Minerals Council of Australia
National Tertiary Education Taskforce

Back from the Brink

Reshaping Minerals Tertiary Education

Discussion Paper
February 1998

MINERALS
COUNCIL
OF AUSTRALIA

Mining Industry House
216 Northbourne Avenue
Braddon ACT 2612

PO Box 363
Dickson ACT 2602

Telephone 02 6279 3600
Facsimile 02 6279 3699

ACN 008455141

"A great deal of attention has lately been given to the discussion as to the education required for engineers, and especially for mining engineers. … The Institute of Mining and Metallurgy had a few years back a very long discussion on the subject, and the subject appears to be one of perennial interest to similar societies."

Lewis JB (1905)

'The Training of a Mining Engineer'

Proceeding of the Australasian Institute of Mining Engineers, Paper 169.

"In his presidential address for 1970 entitled 'Men for Minerals', W.J. Cuming (1970) focussed on the shortage of technically trained personnel for the mining industry and the need for communication skills … [Sir James Foots focussed education] *in his presidential address to The Institute in 1974 which was entitled 'Ore to metal - the education needs'."*

Rose JM and Brady JT (1993)

'Overview of Mining and Metallurgical Education in Australasia'

Monograph 19, The AuslMM, Melbourne.

It would seem that tertiary education for the minerals industry has been and will continue to be an issue for some time.

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Foreword

The Western Australian Minerals Industry Tertiary Education Taskforce Discussion Paper attracted considerable interest from industry and university sectors upon its release in July 1996. The general directions articulated by the Western Australian Taskforce were widely acknowledged as a useful start in a much-needed debate. Major recommendations of the Western Australian Taskforce were that a 'National Centre' for the education and training of minerals industry specialists be established and that the Minerals Council of Australia should convene a working party to progress the establishment of this National Centre.

The Minerals Council of Australia consequently established the National Tertiary Education Taskforce to identify specific steps for improving minerals tertiary education in Australia. This discussion paper, developed by the Taskforce and its Working Party, endeavours to build upon the foundation established by the Western Australian Discussion Paper.

The Taskforce members are:

	Position	**Representing**
RJ Carter (Chairman)	Chief Executive Officer, BHP Minerals Now Retired	Minerals Council of Australia
BL Cusack	Managing Director, Rio Tinto Australia, Rio Tinto Limited	The Chamber of Minerals and Energy of Western Australia Inc.
P McCarthy	Managing Director, Powercoal Pty Ltd	New South Wales Minerals Council
E Muir	General Manager Human Resources Technology Group, Rio Tinto Limited	The Australiasian Institute of Mining and Metallurgy
P Munro	Principal Engineer Metallurgy, M.I.M. Holdings Limited	Queensland Mining Council
C Rawlings	Managing Director, QCT Resources Limited	Queensland Mining Council
D Stuart	Assistant Director - Education	Minerals Council of Australia
K Braund (Exec. Officer)	Executive Officer, National Tertiary Education Taskforce	Minerals Council of Australia

The Taskforce was supported by a Working Party comprising:

	Position	**Representing**
Peter Fairclough	Government and Public Affairs Manager, WMC Resources Limited	The Chamber of Minerals and Energy of Western Australia Inc.
Majella Fowler	Manager Human Resources, BHP Manganese	Minerals Council of Australia
Karin Lorenzon	Principal Adviser Human Resources, Rio Tinto Limited	Minerals Council of Australia
Martin Lynch	Manager - Strategic Marketing, Hamersley Iron Pty Limited	Minerals Council of Australia
Helen Macdonald	Human Resources Officer - Education, Normandy Mining Limited	Northern Territory Minerals Council
Tim Scully	Group Manager - Corporate Human Resources, WMC Resources Limited	Minerals Council of Australia
David Wallace	Manager - Exploration, Aberfoyle Resources Limited	Minerals Council of Australia
Brian White	Director, Tennent, Isokangas Pty Ltd	Queensland Mining Council
Lesley Wood	Graduate Recruitment and Development Adviser, M.I.M. Holdings Limited	Queensland Mining Council

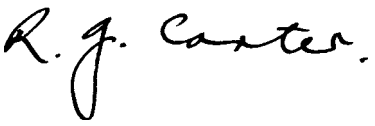
The Australian minerals industry's main concern is that, in various areas, new industry professionals need to be better equipped to deal with current and emerging challenges such as globalisation of companies, ever-toughening competition, and rapidly changing technologies. The industry is seeking to ensure that there are sufficient technically capable graduates available to meet its needs, that these graduates value continuing professional development and that they have had sufficient exposure to industry workplaces to ensure they are aware of broader issues such as safety, environmental care and commercial aspects of their work. The Taskforce believes this will require a much greater industry commitment to, and involvement in, education issues.

