are generally awarded to students who have already decided to study minerals related courses and therefore play a relatively small role in attracting students into the industry. There is one notable exception to this trend: the Cooperative Education Scholarship program operating at the University of New South Wales, which has as its primary objective, the attraction of the best grade 12 students into the mining and metallurgy courses at the University.

While it is the view of the Taskforce that scholarships should, by and large, remain a mechanism by which individual companies attract students, the changing needs of industry as whole require them to be structured in such a way to achieve new objectives:

- while the scholarships were used as tool for attracting the best students into minerals-specific courses this is philosophically incompatible with the intention of broadening the base from which minerals industry graduates are drawn. As such, scholarship programs should cover a broader range of highly capable students, encouraging attraction of these students into any of the alternative pathways, (not just minerals specific courses);

- industry, as a whole, should aim to provide scholarships in the same order of magnitude as their future graduate requirements. In addition the number of scholarships and employment opportunities need to be relatively constant from year to year, independent of capital investment;
- with the increasing student contributions to higher education, scholarship programs should return to being, in part, a system of providing financial support for quality students to undertake higher education. For example, the value of scholarships should be increased to cover HECS payment and the student social activities, encouraging the students to devote a greater focus to their undergraduate education by not having to undertake part time employment; and
- the new model for minerals education will result in a rationalised number of minerals education providers and encourage alternative pathways. To attract highly capable students into a reduced number of institutions the general immobility of the student populations will have to be overcome. To do this the number and value of scholarships will have to be increased to cover students costs associated with relocation and living expenses.

(b) The Role of the Department

A second means of ensuring greater access to students is to provide, early in the undergraduate program, good exposure to minerals education and the industry. Organising this sort of exposure is the role of the department.

One example of this is the common first year minerals subject offered at the University of Queensland. The rationale for this subject is to provide all first year engineering students with some initial exposure to minerals.

Whilst there are obviously a number of factors involved, this initiative has contributed to the results achieved at the University of Queensland over the past few years. Numbers in the mining department in particular have been improving to the point where there are now fifty students in both second and third year of their degree. In the current academic year, more than 200 engineering students have enrolled in the first-year minerals industry subject, and almost seventy of these have indicated further interest in the industry through application for industry-sponsored vacation employment at the end of the year.

(c) The Role of the University

In Appendix B, the differences between universities were discussed. One major element in the success of any course is the university environment in which it is operating. The university in which a minerals course is operating must be able to attract good students, otherwise the reputation of the individual minerals course can become very difficult to sustain. It is also much more difficult for a single department to attract highly capable students if the university as a whole does not have a strong academic reputation. An example of this factor is shown by some recent calls for University of Western Australia to establish a mining engineering course to attract the highly capable students who, as a matter of routine, tend to enrol at University of Western Australia in preference to other Perth universities.

1.3.4. Entrance Criteria

Roles in the minerals industry very often involve living in, or commuting to, remote locations. This is seen by many as an unattractive lifestyle. On the other hand, anecdotal evidence suggests that it does appeal to those who have grown up in rural or remote locations.

Students from rural and remote locations are less inclined to complete secondary schooling and the average TES/TER score is lower than it is for graduates from urban areas. This is despite the likelihood that the average graduate has the same innate capability.

This fact, among other anecdotal evidence, suggests that it would be sensible for minerals departments to adopt criteria other than TES/TER scores to assess the potential of students wishing to undertake minerals studies.

The Taskforce endorses the Western Australian Taskforce's Discussion Paper recommendations 1.7: "*That universities* [engineering and science faculties and minerals departments] *adopt more flexible selection practices and put in place procedures that encourage a broader range of people to seek to study the relevant undergraduate courses. Universities should be discouraged from their over reliance on TES/TER scores as the major, if not the only, selection criteria.*"[15]

This is a wider issue than for just minerals courses. Senator Amanda Vanstone has initiated a search for viable alternatives, or supplements, to the TES/TER score criterion for entrance into university courses. This recognises that TES/TER scores are an imperfect measure of how well-suited a student will be to work in a particular role and should be used as one indicator amongst others.

15. **Western Australian Tertiary Education Taskforce** (1996), '*Discussion Paper*', the Chamber of Minerals and Energy of Western Australia Inc., July.

Appendix F
Tertiary Education in Mining Engineering: History, Current Status and Prospects

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Summary

This paper is an overview of the international condition of tertiary education in mining engineering. The evolution and philosophy of engineering education in the comprehensive universities is described briefly.

Mining engineering education since the mid-19th Century is shown to have split into two streams, one in Schools of Mines and the other in engineering faculties in the comprehensive universities. It is observed that strong contemporary mining programs are provided in the comprehensive universities.

The recent, and probable further, decline in mining programs in the European Union (EU) and the United States of America (USA) is discussed in relation to global trends in the mining industry. The leading Australian mining programs are shown to be more than competitive in graduation rates with their peer programs in North America and the European Union. The European Mining Course, a coordinated program involving four EU mining departments, is presented as a model of some interest in the Australian setting. The Australian mining industry's greater reliance for graduates on Australian mining educational programs will require deliberate effort on the part of the industry in support of local mining departments. Opportunities for cooperative efforts with the leading mining programs in Europe and North America and in the emerging Latin American countries are considered.

1. Introduction

In 1996 the Western Australian Minerals Industry Tertiary Education Taskforce published a Discussion Paper (WA Taskforce, 1996) on the topic of preparation of engineers and scientists for professional careers in the Australian minerals industry. The paper stimulated a healthy discussion on the topic of tertiary education in mining and minerals engineering, although it is arguable that in some respects it was based on inadequate information on both Australian and global conditions in the field. This paper is a contribution to the subsequent deliberations initiated by the Minerals Council of Australia on a national approach to education and training for the mining industry.

Universities have served the state and its institutions continually over many centuries, as a source of professional staff, informed advice and scholarly endeavour. However, in the current context of reviewing mining and minerals education, only developments in universities since the middle of the 19th Century are considered as having a direct bearing on contemporary conditions.

2. The Development of Engineering Programs in Universities

By the mid-19th Century in the economically advanced countries, various schools of physical science, engineering guild schools, and colleges of liberal arts and humanities had been amalgamated into comprehensive universities. They resembled the current model of a university in composition and academic mission. Technically, it was recognised that degree programs in applied science and engineering should be based on sound preparation in mathematics and the physical sciences. Philosophically, logical rigour, breadth of intellectual experience and exposure to many dimensions of culture and science were identified as the proper preparation for a productive professional life. Professional degree programs in universities differed from the strongly vocational programs of the former 'guild schools' in attention to the balance between intellectual development and vocational training. In particular, an engineer was intended to be well prepared in terms of conceptual and analytical capabilities. During the 19th Century, in the period of rapid economic growth, this educational philosophy was also adopted in the French grandes ecoles, the technical and comprehensive universities of Central and Eastern Europe and the private and expanding public university systems of North America.

The new universities derived their mission from a perceived need to serve a local, national or international community and economy, based on the academic traditions of preserving the best in accumulated knowledge and of generating and disseminating new knowledge. In the United Kingdom, some leading examples of these institutions were the red-brick provincial universities, which supported regional industrial and social development. The University of London and its constituent colleges were intended to prepare people for careers in both the City of London and throughout the Empire. In the USA, the Land-Grant universities were established with the specific task of providing readily accessible tertiary education opportunities in new states and territories and supporting their social, cultural and industrial development.

In Australia, the model of the comprehensive university is derived directly from the provincial British one, and also has some resemblance to the US Land-Grant institutions. The university has an economic base in, and a cultural, intellectual and economic mission supporting a fairly well defined community. For universities such as the Universities of Queensland, New South Wales or Western Australia, the relevant community is the population of the state. In such cases, the University may be the state's sole provider of courses in professional fields such as Medicine and some fields of engineering or in the sciences, liberal arts and humanities. For engineering programs, the academic strength of the universities resides in their capacity to provide breadth and depth in preparation of students in the basic sciences and mathematics supporting their discipline, in their ability to recruit academic staff of international stature and the scope to provide elective subjects across a broad spectrum of intellectual endeavour.

3. The Evolution of Tertiary Education in Mining Engineering

Although the first dedicated Mining academies were established in the German cities of Freiberg and Clausthal in the late 18th Century, by the mid-19th Century they had been absorbed as Departments of the provincial Universities. While this maintained the identity of Mining Engineering as a coherent engineering discipline, it also recognised the need to teach it in the context of the related fields of physical science, engineering science, mathematics and other engineering disciplines. In particular, mechanical engineering and mine equipment design were then, and still are, a significant component of the mining engineering curriculum of German universities.

In the United Kingdom (UK) and North America, from the mid-19th Century two different academic institutions developed to provide mining and minerals education. One type was the Schools of Mines, which were essentially autonomous technical academies covering the spectrum of disciplines and skills involved in preparing students for the mining professions. They could be independent academies, such as the Colorado School of Mines (established in 1874) or Camborne School of Mines (1888). Alternatively, they could be affiliated with a larger technical university, such as the Royal School of Mines (1851), which was linked later to the Imperial College of Science and Technology. In the US, a comparable institution is the Henry Krumb School of Mines, linked to Columbia University. A characteristic of these schools was that they emphasised a strongly vocational component of instruction and served a specific, narrow industrial or commercial constituency. These were the mining industries of, respectively, the State of Colorado and the Rocky Mountains area, the south-west of England, the former British Empire and countries of interest to the investment houses of the City of London, and the operations and headquarters of mining companies based in New York.

The other model for a mining education program is represented by a Department of Mining and Metallurgical Engineering course located in the engineering faculty of a comprehensive university. In the UK, examples are the Mining Departments at the Universities of Nottingham and Leeds. In the USA, there are about 20 such mining and minerals engineering departments, which were established within the Land-Grant universities in states that had significant mineral resources. Some examples are Pennsylvania State University, the University of Arizona, Virginia Polytechnic Institute and State University and the University of Missouri at Rolla.

In Australia, the evolution of mining and minerals education showed the same bifurcated development as in the UK and USA. At a comparatively early stage, Schools of Mines were established in provincial cities in the mining districts, in places such as Ballarat, Bendigo and Kalgoorlie. Somewhat later, Departments of Mining and Minerals Engineering (or departments with similar functions) were established in the main comprehensive universities in states with strong mining industries.