In response to industry's concerns the National Tertiary Education Taskforce established the following Mission.

"The Development of World-Class Education for a World-Class Minerals Industry"

To achieve this mission the Taskforce proposes a way to manage these concerns and deliver the desired outcomes for industry and the community. This Paper considers a broad spectrum of options in which all stakeholders in the minerals sector can have clearly defined commitments and accountabilities.

Following the release of this discussion paper the Taskforce encourages all stakeholders to formally respond. The Minerals Council of Australia will consider these responses, along with stakeholder seminars, in the collaborative development of national recommendations. The Taskforce believes it is essential for all stakeholders - big and small mining companies, the tertiary education sector, industry groups, Federal and State Governments, professionals and students to play a crucial role in setting the direction of the final recommendations.



R J Carter

Chairman
National Tertiary Education Taskforce
Minerals Council of Australia

Acknowledgments

In compiling this discussion paper, the National Tertiary Education Taskforce consulted with a significant number of individuals from within Australian universities, government, professional associations and industry.

The Minerals Council of Australia and the Taskforce wishes to acknowledge the assistance and contribution of all parties who participated in interviews, focus groups and discussions.

The Minerals Council would like to thank the considerable financial and resource contributions made by the following companies.

Aberfoyle Resources Limited
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Hamersley Iron Pty Limited
M.I.M. Holdings Limited
Normandy Mining Limited
Powercoal Pty Ltd
QCT Resources Limited
Rio Tinto Limited
Tennent, Isokangas Pty Ltd
WMC Resources Limited

The Taskforce also thanks Professor Alban Lynch and Professor Barry Brady for their valuable commissioned contributions which develop a historical and international picture of minerals education.

The Minerals Council of Australia thanks the Western Australian Chamber of Minerals and Energy for their significant leadership and for the resources it devoted to initiating national discussion on minerals tertiary education in Australia.

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The opportunity

Australia has the potential to be the world's leader in minerals education. University education in Australia is changing, driven by more market orientation, reduced government funding and more flexible delivery of education. The opportunity exists for a true partnership between industry, government and academia to reshape minerals education in Australia and secure the supply of the industry's future specialist professionals.

The threat

If this partnership does not emerge, the same changes to Australia's higher education that have created the opportunity will exacerbate the shortcomings of an already fragmented and unstable system - possibly pushing it over the brink of viability as a long term supplier of the graduates that Australian industry will need in years ahead.

This will pose severe long term problems to the Australian minerals industry, which already faces a chronic shortage of minerals specialist graduates, especially mining engineers and metallurgical engineers. In the past, shortfalls have been met largely by the leading Schools of Mines in the UK, USA and NZ. However, these schools have dramatically weakened in recent years, and many have closed.

The current situation

Australia's minerals education system, in its current form, is fragile and is in no position to seize the opportunity, and is more likely to succumb to the threat. Current trends include:

- an acute shortage of talented academic staff, as a result of University remuneration packages having become hopelessly uncompetitive with those in the minerals industry;
- small student populations and high relative costs, making mineral specific courses vulnerable to closures, when Universities are under extreme cost pressures; this situation will be exacerbated if enrolments drop in response to, say, a cyclical down turn in the industry; and
- under-resourcing of minerals departments because of their comparatively small size, making these departments incapable of delivering top class teaching in all aspects of their courses, despite being excellent in some areas.

The Taskforce (and its predecessor Taskforce set up by the WA Chamber of Minerals and Energy) has identified further weaknesses in the present system:

- graduates often have a poor understanding of how their theoretical knowledge can be applied in practice. They also tend to be unaware of the importance of communication and 'people skills', how business decisions are made, occupational health and safety, the demands of life in (often remote) operational settings and other significant issues facing industry;

- industry has a poor record of employing new graduates, with most companies preferring to recruit professionals with some experience. The Western Australian Taskforce survey found that only 16% of responding companies intended to employ new graduates;
- industry uptake of new graduates is profoundly affected by the business cycle. This has established a 'boom or bust' environment for educators, graduates and ultimately, for industry, which is far from optimum;
- industry has been inconsistent and ad hoc in interacting with the tertiary education system. An example of this is the unwillingness of too many companies to offer students opportunities for their mandatory vacation work experience; and
- industry has adopted too narrow and restricted a view of what constitutes an acceptable preparation for a career as a minerals specialist, particularly as a mining engineer or metallurgist. With some important exceptions, this has robbed industry of the opportunity to diversify its sources of graduates and strengthen its standards of competence. It has also restricted an opportunity to make up the frequent shortages of specialist graduates.

A positive vision for the future

Despite these weaknesses, the Taskforce believes that Australia has the expertise and resources to be the heir to the role once played by leading overseas Schools of Mines. Realising this vision will require a major restructuring of the system in a way that will meet industry's needs for technically excellent graduates and better prepare these critically important people for their careers. The Taskforce believes that the minerals industry must take the lead in this restructuring and go on to become an active partner with universities and government in the new system. It therefore, recommends that:

(i) an organisation, to be named the Minerals Education Council (MEC), be established by the Minerals Council of Australia to initiate and guide the changes needed for the future and to implement the Taskforce's recommendations;

(ii) the MEC, in collaboration with participating universities and governments, establishes a network of selected university departments and other bodies which are dedicated to achieving true 'world class' education in the specialist disciplines;

(iii) the network members are strengthened by programs agreed by MEC and resourced by industry, governments and universities. Industry will also need to contribute concerted and organised non financial support;

(iv) the network members should be selected on the basis of proposals submitted to MEC by interested universities. Selection criteria will include willingness to collaborate with other universities or organisations to ensure first class coursework delivery, ability to attract first class students, vision and willingness to innovate, research capabilities, quality of academic staff, additional resources needed and how they are to be applied, etc;

(v) industry broadens its view of what constitutes an acceptable minerals education and establishes alternative pathways for providing appropriate qualifications; and

(vi) MEC establishes a national school for postgraduate minerals education coursework. This school, to be known as the Australian School of Minerals Resources (ASMR), will be a 'virtual' organisation which will broker coursework programs, from universities and other bodies, to provide:

a) conversion courses for non-minerals graduates to support recommendation (v);
b) masters degrees by coursework in advanced specialist fields; and
c) short courses for continuing professional development.

The network of centres will provide a first class initial degree program as well as being the supporting pillars of the ASMR. The ASMR will also draw on coursework from a wide range of other sources, including private providers and overseas Institutions.

Realising the vision

Significant further resources will be needed to fund the MEC and through it, the network of centres and the ASMR (which in time will become self funding). The administrative support costs of the MEC are estimated to be $2.5 million spread over five years. The additional funding for the MEC's programs will not be known until detailed proposals are made by the universities wishing to participate and these are prioritised by the MEC. However, the Taskforce believes that this extra funding could total around $20 million over a five year period. The industry (including its supporting service industries), universities and government are expected to provide these funds, although a significant proportion could come from the rationalisation of present programs.

The Taskforce therefore further recommends that the minerals industry through the Minerals Council of Australia and government:

(i) commit to funding the MEC's administration costs to a maximum of $2.5 million over five year period;

(ii) agree to provide significant support to implement the MEC's agreed programs;

(iii) develop a method by which industry, government and universities will each equitably contribute to the cost of implementing these initiatives; and

(iv) approve specific funding budgets at appropriate intervals to meet detailed programs submitted by MEC within guidelines to be laid down by the Minerals Council of Australia.

The Taskforce's findings, the analysis of them and the detailed explanation of the way in which its recommendations should be implemented are set out in the body of this report and its appendices. The report is commended to the industry, the universities and governments and the Taskforce looks forward to the debate, which it hopes will ensue.

Summary of Initiatives, Recommendations and Nature of Change

It is envisaged that the initiatives, recommendations and the nature of changes will result in an Australian system of minerals education which will serve the industry well into the long term. Without action, the industry will continue to accept what the system currently provides.

Initiatives

Initiative 1

Create a select network of centres and link this with industry. Each member-centre within the network should:

a) collaborate where desirable with other members to offer a world class minerals program and be able to deliver truly effective and, where necessary, innovative coursework;

b) have a structured practical experience program;

c) have an academic staff mix which is able to provide, as a priority, first class teaching, while also maintaining research skills in at least one significant area of the minerals field;

d) have the commitment and ability to attract talented students;

e) be located close to a research facility;

f) have long-term support from their parent university; and g) have the willingness and capability to deliver education to (full-fee paying) international students.