Nationally, the question of whether courses in the mining and minerals engineering disciplines should be presented at a University or a School of Mines has been a matter of contention for some time. In a discussion of the matter which is remarkably pertinent today, almost 60 years ago the distinguished mining academic, H W Gartrell (1941), wrote:

> *'The question is frequently asked 'Why do Universities have Departments of Mining and Metallurgy?' Often the number of students is small and in consequence the cost per head is high. Further, it is common for a large percentage of the graduates to find employment outside the state in which they have been educated. Sometimes we meet the question in the form 'Would not the industry best be served by Schools (of Mines) in the field?' The answer is easy to find. It is this. The industry needs service in more than one way. The services rendered by the local institutions may overlap those rendered by universities, but the universities have a special function, the leadership in training, for normally they have much superior facilities for teaching of fundamental subjects, and for providing education in its broad and true sense.'*

Notably, Gartrell argued that it is the capacity of the universities to provide a broad education emphasising fundamental subjects, which qualifies them to provide leadership in mining and minerals education.

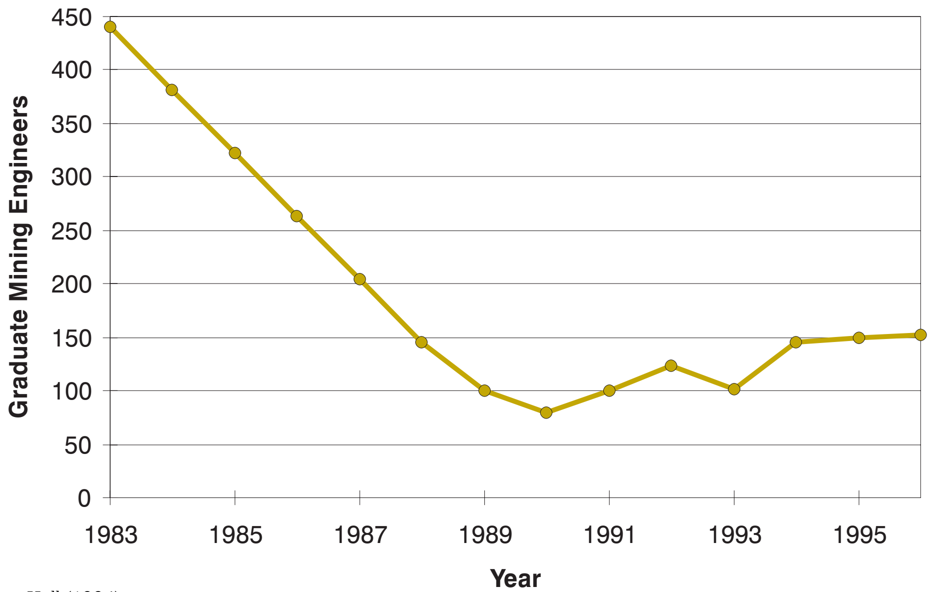
4. The Current Condition of Mining Education

4.1 Conditions and Trends in North America

On the international scene, some episodic changes and general economic trends over the last 30 years can be identified as major influences on output from the Western world's major mining and minerals engineering schools. These are the impact and subsequent attenuation of the effects of the oil price changes in the 1970s, the expansion of market economies into previously centrally directed economies starting during the 1980s, the migration of mining to countries with better or more accessible mineral resources, and worldwide stringencies in funding of tertiary education.

When OPEC raised oil prices in the 1970s, the major OECD industrialised countries pursued ways to increase coal production. In the US in particular, the Federal Government provided funds to educate more engineers for the industry. In 1981, the annual output from about 20 mining departments was about 700 graduates (Consol Inc., 1991). In 1981, Penn State University alone graduated more than 60 mining engineers. With the end of the oil price crisis, there has been a significant decline in the number of graduates. In Figure 1 (taken from Hall, 1994) it is seen that the average number of US mining graduates declined from about 450 per year in the period 1980-87 to less than 100 in 1990. More recent figures (Consol Inc., 1997) on US mining programs show an upward trend in total enrolments (to 780) and annual graduations (to about 150) for 1996, from 19 mining departments.

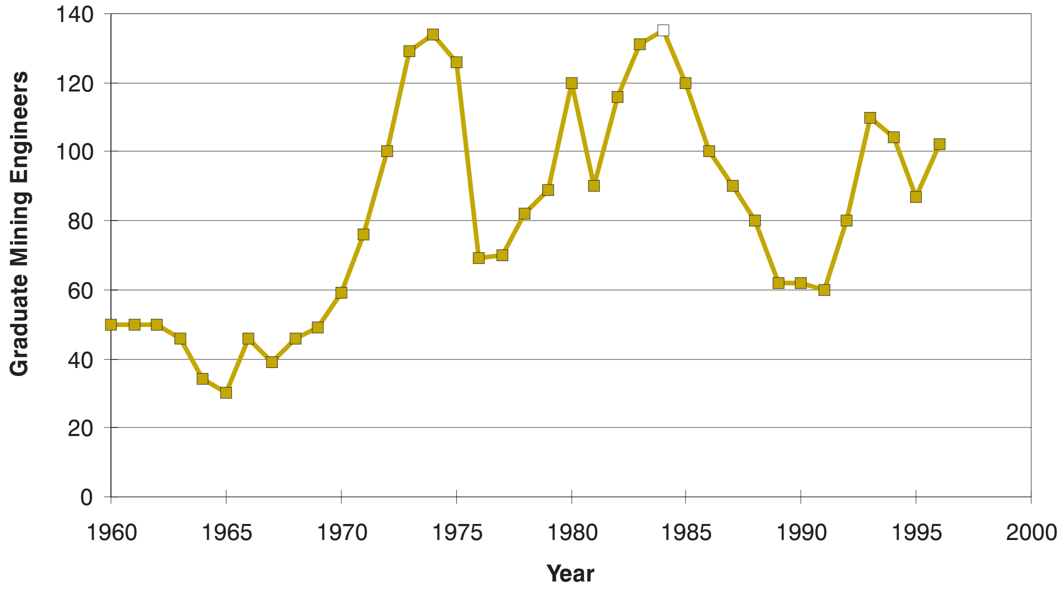
Figure 1. Mining engineering graduates from US universities



Source: Hall (1994)

The record in Canada is different. As shown in Figure 2, there was a fall in the number of mining graduates during the 1980s (as in the USA). However, the overall trend is upward, rising from an average of about 40 per year in the period 1960-65 to about 100 per year in the period 1990-95. There are seven mining engineering programs in Canada, so that the average output per department (about 14) is still quite low.

Figure 2. Mining engineering graduates from Canadian universities



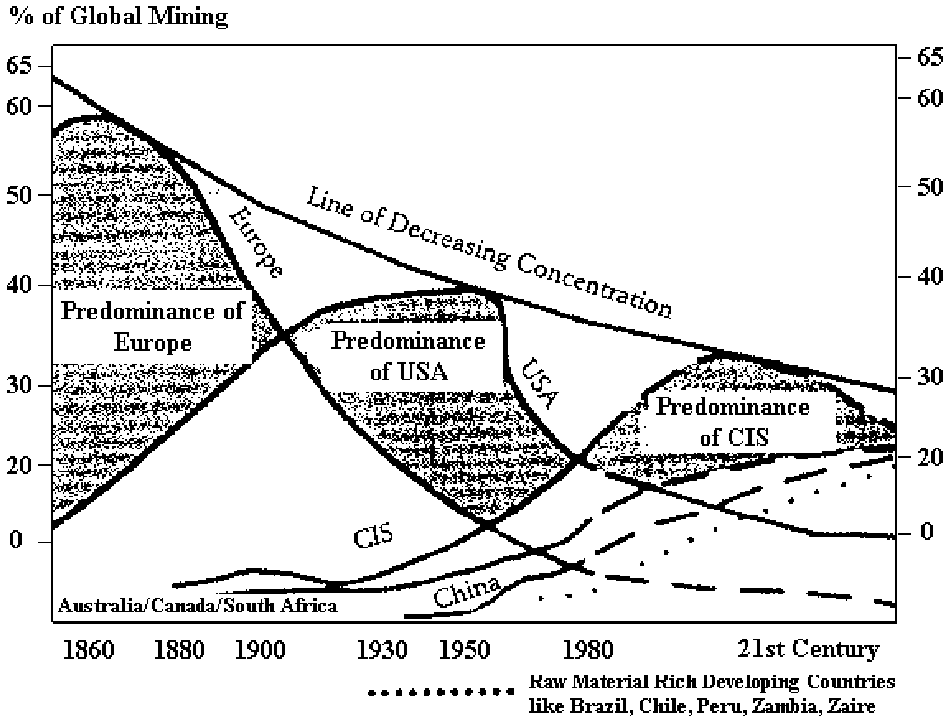
Source: Hall (1994)

4.2 Trends in Europe

In forming a wider view of international conditions, Nemitz (1995) provides some interesting insights into the situation in European mining engineering departments. The trend in Europe is postulated to be related to global changes in mining activity. The schematic diagram shown in Figure 3 indicates an historical migration of mining away from Europe and the US to the resource-rich countries of Australia, Canada and South Africa which have well established mining industries, and to the emerging mining countries of Brazil, Chile, Peru Zambia and Zaire. (The nomination in the figure of the CIS countries as a prospective force in international mining has yet to be realised).

Nemitz also summarised the output of graduates from the mining departments of the European Union, as shown in Table 1. It is seen that the 30 main mining departments of the EU produce about 700 engineers per year, or about 23 per department. This is considerably more than the average for North America, of about 10 per department, although not much greater then the Australian average of about 17 (for 1992).

Figure 3. Historical and projected development of global mining



Source: Nemitz (1995)

Table 1. Mining graduates in the European Union and other national groupings, 1992

Country	Number of Mining Departments	Graduates per Year (1992)
Benelux	5	30
Italy	5	45-50
France	4	150
Germany	4	150
Great Britain	4	50-60
Portugal	3	25-30
Spain	2	10-15
Greece	2	40-50
Austria	1	10-15
Sweden	1	3-4
European Union	**30**	**About 700**
USA and Canada	**27**	**About 250**
Australia	**6**	**About 100**

Source: after Nemitz (1995)

Table 1 requires several clarifications and elaborations. First, not all European mining graduates are employed directly by the European mining industry or the mining houses based in Europe. Many are employed in the fields of machine and equipment manufacturing, services and supplies, for which the EU has a major export market. Second, the EU has a major mining research and development effort, particularly in areas of environmental remediation and advanced mining technology, which absorbs many graduates. Third, in order to find employment, many mining graduates are engaged in quarrying and industrial mineral production, as opposed to the traditional areas of coal mining, metal mining and evaporite extraction.