Initiative 2

Create a system of alternative educational pathways which ensure that the industry benefits from the great strength and depth of graduates in the wider tertiary education system. Three steps are required:

a) describe the broad educational preparation necessary for graduates filling the roles of mining engineers, metallurgists and geoscientists;

b) define a 'road map' of educational pathways into the minerals industry and how they might be followed; and

c) establish a national network of 'service' courses to support the alternative pathways.

Initiative 3

Establish the Australian School of Mineral Resources (ASMR) in order to create a world class centre of postgraduate minerals education. Coursework will cover:

a) conversion courses for non-minerals graduates to support Initiative 2;

b) masters coursework in advanced technical areas; and

c) short courses for continuing professional development.

These courses must be readily accessible to industry through the innovative coursework design and delivery.

Recommendations

Recommendation 1

Minerals Council of Australia should establish and fund a new body, the Minerals Education Council (MEC) in order to progress the initiatives recommended in this review. This would include the following steps:

a) the Minerals Council of Australia develop the charter for MEC and appoint a Chair and Board; and

b) the MEC to appoint an Executive Director to plan the strategy and resources required to progress the initiatives.

This is to be done within a budget of $2.5 million over five years.

Recommendation 2

The Minerals Education Council (MEC) should call for submissions from interested institutions to form a network of centres. These submissions should be made in conjunction with other university departments and minerals companies or industry bodies. The submissions would form the basis of a tendering process, and will result in a collaborative business plan which will be contractually agreed by all stakeholders. Submissions should detail:

a) how the criteria in Initiative 1 will be met by the proposal;

b) how they will support the alternative pathways of Initiative 2;

c) how these centres will contribute to the curriculum of the Australian School of Mineral Resources (Initiative 3);

d) the timetable for implementation;

e) the resources universities will commit; and

f) the resources required from the MEC and a proposal for accessing these resources.

The Nature of Change

Industry must change by:

- accepting there are limitations to the outcomes that can be delivered in an undergraduate degree course;
- accepting its own need for genuine continuing professional development (CPD) among its employees by establishing structured company CPD programs;
- identifying skills requirements needed from new graduates and implementing the necessary graduate orientation programs to deliver them;
- lessening the cycle of demand for newly graduated professionals by adopting more stable recruitment patterns;
- taking a greater role in the provision of undergraduate practical experience;
- increasing the percentage of companies being prepared to employ new graduates; and
- broadening its view of what constitutes a graduate suitable for a minerals industry career and rethinking recruitment efforts to reflect this.

Universities must change by rewarding behaviour aimed at:

- encouraging cooperation between individual departments both within universities and between universities, to share resources and to develop and deliver world class minerals eduction;
- encouraging innovation and regular examination of the traditional design and delivery of tertiary education; and
- placing a priority on the development of teaching excellence in tertiary education.

Federal government should assist change by changing the funding framework for higher education to place greater emphasis on:

- improving educational quality by encouraging cooperation and sharing between universities to efficiently utilise public and private resources;
- developing teaching excellence in tertiary education;
- encouraging and supporting student mobility to pursue cost effective and superior quality courses; and
- reducing the administrative burden on universities and rewarding the quality of educational outcomes.

Professional associations must continue to:

- work together to adopt a broader view of the tertiary qualifications and professional experience necessary for roles in the minerals industry;
- focus on systems for continuing professional development management which encourage strong continuous learning beliefs and behaviour; and
- consider whether consolidation or amalgamation of organisations might be in the best interests of minerals professionals and the industry.

1. Industry's changing requirements of minerals tertiary education

Key points

- Industry has not yet realised just how dependent its future profitability is on technical, engineering and scientific skills.
- Industry needs a diversity of skills and a supply of professionals flexible enough to accommodate business cycles; this demands a broad based education system and a broadening of industry's criteria for employing graduates.
- Industry must articulate its future requirements for professionals if it wants the education system to respond to its needs.
- Undergraduate education should deliver technical excellence in the fundamental principles of science and engineering, an understanding of broader issues facing the industry and the ability to continue to learn.
- Postgraduate education must include technically excellent coursework with pathways that provide access for professionals from non-minerals specific backgrounds.

1.1. Changes in the minerals industry are demanding new and better skills

To adapt to rapid changes in the global business environment, the Australian minerals industry constantly demands different and more highly developed skills of minerals professionals. The industry, therefore needs to reassess its requirements of tertiary education continually.

The forces that have emerged to shape the industry in recent decades are:

Rapid change demands new skills.

- fierce cost competition and declining real prices of minerals commodities;
- the opening up of the resources of developing countries and the globalisation of the operations of minerals companies;
- the technical challenges arising as orebodies become more difficult to find, mine and process; and
- increasing community awareness and expectations.

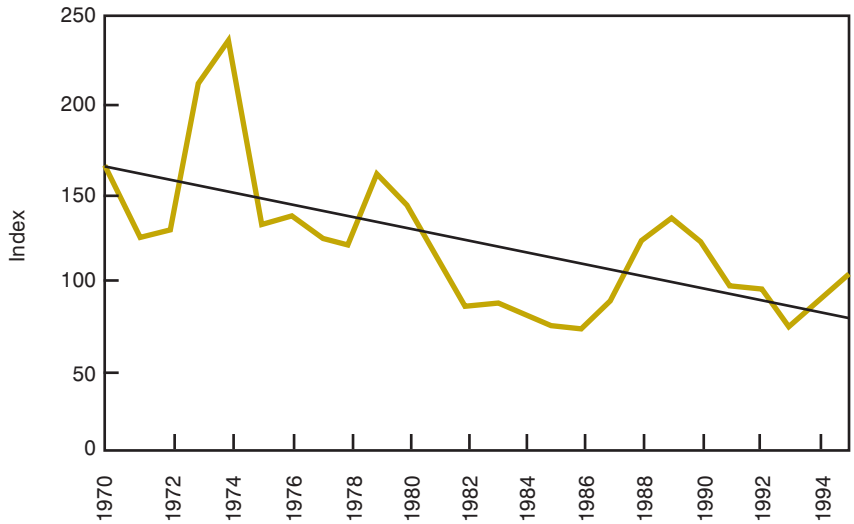
(a) Cost competition

The pressure to improve efficiency and reduce costs will intensify.

Since the mid 1960s, the minerals industry has faced increasingly fierce cost competition as more suppliers have come on-stream and technological advances have occurred. As Figure 1.1 and Figure 1.2 show, real prices for most minerals commodities have been falling steadily since the early 1970s. To deal with falling prices minerals companies have reduced their costs through a combination of better management and work practices and improvements in technology. The pressure to improve efficiency further and reduce costs will intensify.

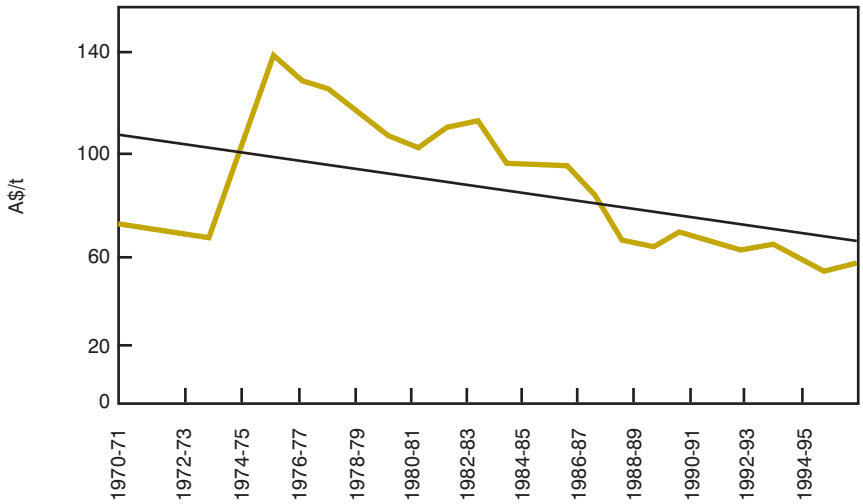
Minerals prices have fallen steadily over the long term.

Figure 1.1 Real Base Metals Prices Index



Note: 1995 Values.
Source: ABARE, Unpublished report to the Minerals Council of Australia

Figure 1.2 Real Coal Prices



Note: 1995-96 Values.
Source: ABARE, Unpublished report to the Minerals Council of Australia

(b) Globalisation

The 'Australian' industry is now international.

Globalisation of the industry, while not altogether a recent phenomenon, is proceeding rapidly. Firstly, developing countries are increasingly opening up their resources to exploitation by foreign companies. This trend is global and has been most notable in South America, South East Asia and Africa. Secondly, the companies leading the exploitation of these new resources are, in many cases, the existing large mining houses from Australia, the USA, the UK and Canada. The Australian minerals industry today is much more international in outlook and responsibility than it was only ten years ago.

(c) Technical challenges

Orebodies are harder to mine cost-effectively.