These considerations notwithstanding, there is a widely held view (Shaw, 1993; Nemitz, 1995) that 30 mining departments in the EU is excessive, particularly when coal production, for example, has declined from 350 Mt in 1967 to about 80 Mt in 1993 and is projected to fall below 70 Mt in 2000. The need for a rational and planned reduction in the number of mining departments is accepted. Currently, the reduction is occurring by attrition. Senior staff are not being replaced on retirement, rendering the host department non-viable.

In an effort to improve the viability of four of the smaller mining departments of the EU, in 1996 those from the RSM, the Technical University of Delft (Holland), the RWTH at Aachen, Germany and Helsinki University of Technology combined to present the European Mining Course (Shaw, 1996). The objective of the course is to share the expertise of the various departments in particular fields of engineering. After preparation in the engineering sciences at their 'home' universities, upper level students take subjects at the cooperating schools for credit towards a degree to be awarded by the home university. In this way, students engaged in the European Mining Course are exposed to expertise in management and rock mechanics at RSM, surface mining at Delft, mine equipment engineering at Aachen and hard rock mining at Helsinki.

4.3 Australian Mining Engineering Programs

The most recent survey of output of graduates from Australian mining programs was reported by Lawson (1997). It records the average graduation rate from the six Australian mining departments over the three year period 1993-95, and also provides data and an estimate for the years 1996 and 1997. The data is presented in Table 2.

The data in Table 2 for the years 1993-95 suggest that, with an average graduation rate of 19 per year, Australian mining departments are, on average, competitive in numerical output with those in Canada and are performing much better than those in the US. When account is taken of the major interest of many European mining engineers in equipment engineering, quarrying and production of industrial minerals, the recruitable numerical output of Australian mining departments compares favourably with that from the European departments. There is also an implied growth in mining programs in the years 1993-95, reflected in the increased graduation rates of 1996 and 1997. The data suggest the University of Queensland is close to being the top performer when compared with any of the mining departments of Europe or North America.

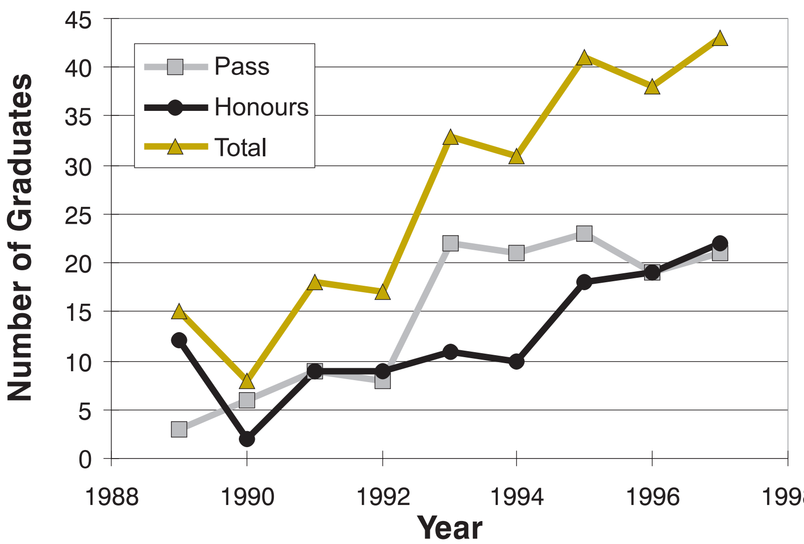
Table 2 Mining graduates from Australian mining departments, 1993-97

State	Annual Graduation	No of Departments	Current Full-time Academic Staff
Queensland	35	1	5
NSW	32	2	9
Victoria	13	1	3
South Australia	9	1	3
Western Australia	25	1	10
Total	114	6	30
1996 graduates	160		
1997 graduates	175 (est)		

Note: The figure for NSW has been revised from the original paper.
Source: after Lawson (1997).

Another factor which is encouraging about the graduation rate from the University of Queensland is the trend in the graduation figures. During the 1980s the annual graduation rate was 15, and varied in the range 7 to 25, reflecting the cyclic employment and recruitment pattern of the industry. Graduation statistics for the period 1990-97 are presented in Figure 4. It is observed that since 1990, the trend has been definitely upward, to the stage where the graduation rate seems to be settling in the 40-45 range. Industry demand (expressed in job advertisements and recruiting activity) is believed to be the main driver for attracting students to the mining course. Therefore it is expected that a steady or increasing level of demand from mining companies should be reflected in steady or increasing graduation rate in the future (provided due account is taken of the time lag in this process). With the staff level at the University of Queensland now 6 full-time academics and two part-time, it is unlikely that an output greater than 50 could be sustained without increase in staff level.

Figure 4. Annual graduation rate in mining engineering from the University of Queensland.



Note: 1997 figure is estimated.
Source: University of Queensland

The conclusion that arises from this discussion is that, some recent reports (WA Taskforce, 1996) notwithstanding, the graduation rates of some leading Australian mining departments have never been higher. The obvious omission from the discussion is consideration of the quality of the graduates, an issue that could not be assessed without a thorough study. However, the author believes, from his experience as an academic at Imperial College during the 1970s and the University of Minnesota during the 1980s, that the quality of current mining graduates from the University of Queensland is comparable with that of graduates from these leading international educational institutions.

4.4 Impact of International Trends

The declines in output of mining graduates in the UK and North America are important as far as the Australian mining industry is concerned. Australia has traditionally recruited a proportion of both new and experienced graduates from these sources.

In the UK in the late 1980s, due to financial strictures imposed by the responsible ministry, the number of mining departments decreased from 7 to 4. The departments at Newcastle-on-Tyne, Cardiff and Strathclyde were closed or merged with those in other universities. Further, in 1992 the mining program at the Camborne School of Mines was absorbed by the University of Exeter to become part of its faculty of engineering (Hall, 1994). The remaining mining departments are located at the Royal School of Mines (RSM, at Imperial College), the University of Nottingham, the University of Leeds and, as noted above, the University of Exeter.

In an address to the annual meeting of the Society of Mining Professors/Societat der Bergbaukunde, Mousset-Jones (1997) suggested that of the 19 operating mining engineering programs in the US, there was probably demand and support in the educational system for seven. Of course, a decrease in viable US mining programs is consistent with the scenario described by Nemitz (1995). The worldwide mining industry, the mining profession and mining education are expected to migrate from the US (and Europe) to the more active and emerging mining economies of Canada, Australia and South Africa, and Brazil, Chile, Peru and central Africa. In mining education, this process is well under way.

In Canada, the main mining programs are relatively stable. However, the recognised need for a high level mining program led recently to the announcement of a plan to create a mining department at the University of Toronto. The plan is supported by an endowment of $C10 million provided by Canadian mining personalities and companies.

It seems that, over the last 100 years internationally, the Schools of Mines have not been able to develop in a way comparable with engineering education in general. In contrast to this, large and productive mining programs exist at several comprehensive universities, such as VPI & SU and the University of Missouri, Rolla and several of the Canadian universities, such as Queens University and the cluster of engineering departments in the Montreal universities. It can be argued that the model of a highly vocational 'School of Mines' is an educational concept not suited to the academic, professional and societal demands of the late 20th Century or the future. As noted above, Gartrell implied as much almost 60 years ago. The decision by leaders of the Canadian mining industry to establish a mining degree course at the University of Toronto indicates their confidence in mining education being conducted in a comprehensive university rather than an autonomous School of Mines.

5. Prospects and Planning for Future Mining Engineering Education

The preceding discussion provides a basis for some projections on the short term (5-year) future of international education in mining engineering. Such projections could be used to propose some guidelines for a long-term (25-year) plan to assure the future of Australian mining education programs.

As suggested by Nemitz (1995) and Shaw (1993), the migration of mining from Europe and the US to the technically developed and developing mining countries (Canada, Australia and South Africa, and Brazil, Chile, Peru and central Africa respectively) has important educational implications for each set of countries. In Europe and the US, it can be expected that there will be increased pressure to rationalise mining education. This is recommended explicitly by Nemitz. Because the UK and US are traditional sources of graduates for the Australian industry, the Australian mining industry will need to move deliberately to avoid dislocation of recruitment by developing local sources of graduates.

In Canada, the steady increase in graduation numbers can be expected to continue in line with the growth of the Canadian mining industry. The recent endowment of a Chair and Department of Mining Engineering at the University of Toronto (the leading comprehensive university in Canada) is indicative of the local mining industry's commitment to promotion of a stronger mining education program. It is notable that, in the past, the Canadian industry was also a recruiter of graduates from the mining departments of the UK. Their contraction and the demand for staff for Canadian companies operating in South America is probably the motivation for starting a new mining department.

In Australia, several large mining departments in comprehensive universities are undergoing steady growth, admittedly under conditions of moderate to severe financial stringency. In spite of comments to the contrary (eg. WA Taskforce, 1996), there is a significant cohort of Australian students interested in careers in mining engineering. Indeed, it seems there is a long history (eg. Gwillim, 1916; Gartrell, 1941) of adverse comment on the ability to attract suitable students into mining engineering. The view of University of Queensland staff is that, for a mining program with a sound curriculum and a stable staff complement, the limits to growth are not defined by the availability of prospective students. Instead, the controlling factors are:

- the financial capacity to recruit and retain high calibre academic staff and to support both operating and capital expenditure;
- continuity of corporate recruitment pressure to assure prospective students of career opportunities in the industry; and
- provision by the industry of scholarships, bursaries and internships to engage students in systematic recruitment and para-professional training.

This suggests that, unless there is a substantial commitment of funds and effort, the clear potential of Australian mining departments to achieve international leadership in both size and academic stature will not be realised.

On a national basis, educational institutions need to act deliberately to attract top calibre students into mining engineering programs. The way to achieve this is to ensure that selected metropolitan universities present first-class mining engineering courses. It is unrealistic to expect high calibre, high potential students who are aware of the standing and reputation of the major comprehensive universities to move to a provincial city to pursue a mining degree. Universities which have a common first-year engineering syllabus have further advantages for effective presentation of mining engineering courses. Because choice of an engineering specialisation is postponed until at least the end of first year or later, there is time for students to understand the functions, career prospects and work environment of a mining engineer. An effective interview procedure to assess aptitude and interest would further help to engage appropriate people in mining programs.

In the medium term, there is likely to be an acute shortage of mining academics, arising from the contraction of mining departments in the UK and the USA. In the past, these departments have provided doctoral and postdoctoral training for many people who subsequently staffed Australian mining departments. Deliberate efforts are required to promote postgraduate research in Australian mining departments and to provide opportunities for work in the best remaining mining schools of North America and Europe. In that regard, some preliminary discussions have been held with a view to establishing a global network of leading mining departments.

An encouraging recent development is the emergence of promising mining engineering programs in Latin American universities in general, and in Chile in particular. The interest expressed to Australian departments by their lead academics in developing cooperative programs with them provides interesting academic opportunities, with obvious commercial advantages to companies engaged in South America and professional and cultural advantages for students.

In considering mining engineering curricula for the future, due account needs to be taken of the concepts defined in the recent report of the Review of Engineering Education (The IEAust, 1996). Further, most mining academics are aware of the principles involved in constructing both a modern engineering curriculum and a modern mining curriculum. The papers by Finniston (1980) and Allen (1981) are particularly relevant in drawing attention to professional functions of engineers and the need to provide education and professional formation in both technical and management dimensions. The particular local need is to prepare students to meet mining company expectations, in terms of knowledge, attributes and competencies. Aspinall and Brady (1997) present the results of a survey of staff of mining corporate staff which identifies preferred profiles of preparation of graduates, and propose some educational initiatives to meet them. An extract from the paper is provided in Appendix 1.

The renewed interest shown by the Minerals Industry in tertiary education issues opens the way for a genuine partnership between the industry and the universities. This should be based on recognition of their mutual interests, but also acknowledge that a university has an autonomy and accountability defined by both legislation and convention. Further, it has a responsibility to the student population and society at large. The common ground for the industry and the universities is that both are seeking continuous improvement in the structure and delivery of mining tertiary education in Australia, and it is accepted that the mining industry deserves an effective voice in the academic and vocational preparation of its professional workforce.

A mechanism of interaction between universities and the industry needs to be constructed with due attention to the ideas noted above. As will be apparent from the earlier discussion, the model of a 'National School' of Minerals Education answerable to the mining industry is not considered academically sound. An alternative is for the industry to support the further development of the existing, successful Mining Engineering departments in their attempts to achieve genuine world leadership. If the minerals industry established a minerals education council, it could promote a coordinated approach to the development of mining and minerals education in Australia by formal interaction with the relevant parts of the university community.

The minerals education council would have several functions. In an era of declining government funding for tertiary education, a primary function would be to augment capital and recurrent funding of graduate and postgraduate education in Mining Engineering and Mineral Engineering at a number of key institutions. These would be selected and sustained on the basis of their educational profile and potential and the international standing of their undergraduate and postgraduate programs. Another function would be to define and underwrite a program of specific educational initiatives using the AMIRA model successfully applied to research activities. Finally, the Minerals Education Council would have a planning function, in which short-term projections are made of industry needs for professional staff, to guide the educational institutions in the number of students recruited into mining programs.

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Appendix 1 of Appendix F

Preferred attributes and competencies for mining graduates (from Aspinall and Brady, 1997)

A sensible balance must be obtained between the academic objectives of a university education and the current and future needs of the minerals industry, in terms of job-readiness of graduates. In seeking such a balance, views were sought from industry representatives to enable ideas on course content, mode of presentation and assessment to be formulated. A questionnaire was prepared and sent to a representative sample of selected individuals covering a range of experiences (from recent graduates to recently retired), job functions (covering operating, technical, consulting, personnel and senior management roles) and mining activities and geographic locations around Australia. The questionnaire was structured to obtain views on attributes, taking account of knowledge, skills and attitudes, and how these were related to:

- competencies sought in a new graduate;
- how these competencies are currently assessed by employers of graduates; and
- how these competencies could be better developed during the university education of mining engineers.

The thoughtful and detailed responses from 31 professionals (or 61% of those contacted) reflect a wide interest and willingness to contribute to the future development of mining engineering graduates.

From the responses of industry professionals, the significant attribute and competency factors assessed as industrially important have been identified in terms of knowledge, skills and attitudes, as follows.

Knowledge

An important observation from the responses was that employers do not specifically test applicants for technical knowledge. Instead, they concentrate on skills and attitudes. The implicit assumption is that the degree program provides the graduate with adequate technical and practising knowledge. This places the onus on academic staff to ensure that this is achieved. The required fields of knowledge identified from the responses were:

- mathematics, science, engineering sciences, geology, geomechanics, ventilation theory; environmental sciences applied to mining;
- mechanical and electrical engineering applied to mining;
- basic understanding of mining and minerals processing methods and applications;
- business concepts, feasibility studies, project evaluation, project risk evaluation;
- management systems, safety, industrial relations, budgetary control;
- legislation (particularly affecting mining, environmental, contract, occupational health and safety matters); and
- practising as a professional engineer.

Many, if not all, of these fields of knowledge are already represented in existing courses. However, there was a notable emphasis on business concepts and legislation issues (the management and social dimensions) which perhaps reflects the needs of the current commercial world in developing and operating mineral projects.

Skills

The responses suggested that this is where significant attention may be required. The main skill factors identified were:

- communication skills in written, oral and formal presentation formats;
- computer application skills, particularly with word processing, spreadsheets and CAD applications;
- skills in forming and working in teams;
- thinking skills, expressed in independent, clear, creative thought processes and a spirit of enquiry;
- problem solving skills, in problem definition, analysis, synthesis of solution options, resolution, and dealing with uncertainty;
- interpersonal skills, with a capacity to understand and adapt to differences in personal styles;
- time management skills; and
- ability to acquire knowledge (in a non-academic environment).

In addition to the task performance aspect, some of these dimensions of skill have a knowledge component, in which a body of theory is required. These include problem solving, team skills (sociology of teams), time management skills (theory and tools), and computer skills (applied computer science). The skills identified are significant in the assessment processes used by employers in the selection of graduate mining engineers. An issue for educators is how best to develop the student in learning, practising and improving these skills during the course and how to assess progress effectively.

Attitudes

These are personal attributes influenced by upbringing, worldly experience and other aspects of personal formation. In their responses, potential employers indicated their interest in a graduate's outlook on life and how it might conform with the company's characteristic profile. Some respondents indicated that they considered that academic staff can influence the development of undergraduates through example, by the way they deal with and develop the individual student as a young professional.

Also identified as preferred attitudes were: an eagerness to continue to learn; a willingness to improve processes and self; personal integrity; willingness to accept responsibility; tolerance for change. Attributes such as these are more difficult to inculcate and assess than skills, and represent a further challenge to academics in how they should be dealt with in an academic setting.

Appendix G
Mining Education 1955-1995: A Memoir

by Professor Alban J Lynch

This memoir is a response to an invitation from the Minerals Council of Australia to comment on recent developments in mining education. 'Recent' is flexible and 4 decades have been chosen for this memoir. Mining will be assumed to include mineral processing and universities will also refer to schools of mines. The memoir has been written without review by contemporaries or access to references. Consequently errors are inevitable.

1. Preface

In the mid 1950's the colonial era was ending, manufacturing in many countries was increasing as the shattered economies in Europe and Asia were being rebuilt, and there was a growing international demand for minerals. Tertiary education was starting to change due to increasing investments by governments but it had not yet had time to move far from the position which had been reached before the second world war started. Mining education world wide was still in the form which reflected its stability during the past 50 years but it was soon to commence a prolonged period of extensive change.

So the mid 1950's is a good starting point for this memoir. Where was mining education then, what has happened since, why has it happened and how should the experience of 40 years be projected towards the future?

2. The End of Stability

The centres of mining education in the English speaking countries in the mid 1950's were UK and USA. Each had many strong university mining departments. These departments usually had links with and received good support from industry and they reciprocated by providing industry oriented courses with academic merit. Many graduates from the UK went to mines in Asia and Africa, while Central and South America were the destinations for some from the USA.

In the non English speaking countries, mining in Western Europe was well supported by schools which had operated in that region for decades. In the centrally planned economies of Eastern Europe, the trend was to have universities which concentrated on specific areas of industry and there were many mining universities, notably the Leningrad and Moscow Mining Institutes, and the Freiburg and Cracow Mining Academies.

In the newly independent countries in Asia, which are now so important to Australia, limited attention had been given to tertiary education during the colonial period. For example, Malaya had been the dominant tin producer in the world for many decades but there was no school of mines and only one small university which had no mining interest. In China a mining school had been established in 1905 but decades of revolution and wars were disruptive for the mining industry and education. The change in leadership in 1949 brought the establishment of large mining universities similar in style to those in East Europe.

In Latin America as in Asia there were a few good quality mining departments, for example at the University of Chile in Santiago, the Guanajuato School of Mines in Mexico and the School of Mines in Ouro Preto in Brazil. But the dramatic changes which were to come in Asia and, more slowly, in Latin America were still some distance away.

In Australia, the mining schools at the Universities of Melbourne and Adelaide, which for many years had supplied a lot of the graduates which the mines required,, were in decline. However, the new schools at the Universities of New South Wales and Queensland under their dynamic heads, Professors David Philips and Frank White, were growing. The Schools of Mines at Ballarat, Bendigo, Broken Hill and Kalgoorlie were a good source of mining engineers but Australia still recruited many graduates from UK. Australian mining schools had some interactions with those in UK and USA, but few with those in the non English speaking countries, particularly in Asia.

In summary the mid 1950's was still a time of stability in tertiary education and universities were in a quiet backwater. There appears to have been a rough balance between supply and demand for mining engineers with some of the demand by the former colonies being met by universities in the former colonial powers. But the economic and industrial growth which was on the horizon was soon to bring about changes in tertiary education which would affect mining education.

3. The Growth of Tertiary Education

Strong growth was a feature of tertiary education in many countries in the 1960's and 1970's. Governments realised that advanced training was essential to underpin economic progress so they took actions to increase the number of students at universities. Tertiary education became a large item in national budgets.

In Australia the tertiary system at the end of the second world war consisted of six universities, four technical colleges, four schools of mines, and some teachering and agricultural colleges. The first new universities after the war were the University of New South Wales and Monash University. One of the first departments at University of New South Wales was mining engineering and it was well supported by the Joint Coal Board which was then responsible for the large coal mining industry in NSW.

Further expansion of tertiary education resulted in many new institutions and led to a two tier system being instituted in the 1960's in which universities had responsibility for research and courses while other institutions such as institutes of technology had responsibility for courses only. By 1975 mining engineering was offered in seven and mineral processing in nine university departments.

Eventually all tertiary institutions sought and were given university status. The result was that there were 35 universities in Australia, all with ambitions to be top research universities but few with the primary objective of training for industry. It was not surprising that national priority in the budgets in the 1980's started to move towards technical and further education. The TAFE colleges responded vigorously and received much industry encouragement and support. Some excellent training courses were developed for the mining industry. For example the Box Hill College for Technical and Further Education organised a series of courses for quarry management in collaboration with the Institute of Quarrying, Australia, which is now sold overseas.