Within Australia, the massive underground and open-cut orebodies developed in the 1960s and 1970s are well advanced in their lives. In many cases they are becoming harder to mine cost-effectively and their replacement is becoming a significant issue. Finding and developing new orebodies in the future and efficiently exploiting existing orebodies will demand higher levels of technical skill than the industry has previously needed. The Taskforce believes that industry has not yet properly understood how dependent it is on technical, engineering and scientific skills and the education system that develops them.[1]

(d) Public expectations

Society has greater expectations of the minerals industry.

Issues such as native title and ecological sustainability have had a major impact on the minerals industry in many countries. In Australia these issues have been particularly acute and are expected to remain a feature of minerals development here and elsewhere. The industry is learning how to deal with these issues and how to turn them into a positive force for the industry. Further new issues can be expected to emerge which the industry will need to address progressively.

1.1.1. The minerals professional of the future

All these factors have combined to place new demands on minerals professionals ? demands which even ten years ago were only dimly realised. These new challenges show every sign of increasing in intensity. Furthermore, history suggests that different, and as yet unforseen challenges, will emerge in the years to come. This pace of change "*has prompted Leon Davis[2] to publicly raise a vital question - is the minerals industry capable of adjusting quickly enough to emergent pressures in the future - particularly if significant segments of it continue to rely on a traditional, reactive approach to change?*"[3]

Successful companies will need hghly capable people who continually develop new skills.

As an outcome of these trends and challenges, the Taskforce believes that for minerals companies to be successful, the critical requirements will be:

- to attract highly capable people into their companies, placing less emphasis on their specific educational background and job readiness and more on their ability to learn and to bring new and valuable insights to minerals operations; and
- to develop their professionals continuously, equipping them with high levels of specific technical and managerial skills to enable them to meet the changing demands of industry.

1.2. What are industry's requirements from tertiary education?

Industry needs a diversity of graduates and a flexible supply.

To meet the above challenges, the minerals industry requires three outcomes from tertiary education:

1) the best possible individual educational outcomes;
2) a diversity of graduates in flexible numbers; and
3) a strong and stable system.

1. The connectivity between the minerals industry and minerals education is further discussed in Appendix A Section 1.4 and Appendix H.
2. **Davis L** (1995), '*The New Competencies in Mining*', Address to the Australian Institute of Company Directors, Melbourne, October.
3. **Gaulton R** (1997), '*Minerals - Old Industry, New Realities*', The AusIMM Bulletin, No.5, August, p44-48.

1.2.1. Individual educational outcomes

The Taskforce's view of educational outcomes required from tertiary education has no better expression than in the following quotation from May and Lynch: "*The success of the Australian mining industry depends on the quality of its skills. High quality skills supported by a culture, which demands success lead to innovations, good practices and prosperity. Average skills lead inevitably to mediocrity.*"[4]

(a) Undergraduate education outcomes

Undergraduates need fundamental technical excellence, an understanding of broader issues, plus the ability to learn.

The Taskforce has concluded that universities must continue to shape undergraduate education and the minerals industry must play a greater role in the education process by contributing experience, resources and above all leadership. The primary responsibility for excellence in undergraduate tertiary education will continue to rest with academia.

The Taskforce believes that undergraduate education achieves its highest levels when the graduates are equipped with:

- an understanding of the basic science and engineering principles and the fundamental concepts of a technical discipline appropriate to a role as a geoscientist, mining engineer or metallurgist;
- the ability to apply these concepts to practical problems, preferably, but not limited to minerals - both in the classroom and in the field;
- an understanding of the linkages with other technical disciplines and of the need for leadership, teamwork and different perspectives when addressing complex problems;
- an appreciation of the limitations of the knowledge provided at the undergraduate level and the need for lifelong learning; and
- an understanding of broader issues such as economic evaluation, human relations, professional ethics, occupational health and safety and community expectations, and the relative importance of these issues when applying the concepts of the technical discipline in the workplace.

These requirements do not reduce the importance of an excellent technical education. On the contrary, excellence in the technical aspects of undergraduate education is as important as it has ever been. The essential point of 'technical excellence' is instilling a deep understanding of the fundamental principles of a discipline and not just imparting specific knowledge and skills. Given this, graduates should have an excellent foundation for continuous learning throughout their careers.

(b) Postgraduate education outcomes

Employers' requirements of minerals professionals will never be satisfied simply by undergraduate tertiary education, since it is impractical to teach every possible technical detail or to teach maturity and judgement. It is at the postgraduate and industry level that training develops the higher-level skills needed in particular technical areas.