The pattern of events in Australia was similar to those in many other countries although it was always influenced by local considerations such as the political system, the state of development of the country, and its objectives. Malaysia is a good example of what occurred in some of the developing countries. In 1970 it was an impoverished country with an economy based on natural resources, it had only one university and there were serious racial problems. During the next 15 years the national government built a network of universities and training colleges throughout peninsular Malaysia and later extended it to Sarawak and Sabah. Part of the objectives of these institutions was to support an industry policy which capitalised on the natural advantages of Malaysia. There is no doubt that while they were never strong research universities they contributed much to the remarkable economic success of the policy through the training they provided.

The story of the growth of universities during the past 40 years is fascinating with many examples of success and failure but it will not be discussed further here. Suffice it to say that the overall result of the expansion of tertiary education in Australia and other countries has been excellent and the large increase in the number of trained graduates has transformed many of them. Japan, Korea and Singapore are notable examples.

The expansion has moved universities from a quiet backwater in the 1950's to the turbulent mainstream of politics and society in the 1990's. But with the benefits have come large increases in costs and in almost all cases these have been met from the public treasuries. Procedures have been created by the universities and government officials for cost management and control and these have had a significant influence on courses, staff and policies. Finance will be discussed in section 4 and the impact of university growth on mining schools will be discussed in section 5.

4. The Matter of Finance

Increase of students in universities meant a rapidly rising growth in expenditure in terms of staff, equipment, libraries and general facilities. The rather informal procedures for budget allocation, and staff appointment and promotion of the 1950's had to be replaced by formal systems which ensured equity and promoted the welfare and development of each university.

The obvious base for the allocation of funds was the number of students modified by some factor related to the cost of equipment and tutors required for training in particular departments. For example medicine and engineering are higher cost courses than arts and law because they are capital intensive. Universities had no option but to move to some form of market based allocation of finance where students were the main element of the market. The reason was that the tertiary education component of the annual national budget became immense, the actual amount in Australia is not known but it is now probably of the order of $A5 billion. There could be no question that this had to be handled in an orderly, equitable and transparent manner and it was this result that the universities sought to achieve by developing formal methods for the allocation of funds to departments and the reward of personnel.

The total amount of public money which is currently spent in Australia on mining and mineral processing education is also not known but an estimate based on the number of staff involved, and including overheads, suggests that it is of the order of $A12 million per year. This is a small amount if departments are considered individually but a large amount if they are considered collectively. The question which is important when considering the future of mining education is, how can best value be obtained from the public funds which are available?

In the same vein, the number of published papers in reputable journals became an obvious base from which to work in the appointment and promotion of staff. Like the base for the allocation of funds this imposed some difficulty on mining departments because the objective of these departments is related aspects of mine production and not to conforming to the norms of other university departments. But it is difficult to justify special cases in a comprehensive university.

In the next section the effect of university growth and the evolving procedures for administration and control on undergraduate mining education will be discussed. The emphasis in the next section will be on undergraduate education. Later in the memoir the factors which led to different results with postgraduate and undergraduate education will be discussed.

5. The Impact of Growth on Mining Education

Some of the effects have been:

1. the growth in the total student population at universities means that the proportion of new university students who enter mining engineering departments has fallen to a very low level even though the number of students may have increased slightly. This has put financial pressure on departments because of the link between finances and proportion of students
2. an academic career became unattractive to experienced mining engineers because of their reluctance to become involved with cumbersome university procedures for appointment, promotion and resource allocation. This was a problem as it is only these engineers who are able to transmit the excitement of a mining career to students and to attract the high quality students
3. departments competed rather than collaborated, their objective being to gain an advantage by establishing comprehensive courses in their own institutions. This has led to duplication of, rather than sharing and building on, resources. In many countries including Australia the expenditure on mining education is adequate to train sufficient skilled mining engineers to meet national needs but this is difficult with current methods for allocation of resources
4. reluctance by some companies to continue to support departments because of the divergence between academic and industrial objectives.

The problem which university growth has brought to mining departments is that they do not have automatic stability in their resources as do many other departments which can rely on a large and stable number of students. Mining departments are dependent on the quality of staff to attract students and earn industry support, and as noted above, experienced engineers who are capable of doing this are not usually attracted to academic careers.

The result has been a general decline in mining education at undergraduate level world wide. In North America and West Europe, the source of skilled mining engineers for years, many mining departments have closed, joined other departments or turned towards environmental studies. In South Africa, South America, Russia and China where there were large mining industries the problems which their universities had in common with universities in the developed countries were exacerbated by serious social problems.

Some developing countries with growing mining industries have established mining departments which often have been well equipped with facilities such as mineral processing pilot plants. These departments have attracted excellent students but their problems in attracting and retaining experienced staff have been much more serious than those encountered by departments in the developed countries because of dismal salaries, less than half the prevailing rate in industry.

The conclusion is that undergraduate mining education in Australia, after coping with the problems of 40 years of university growth, is in a good position compared with other countries. But it should be much better than it is, indeed Australia is so dependent on its mining industry that it should have an undergraduate mining education system which ranks highly amongst world engineering schools and not just mining schools. It should, and it can if it wishes, assume international leadership in mining education with all the financial benefits that would accrue.

6. Research and Postgraduate Studies

Research and postgraduate studies were not strong in engineering education in Australia in the mid 1950's although in the mining area there was significant research on rock mechanics at Australian National University and pyrometallurgy at University of New South Wales. This changed in the 1960's and 1970's with the rise in mining and mineral processing research sponsored by the mineral industry. It was not affected by the general decline in mining education because the finance which supported it came from industry. Its success was linked to the culture of mining industry research which had developed in Australia after the success of flotation at Broken Hill.

What happened was that in the early 1960's, the Australian Mineral Industries Research Association Limited (AMIRA) started its first small and tentative support of research programs at universities on topics of interest to several mining companies. Graduate students were attached to these programs and much of the research work for their theses was carried out at mine sites. The mixture of interesting and industrially relevant programs, good graduate students, and reasonable finance, with the only requirement being the necessity for high quality work, was a recipe for success.

The expenditure by AMIRA at universities increased during the 1970's and while research results were always the first priority, the training of good engineers at postgraduate level became a very important by-product. One outcome of the AMIRA involvement was the emergence of strong groups dedicated to specific areas of industrial research and which were very productive in results and in advanced training. These groups were self funding and they were not limited by the type of difficulties encountered by undergraduate groups and discussed above. By the late 1980's there were strong groups in several universities, they collaborated where they saw mutual advantage and collectively they provided an excellent resource in research and advanced training for the mineral industry. An unfortunate development in view of the cost and importance of mining techniques was that these groups were almost all in mineral processing. This is a problem which is still to be corrected.

A parallel activity during the 1960's and 1970's was the growth in university research programs funded by the government and administered by the Australian Research Grants Committee. They were usually concerned with basic rather than industrial research and their results contributed little to the national wealth. So, by the end of the 1970's, the decision was taken to divert some research funds to support large research programs in areas of national importance. These programs, which were carried out in Special Research Centres, as they were then known, were rather similar in concept to the programs funded by AMIRA and they were successful. Later they evolved into Cooperative Research Centres which linked compatible units in universities and CSIRO with industrial partners to undertake large programs on problems of national priority.

What these groups have shown is that the Australian mining industry is prepared to financially support university research and training units which are strongly focused on industrial problems and requirements. This has not occurred to nearly the same extent in university mining departments in other countries although many attempts have been made to develop AMIRA style programs.

There is no doubt that Australia leads the world in its mining industry postgraduate research and training units in universities. Brazil probably has a better system of external part-time master degree programs because they are contracted directly by the mining industry but its research programs are inferior.

7. Towards 2020

In 40 years the world has moved from the late stages of the industrial revolution, involving immense machinery and production lines, to the early stages of the computer revolution. Governments have responded by introducing tertiary education on a massive scale but the cost has been high and the results, while generally good, have at times fallen short of expectations.

Mining education in Australia has moved from almost total dependence on governments for finance, to a system in which undergraduate education is funded by government and research and postgraduate training in the industrial area is mainly funded by the mining industry.

Attempts have been made in other countries to develop strong industry funded postgraduate research and training systems but with success which can at best be described as limited. The mining industry in South Africa gives remarkable support to mining education but circumstances there are unique and it would be unrealistic to consider the application of the South African model to other countries.

How can an understanding of the past 40 years (and 240 years) help in planning for the future? Some conclusions are:

- mining education and research are most successful when they are required to earn a large proportion of their expenses from private industry. This ensures that their objectives are related to industry objectives, and that they are not unduly constrained by procedures devised for dissimilar departments
- the high cost of universities means that the days of easy funding from the public sector have passed and that the demands to reduce public expenditure will require decreased rather than increased public funding of universities. This is already happening in many countries, for example in Malaysia the government universities are being ‘corporatised’, ie required to earn part of their operating funds from the private sector, and new universities are being established by large corporations such as Petronas and Telekom. It can be expected to happen in Australia and private universities, or departments in public universities which are dedicated to specific areas of industry and are self funding, can be expected to emerge.

The question is, can a high cost discipline such as mining engineering, operate successfully in semi-private or private mode? A good example of a self funding engineering university is the Monterrey Institute of Technology in northern Mexico. Monterrey is a large city with many plants involved in heavy industry such as glass making and metal smelting. This Institute was established in 1943 by local companies who were dissatisfied with the quality of graduates from the state supported universities. It is self funding and is in high demand by students from all over Mexico. Fees are 10 times the fees at state universities, it now has 26 campuses throughout Mexico and it has a Virtual University extending to several other countries which is so well equipped and of such a stature that it can only be dreamt of in Australia.

Monterrey Institute of Technology points the way to the future in tertiary education. It has a specific focus, its objectives are well defined, and it is prepared to invest in modern technology to enhance its own business by satisfying the needs of its customers in the best possible way.

In Australia it can be expected that small, specialist, high cost departments in universities, such as mining departments, will come under increasing pressure with regard to support from public funds. There is no industry better equipped to make use of the concepts which have been applied successfully by the Monterrey Institute of Technology than the mineral industry. It needs new ideas and a new style of working in mining education and it is believed that a system which is partially dependent on public funds but which introduces new concepts to meet the specific objectives of the industry will be very successful. It has every prospect of becoming the centre of world mining education, with the many financial, technical and cultural benefits that this would bring.

It takes years and much effort to construct a sound academic culture. It takes a moment and little effort to destroy it. The mineral industry showed remarkable foresight and initiative in education 240 years ago, the time is ripe for this to happen again.

Appendix H
The School of Mines - 1757 to 1997 and Beyond

by Professor Alban J Lynch

The mining industry is an industry which, while at the forefront of progress, has its roots firmly planted in the past. There are common themes in the problems, the successes and the failures which it has seen, particularly since the Industrial Revolution. Understanding the past of the mining industry assists greatly in planning for the future. This applies as much to the formation of the intellectual resources of the industry as it does to any other aspect of it. This contribution is based on notes which are being prepared on the evolution of mining education and the lessons which can be learnt through 240 years of experience. Mining is considered to include mineral processing and the term 'schools of mines' is regarded as a generic term which includes departments, faculties, institutes or sections which work on mining technology in universities. The paper in its present incomplete form is a response to the invitation by the National Tertiary Education Taskforce to present comments on mining education. Thanks are due to Fathi Habashi (1997) for his informative and interesting paper on the early Schools of Mines.

1. Preface

Why were the early Schools of Mines established? How has the system evolved since then? What is its present position? What have been the factors leading to success or failure? What are the lessons contained in the past which are important for the future? These are some of the questions to be considered when planning the future of a 240 year old system of advanced training for mining engineers which, for all its faults, is an indispensable part of the mining industry. Case studies will be used to illustrate features thought to be of particular significance.

2. The Evolution of the Schools of Mines

The chronology of important developments in mining education is:

Middle Ages	rise of the universities with courses in law, theology, medicine and arts
Early 16th century	the first mining textbooks, e.g. Agricola (1554)
Before 18th century ...	training by apprenticeships and on-the-job work
1700-1720	vocational mining schools, ie Schemnitz (1702), Joachimsthal (1716)
1747	first professional engineering college in modern world opened in France
1757	first School of Mines at Potosi, New Spain, now Bolivia (closed in 1786)
1765-1792	**The first wave of mining education**. Schools of Mines established in Europe where mining was expanding and serious difficulties were being encountered. Early Schools were at Freiberg (1765), Berlin (1770), St. Petersburg (1773), Paris (1783), Mexico City (1792). Spanish colonies in the Americas were regarded as part of European Spain at the time.

1794	first Technical University, Ecole Polytechnique, founded in Paris 1800-1860 growth of mining education in Europe due to the expansion of the mining industry caused by the Industrial Revolution. Schools of Mines established in Sweden (1820), Liege (1831), Leoben (1840), London (1851), Camborne (1859)
1860-1900	**The second wave of mining education**. Schools of Mines established in countries remote from Europe with expanding mining industries and few mining engineers e.g. USA (New York 1864), Australia (Ballarat 1870), New Zealand (Otago 1871), Brazil (Ouro Preto 1876), South Africa (Kimberley 1896)
1900-1960	continuation of mining education in the major mining countries, with occasional initiatives e.g. USA (MIT, University of Minnesota), Australia (University of Melbourne)
1960-1997	explosive growth of tertiary education leading to difficulties in mining education. Initiatives in activities related to education, e.g. Australia (AMIRA).
2000	**The third wave of mining education**

2.1. Case Study 1 - The College of Mining in Mexico City

This study is relevant to the first wave of mining education. It is thought that it has features in common with other Schools established at this time but these are still to be verified.

2.1.1. Background

The Spanish invaded Mexico in 1521. They annexed it as a colony of the Spanish Crown, found rich deposits of silver, and commenced what was for the day large scale mining operations. Even in their early years of mining in Mexico the Spanish contributed much to mining technology, particularly with the industrial development of the amalgamation process by Bartolome de Medina in Pachuca in 1557. This process had an impact on the mining industry for 300 years which was similar to the impact of flotation during the 20th century. The average annual production (tonnes) of gold and silver from 1521-1990 was:

	1521-1600	1601-1700	1701-1800	1801-1900	1901-1990
Gold	0.30	0.38	0.912	2.12	15.63
Silver	35.20	95.38	324.88	577.82	1899.39

From 1521 mining in Mexico became essential to the wealth of the Spanish Crown and to the prosperity of the colony. But by 1771, after 250 years of mining, it was recognised that "*During the centuries the Mexican mines had been exploited irrationally, without prudence, without the slightest sign of planning, and above all without thinking of anything except the immediate benefit. This had produced an alarming state of affairs for the government in Madrid. Flooded mines, lost veins, and discontented miners were to be found everywhere......*".

To solve the problems workers, owners and governors "*....put together a body of mining ordinances and laws which permitted an orderly development of the industry based on the formation of professionals with solid scientific training to whom could be entrusted the leadership of this most important activity*"

In 1774 a delegation went from Mexico to Madrid to present their proposals to King Carlos III. They had a clear vision for the future "*....we know the great necessity which our mineral industry has for men well and sufficiently trained so that the management* *of this most important and delicate profession can be guaranteed. There is no better action than to train them and for this it is necessary to create a Metallurgical Seminary which is led by a Director learned in mathematics, experimental physics, chemistry and metallurgy, and profoundly learned in the mining practices of New Spain*"

The King consented to the proposals. "*The Royal Seminary of Mining was opened in 1792 .... led by the famous Fausto de Elhuyar......The Mining Seminary was the site of the first institute of scientific investigation on the continent, and those graduating as experts in the faculty of mines obtained the privilege, starting in 1797, of being accepted with the generic name of engineers in the rest of America, in the Philippines and in all Europe. Mexico then converted itself into the principal exporter of scientific and technical knowledge of the continent and perhaps according to many of the world*".

There were many difficulties in bringing the School into operation. These included:

- a new style of education "*During the colonial era the church had held a monopoly on education in New Spain.....The mining education project moved away from the traditional pattern towards a system of professional, technical and specialist formation. The mining delegates defined the school policy clearly ; they wanted the preparation of modern professionals who could be entrusted with the direction of production*"
- the recruitment of the right type of students "*In the initial project for the College in 1774 those to be educated were to be descendants of poor Spanish miners and sons of indigenous chiefs. The mine owners knew which social stratum would be found to be loyal servants of the miners' interests, always offering them an adequate education. However the composition of the students in the School when it was opened in 1792 was very different, the students were a small elite from Mexico City....only a few worked on problems associated with productive mining work*"
- the building available for the School "*renting a site was found to be inadequate.....Elhuyar insisted on the construction of an adequate building. In 1797 the services of the prestigious architect Manuel Tolsa were contracted for the work. The new building was occupied by the students in 1811*".

Fausto de Elhuyar set up an excellent academic and practical training program, including clear instructions for thesis writing, and won the battles of staff recruitment and building construction.

2.1.2. The Years of Operation

It was ironic that after 300 years of relative political stability in Mexico the College, which was the result of extraordinary vision and perception in those early years of tertiary technical education, was established only a few years before the start of a period of wars and instability which convulsed Mexico for 100 years. The War of Independence occurred during 1811-21and this war led to the departure of Elhuyar for Spain in 1821. Perhaps it was not coincidence that his departure was followed by prolonged arguments by academic staff about the nature of the courses, by the interventions of government in the affairs of the College, by financial problems, and ultimately by the reluctance of the mining industry to employ the graduates because of the theoretical nature of their training (many of these problems still occur today in spite of 150 years of experience). To improve the quality of the pool of graduates available the industry established a Practical School of Mines near the great silver mine at Fresnillo in 1853 and a 2.5 year course in beneficiation, mining and exploration techniques was offered.

The College of Mines was successful because through it the mine owners introduced tertiary education to Mexico and established a culture of advanced training and research. But it did not achieve all that the founders hoped, partly because of the turbulence of the times. The College was converted into the National School of Engineers in 1867 with Mining as one of the courses, and this School was integrated into the National University as the Faculty of Engineering in 1910.

2.1.3. Features which are relevant to 1997

1 The vision of the mine owners in 1771 in recognising that advanced training at a specialised School in both the theory and practice of mining, beneficiation and exploration operations was necessary to support the mining industry, and in being prepared to step outside the bounds of conventional practice to achieve it. This was at a time when tertiary education in engineering was still in its infancy.

2 The strong leadership of the Director Fausto de Elhuyar in technical and academic areas and in providing the infrastructure which the School required for reasonable operation.

3 The commitment of the mine owners to ensure that the activities which were necessary to convert the vision into reality could be supported financially, at least early in the project.

4 The interest of the mine owners in providing an alternative education system in Fresnillo when the deficiencies in the existing College in Mexico City became apparent.

2.2. Case Study 2 - Michigan School of Mines

This case study refers to the second wave of mining education which occurred in countries remote from the centres of mining education in Europe.

2.2.1. Background

By 1860 the Industrial Revolution had given some countries in Europe a commanding position in world economics and USA was beginning its spectacular industrial growth. The essential raw materials were silver and gold for money and coal and iron for steam power and steel. Metals such as lead, tin and copper were also very important. Universities, including engineering schools, had become a recognised tertiary branch of education and were being funded by governments. Mining in countries remote from Europe by then had encountered serious technical problems and these were exacerbated by a shortage of skilled mining engineers which could only be corrected by local training courses.

The first School of Mines in USA was created at Columbia College (now Columbia University) in 1864. This study refers to the School of Mines which was opened in Upper Michigan in 1885 to support the great copper and iron ore mines in the region. The first step in establishing the School occurred in 1861 when the Committee on Education in the Michigan House of Representatives reported favourably on it, commenting inter alia that: "*The greatest difficulty the companies have had to contend with, in mining for copper on Lake Superior, has arisen from the want of competent mining engineers to superintend and direct their mining operations. In looking back, and carefully studying the history of the various companies and the causes of their failure, the wonder is that any have succeeded. Many of them have been ruined by ignorant, self styled geologists and engineers, who have had no knowledge whatever to fit them for the business they undertook to manage......*".

The Governor signed the Bill approved by the House to establish a School but the start of the Civil War and competing interests delayed the project.

During the next 20 years the mining industry and the population dependent on it continued to expand in the area. In the early 1880's two men who were successful in their professions and had vision and an interest in developing the state, mining engineer J Parke Channing and lawyer-politician Jay A Hubbell, marshaled support again for a Bill to establish a Mining School. This was passed by the House and signed by the Governor in 1885.

2.2.2. The Years of Operation

The early years were difficult with poor accommodation - the first classes were held on the second floor of a fire station - and problems in attracting staff and developing an adequate range of courses. But the Director, Marshall E Wadsworth, was a strong and determined man and during his 12 years tenure the School changed from "... *a weak and sickly infant for which death was momentarily expected*.." to a "*....strong and vigorous institution*".