Employers and professional are responsible for continuing professional education.

The Taskforce believes that employers and professionals must both take responsibility for building on undergraduate education and for developing those skills vital to their company's needs. Companies will need to implement programs that will continually identify and deliver the further education requirements for their professionals - starting from structured graduate induction programs through to recognised postgraduate qualifications. However, both employers and graduates require assistance in achieving

this. Higher education available at postgraduate level is one important mechanism for providing this assistance.

A postgraduate system must enable industry to draw from a wider range of graduates.

A postgraduate education system must provide a comprehensive range of relevant, readily accessible and technically excellent coursework, which will support all companies in developing their employees in minerals-related technical areas. This should provide the opportunity and the means for employers and employees to develop and achieve ever-higher standards of technical capability in the minerals field.

To support the supply of flexible numbers into the roles of minerals professionals the curricula of postgraduate coursework must also enable a system of pathways that readily educates professionals from non-minerals specific backgrounds.

1.2.2. Diversity and the ability to respond to short-term swings in activity

A characteristic of the minerals industry is the diversity of companies within it. There is no single graduate profile or professional model that suits the requirements of all employers. Different requirements are determined by employer behaviour and by the current and future roles of professionals. Even in a single company, different roles require different qualities in a professional. Minerals companies increasingly need professionals who can bring genuinely new perspectives to minerals industry issues. To integrate the minerals professions with the rest of society, a diversity of 'cultural' backgrounds is required, including gender, as well as a diversity of people with different educational and professional backgrounds.

Investment activity in the minerals industry is cyclical and, therefore, the industry has historically been characterised by alternating periods of shortage and oversupply of minerals professionals. While the industry should take steps to reduce the severity of these cycles, they will remain and will result in continued fluctuating demands for professionals.

Diversity and cyclic demand require a broad based system and for industry to broaden its criteria for the employment of graduates.

The requirements for diversity in culture and in perspectives mean that the system of minerals tertiary education should be designed to allow companies to draw from a wider range of professionals in flexible numbers - both graduates and more experienced professionals. The Taskforce believes that a broad-based system is the only way to achieve this.

This broad-based system will rely on minerals companies taking a wider view of what higher education and professional experience is necessar for roles in the minerals industry. Similarly, minerals tertiary education must recognise its role in developing a flexible system of high quality education which is accessible to many more students and professionals than is currently the case. This, however, must not lead to a lowering of educational standards.

1.2.3. A strong and stable system of minerals education

Without concerted action, minerals-specific education to support the Australian industry may become a thing of the past.

There is concern within industry that the current changes in higher education and the growing disconnection between industry and universities are jeopardising the current system of minerals education in Australia. It is feared that, without concerted action, minerals-specific education may decline.

A strong and stable system for delivering excellent minerals-specific education is an essential factor in ensuring the continued prosperity of the industry.

4. **May JR and Lynch AJ** (1995), '*The Education Factor*', Proceedings from the World's Best Practice in Mining and Processing Conference, The AusIMM, Sydney, 17-18 May, p1-3.

1.3. Conclusions

A technically strong and broad-based system of minerals education is critical to the success of the Australian minerals industry.

A technically strong and broad-based system of minerals education is critical to the future success of the Australian minerals industry.

Successful companies will be those that understand and accept their responsibility for enhancing and developing the capability of their professionals. While higher education has a large role to play in assisting the industry to meet its aims, it is important to emphasise that minerals education cannot of itself build managerial and technical excellence within minerals companies. Employers must commit to supporting professional development and to attracting the best people into the industry. In particular, at the postgraduate and continuing further education level, industry must drive the course content and standards that it wants from educators.

The Taskforce considers that the industry must take the first steps towards articulating its requirements for professionals. This will require significant, indeed major, cultural change within the industry. It will also require significant support from the higher education system. The next chapter will assess whether the current system of minerals education is capable of fully supporting the industry in meeting its requirements.

2. Can minerals tertiary education deliver?

Key points

- The Taskforce doubts the ability of the current system to deliver industry's requirements, but acknowledges some pockets of excellence in the system.
- The lack of effort and leadership by industry has contributed to the current weaknesses of the minerals education system.
- There are many institutions and departments offering minerals education; none have the resources to offer a comprehensive program that is world-class.
- The quality of minerals education in Australia is being undermined by the combined effects of a fragmented system, government funding framework and salary disparities.
- The current system is more vulnerable to the threats of imminent changes in Australia's higher education than it is capable of exploiting the opportunities created by new methods of education delivery.
- Changes in higher education are threatening the stability of the system to the point that current minerals-specific education could become a thing of the past.
- The number of minerals departments needs to be reduced by up to 50%.