The School, with continued strong leadership and the support of the legislature, went from success to success. It became the Michigan College of Mining and Technology and, ultimately, the Michigan Technological University. Metallurgy is now a particular strength of the University.

2.2.3. Features which are relevant to 1997

1 Recognition of the objectives to be achieved by the School and the support of industry and government in establishing the School and giving it a focus.

2 Strong leadership.

3 Flexibility in changing objectives as circumstances changed.

2.3. Case Study 3 - The University of Melbourne

This case study is concerned with the rise of mining research in universities and its beneficial effect on education. It is set in a time of depression and low metal prices. The research initiatives by the mining industry at the University of Melbourne had a major impact on the mining and metal industries.

2.3.1. Background

By 1910 Australia had an adequate mining education system with courses being offered at the Universities of Sydney and Melbourne and Schools of Mines operating in several states. The triumph of flotation at Broken Hill, the new zinc industry in Tasmania based on Broken Hill zinc, and advances in lead smelting at Port Pirie, had transformed the lead-zinc industry in Australia. In addition, it had given an appreciation of the worth of technical skills to the engineers who managed the Australian mining companies. The head offices' of the companies were at that time mainly in Melbourne and the University of Melbourne was thus a natural focus for their research interests. The mining industry, led by men such as Harry Hey from Tasmania and W E Wainwright from Broken Hill, supported several mining and metallurgy programs at the University of Melbourne which led to it becoming one of the great universities in mining and metallurgy in the world from 1920-50.

2.3.2. The Years of Operation

The programs were concerned with:

- the fundamentals of flotation in the Department of Chemistry from 1925 sponsored by several mining companies. The leader was Dr Ian Wark who was to prove himself one of the great Australian scientists. He was supported by Dr Keith Sutherland, among others, and the program was very successful. It moved out of the University in 1940 when Dr Wark was asked to set up the CSIR Division of Industrial Chemistry.
- mineralogy in the Department of Geology from 1921 was sponsored partly by the mining industry through the AusIMM. Professor E W Skeats, a President of the AusIMM, started the project, and it was led by Drs Frank Stillwell and Austin Edwards. Due to their efforts and supported by the mining industry this Department was a world leader in studies concerned with the textures of the ore minerals for some decades. Dr Edwards in particular had a great reputation as a lecturer.
- secondary metallurgy in the Department of Metallurgy in 1922. BHP established its Newcastle steelworks in 1915 and this underpinned the industrialisation of Australia which followed the first world war. The leaders of the mining industry supported the University of Melbourne in establishing a Chair of Secondary Metallurgy and in appointing Professor J Neill Greenwood from England as the Professor. Through his research and his students, and as a President of the AusIMM, he contributed much to industry. Like others who were successful he was a strong leader.
- ore dressing in the Department of Metallurgy. In collaboration with CSIR Professor Greenwood set up the Ore Testing Section which for many years was the main independent ore testing laboratory in Australia. It also contributed much to teaching and research in the University.

Mining activities at the University of Melbourne declined from the 1960's and finished around 1985.

2.3.3. Features which are relevant to 1997

1 The vision of the mining industry leaders in recognising the importance of university research to the mining industry and in supporting this research in difficult financial times

2 the strong leadership and the high technical competence of the Directors of the programs.

2.4. Case Study 4 - The Australian Mineral Industries Research Association Limited

AMIRA has no direct responsibility for education but there are lessons to be learnt from its 40 years of evolution which are important as far as mining education is concerned.

2.4.1. Background

By 1955 the world was recovering from 30 years of depression and wars and the pent up demand for materials was leading to a mineral boom. The Australian mining industry was led by skilled engineers who could see the boom coming and who recognised that their companies needed better technology. They took the innovative step of establishing a cooperative research association, the Australian Mineral Industries Research Association Limited, which had to earn its own income and had no facilities or staff to carry out its own research. The modus operandi was: to define research programs of sufficient interest to several companies to attract financial support, let a limited term contract to a suitable organisation to carry out the work - usually a unit in a university - and ensure that there was adequate technology transfer at the end of a project if it was successful. The expenses of AMIRA were debited to project funds.

2.4.2. The Years of Operation

AMIRA has proved to be a real success although it took a few years for many companies to understand the unusual concepts involved and to realise the benefits which could be obtained. It has extended the conventional boundaries in research projects in mining, metallurgical and geological engineering just as the Mexican School of Mines extended them in education 200 years ago. It has taken a leading role in defining and funding projects which are of interest on an industry wide basis, it has supported financially large research units in universities through research contracts, and through this support it has contributed strongly to post graduate training in areas of industry needs.

Many countries have thought about or attempted to duplicate the AMIRA story, but few have useful results to show. Changing conditions continue to modify the AMIRA style, and this flexibility is expected to continue to generate success.

2.4.3. Features which are relevant to Mining Engineering Education in 1997.

1 AMIRA as a mineral industry organisation operates on a pay for performance basis, poor performance means no continued finance. It is generous in its support but demanding as far as quality of work is concerned.

2 It has found a way to utilise a small part of the immense resources in publicly funded organisations to benefit the country through involving their scientific skills in specific industry problems.

3 It contributes to the pool of highly trained personnel in technical areas required by the mineral industry.

3. The Third Wave of Mining Education - 2000-2040

Mining education is concerned with the technologies involved in the extraction and processing of ores and minerals and, as such, is directly related to mineral production. Declining mineral production in a country means a declining need for mining engineering education, increasing mineral production means an increasing need. Mineral production on a world wide basis can be expected to increase for at least 50 years and probably much longer as the large and growing populations in developing countries slowly improve their standards of life through increased consumption of energy and materials. The trend of mining production to move towards the developing countries can be expected to continue.

Is a third wave of mining education in prospect ? Yes, it is beginning to rise now and it can be expected to peak in 20-30 years in the developing countries as the mining industry grows in those countries. It is only a few developed countries, such as Canada and Australia, which will participate in this wave and it is these countries, which can reap the benefits from renewing their mining education systems and participating in the international aspects of this third wave .The importance of the past as far as mining education is concerned is in the lessons which it has for the future. Some of the lessons which can be derived from the experience of 240 years are :

1 mining schools provide the intellectual resources of the mining industry. These are second only in importance to the mineral resources. When establishing a school or being involved with mining education it is essential that the mining industry defines its short term (5 year) and long term (30 year) objectives clearly with careful attention to the academic and financial environments in which the school will operate.
2 a long term commitment by the mining industry to education is necessary to achieve these objectives. This commitment requires:
   - a reasonable financial investment for a long term
   - involvement by senior industry personnel in the affairs of the school
3 the crucial factor is the appointment of a Director who is outstanding technically and as a leader, who understands the mining industry well, and who is totally committed to the success of the school.
4 occasionally it is advisable to go beyond the conventional boundaries of operation when these are found to be restrictive, as was done by the Mexican School of Mines, the University of Melbourne, and AMIRA.
5 the courses must have a clear objective of relevance to the mining industry.

There is no surprise in any of these but that does not make them any easier to achieve. A challenging and rewarding exercise now is:

- to define the short and long term objectives of a modern School of Mines,
- to write a plan to achieve these, and
- to cost the various alternatives

recognising that the mining industry has become international and that the third wave of mining schools is beginning to rise in developing countries.

Some possible characteristics of a successful School in the third wave are:

- it will follow the AMIRA model, ie. use resources supplied from public funds where appropriate but augment them considerably with funds from the industry. This will give the industry a degree of control which in today's academic environment is necessary to ensure progress;
- it will have access to expertise in all areas of mining and processing, not necessarily at its central location but by use of advanced communication techniques which can link distant locations instantly;
- it will have an international outlook and international Schools of Mines will be its partners in accordance with the trends in the mining industry;
- through linkages it will provide a continuous spectrum of education with the ability to move between levels, ie certificate, diploma, degree, postgraduate and continuing studies.

Appendix I
The Australasian Institute of Mining and Metallurgy - Graduate Outcomes

The following graduate outcomes illustrate how The AusIMM has changed its approach to accreditation of university courses. In future, The Institute will assess the outcomes rather than details of content and programs. The AusIMM will provide a set of educational outcomes for courses relevant to the disciplines, based on the maintenance of professional standards and minerals industry needs covered by geoscience, mining engineering and metallurgy (science and applied science), and environmental science and engineering that relate to the minerals industry. Universities seeking recognition will be invited to demonstrate how their courses' graduates meet these outcomes.

The AusIMM Task Force in each of these four disciplines, with representatives from both industry and academia, have identified the attributes a graduate should have at the completion of their university course.

1.1. Geosciences

The AusIMM expects graduates looking for employment in the minerals industry to have had the opportunity to achieve the following educational outcomes from recognised geoscience courses (numbers are for reference only, not ranking):

1.1.1. General Geological Outcomes

1. A sound basic knowledge of chemistry, mathematics, physics and statistics with an ability to apply this to geoscience issues.
2. Ability to identify common rock forming and ore minerals in hand specimen and under the microscope.
3. Ability to describe and classify rock specimens, and to understand their geological context and origins.
4. An understanding of global tectonic theory and basic geodynamic processes.
5. An understanding of geological processes leading to the formation of common igneous, sedimentary and metamorphic rocks.
6. An up to date understanding of rock weathering processes and the mobility of constituents in the surficial environment.
7. An understanding of basic physical, chemical and biological processes relevant to the formation of petroleum, coal and ore deposits.
8. Ability to produce and interpret geological maps of a variety of terrains, including those with complex topographic and structural features, and to utilise Global Positioning Systems.
9. Ability to plan, undertake and interpret basic geophysical and geochemical surveys and to interpret results from borehole logging, using basic statistical assessment.

1.1.2. Industry-related Outcomes

These must encompass both metalliferous and coal mining. Some will be expected to arise from a documented breadth of practical experience which is relevant the individual's chosen discipline, rather than simply from course work.

1. An understanding of ore deposit models and their use and limitations in mineral exploration and exploitation.
2. Familiarity with basic mining methods including the application of engineering geology and geomechanics, and the ability to undertake basic mine surveying.
3. Ability to undertake simple statistical and geostatistical analysis of assay data, and a demonstrated familiarity with sampling theory.
4. An understanding of the way companies conceive, plan and undertake mineral exploration programs, and why such exploration is necessary.
5. An understanding of exploration techniques applicable to metalliferous mineral deposits, coal, oil & gas, and industrial minerals, including seismic survey methodology.
6. Ability to log both diamond drill and percussion drilling holes.
7. An understanding of the factors involved in valuation of mineral properties.
8. Familiarity with geographic information systems, image analysis, and mine data packages, and an understanding of their use in the mineral exploration and mining industries.
9. Ability to carry out basic geotechnical studies and familiarity with some aspects of engineering geology, including rock mechanics and slope stability.
10. An understanding of chemical mobility in the surficial environment, and its relationship to physical hydrology, giving a working knowledge of hydrogeology.
11. Ability to undertake basic mineralogical and metallurgical studies relevant to the initial assessment of ore and coal deposits.
12. Familiarity with ecology.
13. Knowledge of occupational health and safety, environmental and cultural obligations.
14. An understanding of professional responsibility towards the broader community, and of its expectations related to the industry and chosen discipline.
15. A basic understanding of economic analysis and the factors affecting business decisions in the minerals industry.

1.2. Mining Engineering

The AusIMM expects graduates looking for employment in the minerals industry to have had the opportunity to achieve the following educational outcomes from recognised mining engineering courses (numbers are for reference only, not ranking):

1.2.1. Mining Engineering Outcomes

These must encompass both metalliferous and coal mining. Some of the more industry-related outcomes will be expected to arise from a documented breadth of practical experience which is relevant to the individual's chosen discipline, rather than simply from course work.

1. A sound basic knowledge of mathematics, statistics, physics, chemistry and geology and an ability to apply them to engineering and technology.
2. A basic understanding of mineralogy and mineral processing from ore to concentrate production, and of coal processing and preparation.
3. An understanding of the structure and properties of metals and other materials and their applications.
4. An understanding of fluid mechanics and particularly thermodynamics as applied to mining engineering.
5. An understanding of geomechanics and the ability to apply it in designing surface and underground excavations in a variety of ground conditions.
6. An understanding of mining methods and systems, with the ability to apply them to a variety of routine projects involving surface and underground excavation for all kinds of mines.
7. Ability to undertake basic surveying, both on the surface and underground.
8. An understanding of hydrology and mine drainage and the ability to design simple dewatering systems for surface and underground excavations.
9. An understanding of mine ventilation and the ability to design a basic system for underground workings.
10. An understanding of civil, electrical and mechanical engineering principles and technology and their application in mining.
11. An understanding of mineral sampling and estimation techniques, including geostatistics, with the ability to apply these in assessing resources and reserves, in mine planning and mine design and in operating grade control.
12. An understanding of systems engineering particularly as applied to mine production systems, both surface and underground.
13. An understanding of mine transport systems with the ability to design straightforward concepts for personnel and materials haulage.
14. Knowledge of occupational health, safety, industrial relations and cultural obligations in general and mine safety legislation in particular.
15. An understanding of the environmental factors which must be integrated with all phases of mining from exploration through to final rehabilitation of the land.
16. An understanding of professional responsibility towards the broader community, and of its expectations related to the industry and to mining engineering.

17. A basic understanding of accounting principles, financial analysis, mineral economics and the factors affecting business decisions in the minerals industry.
18. Ability to design and conduct feasibility studies and undertake project evaluation.
19. An understanding of the role of technology in wealth creation and of the role of Research & Development in technology development.

1.3. Metallurgical Science and Engineering

The AusIMM expects graduates looking for employment in the minerals industry to have had the opportunity to achieve the following educational outcomes from recognised metallurgy, materials sciences or other courses (numbers are for reference only, not ranking):

1.3.1. General Metallurgical Outcomes

1. A sound basic knowledge of chemistry, mathematics, physics and statistics with an ability to apply this to metallurgical issues.
2. An understanding of experimental design and the scientific method.
3. An understanding of the structure and properties of metals and other materials and their applications.
4. An understanding of stoichiometry and the ability to perform mass and energy balances, including using common software.
5. An understanding of the theory of particle mechanics and surface chemistry and their application to mineral beneficiation and agglomeration.
6. An understanding of chemical thermodynamics with the ability to perform chemical equilibrium calculations and the ability to apply thermodynamic principles to metallurgical processes.
7. An understanding of reaction kinetics and the ability to apply it to metallurgical reactions.
8. An understanding of heat, mass and momentum transfer principles and the ability to apply these to metallurgical processes.
9. Familiarity with laboratory techniques for chemical and mineralogical analysis.

1.3.2. Industry-related Outcomes

Some of these will be expected to arise from a documented breadth of practical experience which is relevant to the individual's chosen discipline, rather than simply from course work.

1. A basic understanding of geology, mineralogy and mining engineering in relation to metallurgical processing; a basic knowledge of other engineering disciplines.
2. An understanding of a broad range of unit operations in mineral processing, hydrometallurgy and pyrometallurgy and their integration in flowsheets.
3. An understanding of the principles of sampling theory and an ability to apply it in plant operations.
4. An understanding of flowsheet development and plant design and the ability to use flowsheeting packages and to select and size equipment.

5. An understanding of process control principles and the ability to apply these to metallurgical processes.
6. Knowledge of occupational health and safety, environmental, industrial relations and cultural obligations.
7. An understanding of professional responsibility towards the broader community, and of its expectations related to the industry and chosen discipline.
8. A basic understanding of financial analysis and the factors affecting business decisions in the minerals industry.
9. An understanding of the role of technology in wealth creation and of the role of R&D in technology development.

1.4 Environmental Science and Engineering

The AusIMM expects graduates looking for employment in the minerals industry to have had the opportunity to achieve most of the following educational outcomes from recognised environmental courses as they apply to mining. It is envisaged that these will normally be four year courses. (Numbers are for reference only, not ranking):

1.4.1. General Environmental Science and Engineering Outcomes

1. A sound basic knowledge of chemical, physical, biological and earth sciences, mathematics, and statistical techniques with an ability to apply these to a wide range of environmental issues.
2. In the case of environmental engineering, an understanding of the application of engineering principles and technology in mining and mineral processing.
3. A detailed understanding of, and research experience in, one or more areas of environmental application.
4. Ability to apply this experience and the fundamental techniques involved in science or engineering method to other environmental areas.
5. An understanding of the interdisciplinary nature of environmental problems and ability to deal with them in their context.
6. A detailed understanding of major processes which have shaped biogeochemical systems (land, air and water systems and their ecology).
7. An understanding of quantitative investigative techniques, including experimental, instrumental and analytical techniques.
8. Ability to plan, undertake, interpret and report environmental investigations, including the ability to summarise and present data clearly.
9. Ability to analyse and synthesise data, define problems and formulate solutions to environmental problems.

1.4.2. Industry-related Outcomes

Some of these will be expected to arise from a documented breadth of practical experience which is relevant to the individual's chosen discipline, rather than simply from course work.

1. An understanding of the environmental factors which must be integrated with all phases of mining from exploration through to final rehabilitation of the land, and with mineral processing.
2. Familiarity with basic exploration, mining and mineral processing terminology and methods, and the environmental implications of those activities.
3. Ability to understand the social and community relations issues in mining and mineral processing and an awareness of methods of dealing with them.
4. Ability to undertake scientifically sound monitoring programs and an understanding of techniques for spatial data analysis, such as geographic information systems.
5. An understanding of sustainable development and eco-efficiency (doing more with less) principles relevant to mining and mineral processing, including waste minimisation and management.
6. Ability to communicate environmental principles and practice within the organisation and to the outside community.

1.5. Personal Skills

(The following are basically from Geosciences, but the others differ little, and are as far as possible identical.)

These will be developed during each student's entire tertiary education experience. Courses should provide an opportunity for students to develop these skills during their study. They are important and will affect a graduate's career in industry as much as anything preceding.

1. An awareness of own strengths and areas which need development, together with realistic expectations regarding career and roles.
2. Ability to manage self, and potentially, others.
3. Resourcefulness and ability to operate effectively in diverse situations and cultures.
4. Ability to observe and to learn by reflecting on observation and experience.
5. Ability to define problems from inadequate data and to formulate and carry out logical approaches to solving problems.
6. Ability to negotiate, share information, work in a team and deal with conflict, while being confident in independent thought.
7. Ability to listen and to communicate effectively, both orally and in writing.
8. Ability to access knowledge and undertake independent investigation, particularly to research and compile information for reports.
9. A high level of computer literacy and the ability quickly to learn and use new systems of information technology for communication and mining applications.

10. Ability to recognise and appreciate alternative views, as well as to negotiate and influence others. (Environmental Science only).
11. Ability to distinguish personal belief systems from a professional approach to environmental issues. (Environmental Science only)

1.6. Personal Attributes

These are basically attitudinal and many will be formed well before leaving school, though they may be reinforced during tertiary education, including vacation experience.

1. Commitment to high professional standards.
2. Capacity and willingness for involvement in complex, demanding and also routine activities.
3. Capacity and willingness for involvement on new sites and with new groups and projects.
4. Preparedness to be flexible and adaptable while maintaining a sense of humour.
5. Community and environmental responsibility.
6. Commitment to act ethically and with integrity.
7. Personal responsibility and a willingness to be accountable for work.
8. A commitment to continuous learning and professional development.
9. A recognition of the importance of safety in the workplace.
10. A sense of history related to the minerals industry.
11. Enjoyment of living and working in the field for lengthy periods.

Appendix J
Guidelines for Submissions to the National Tertiary Education Taskforce

This Discussion Paper is the Minerals Council of Australia's response to industry concerns that there are not enough people with good industry focussed tertiary education and training entering and staying in the minerals industry. The National Tertiary Education Taskforce has developed discussion and initial recommendations based on preliminary consultations with industry, university and industry associations. The Taskforce is now seeking submissions, from all stakeholders, to develop wide ranging debate in relation to this paper. A summary of these written submissions will be combined with seminars drawing all stakeholders together, from which industry will develop collaborative final recommendations.

In developing submissions the Council asks that each response to this discussion paper be considered in terms of how it will attract an adequate number of the right people to the minerals industry; how the graduates of each system will serve the needs of the industry; and what each offers to continually develop managerial and technical expertise in the industry. In aspiring to address these goals it is important to develop an insight into the long term future, so that a strategic long term direction of national interest can be developed and managed. The Taskforce wishes to develop conscious thought into issues that would benefit from national coordination, while considering the maintenance of diversity in appropriate areas. It is important for all stakeholders to think beyond individual interests and consider recommendations that provide national solutions for national problems.

The closing date for submissions is 10th April, 1998.

Please forward submissions to the following address.

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National Tertiary Education Taskforce
Minerals Council of Australia

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An electronic copy of each submission would be appreciated. All submissions will be published on the Minerals Council of Australia's World Wide Web Site. It is also possible to down load an electronic copy of this document from the web site.

World Wide Web Site for the Minerals Council of Australia is
http://www.minerals.org.au/

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