2.1 Strengths and weaknesses of current graduates

The next generation of specialist professionals must be better equipped.

The Taskforce acknowledges that there is excellent work being done in minerals education. Graduate numbers reached record levels in 1996, and are predicted to increase further.[1] In some cases, departments are effectively addressing the problems and issues identified below.

However, the Taskforce doubts the ability of the existing system to meet changing industry requirements, both in terms of the number and quality of graduates.

The strengths and weaknesses of the quality of today's minerals graduates, as perceived by industry in general, are well summarised in the recent publication *Western Australian Minerals Industry Tertiary Education Taskforce – Discussion Paper*.

The Western Australian Taskforce *"believes there is widespread view in industry that the graduates, from all the relevant disciplines, have a solid theoretical understanding of their respective areas. … Whilst acknowledging the basic technical competence of current graduates, the Taskforce believes that the next generation of specialist professionals must be better equipped to work in and understand the realities of an internationally competitive industry. The specialist professional of the future must be more than technically competent."*[2]

The Western Australian Taskforce's view was based on a survey of senior minerals and energy industry managers in late 1995. The managers described the strengths and weaknesses of graduates of minerals courses as follows:

- *Strengths* – Graduates are generally well trained with technical, including computer skills, and were enthusiastic, motivated, keen, flexible and adaptable.

1. A more detailed description of the current state of minerals education in Australia is outlined in Appendix D.
2. **Western Australian Tertiary Education Taskforce** (1996), '*Discussion Paper*', The Chamber of Minerals and Energy of Western Australia Inc., July.

- *Weaknesses* – Graduates are too theoretical and lack basic knowledge or understanding of economics and management. Furthermore, they lack basic communication and people skills and are unaware of life in remote settings. They tend to be unaware of issues confronting the industry and are unfamiliar with the importance of occupational health and safety, labour relations and finance. They also have an elevated sense of self-importance.

Current graduate numbers are meeting demand.

Measured by the numbers of graduates, minerals education is in the best condition that it has been for years. However, while the absolute numbers of graduates is important, the relationship between industry demand and the supply of graduates is more significant in its impact. While the current relationship between the supply of graduates and industry's demand is balanced, the frequently severe imbalances in the past are a significant factor reinforcing the Taskforce's doubts.

History shows that changes in short-term industry demand can disrupt long term graduate supply and quality.

The Taskforce's concerns about these strengths and weaknesses can be grouped into three themes:

- **industry's commitment to professional education has been poor** - industry has, in the main, developed ad-hoc relationships with the tertiary education system. These relationships have run 'hot and cold' depending on the industry's short-term requirements;
- **the current system is narrowly based and fragmented** - in short, it is not a robust system which can deliver the world's best minerals education from a position of real strength; and
- **the higher education system will change greatly in the coming years** [3] - while this presents both opportunities and threats, the Taskforce believes that minerals education in its current form is vulnerable to the threats and is unprepared to take advantage of the opportunities.

2.2 Industry's commitment to professional education is poor

Industry has not provided leadership in minerals education and so cannot expect its needs to be met.

In the past, industry has voiced concerns over the quality and quantity of minerals graduates. However, there has been limited effort by the industry to shoulder its role in addressing these issues.

This is illustrated by the continued existence of such factors as:

- the short-term recruitment practices in some sectors of the industry, which are accentuated by the traditionally cyclical nature of the industry;
- an ad-hoc approach to university/industry linkages, with limited industry input into course design, curriculum development and quality assurance; and
- expectations by some employers that recent graduates should be job-ready, and by the graduates that they be considered 'fully educated and trained at graduation'.

Factors such as these are combined with an over-reliance on the larger companies to provide early industry experience for undergraduates and new graduates in the industry. Broad-based employer commitment has been lacking in the past and was identified by the Western Australian Discussion Paper[2], which indicates that *"only 16% of respondents* [to its survey] *employed new graduates, the rest preferring young professionals with at least 2-3 years experience!"*.

The lack of effort and leadership by industry has contributed to the current weaknesses of the minerals education system.

2.3 Narrowly based and fragmented system

There has never been a structured national system of minerals education.

The very description of minerals education as a 'system' is contentious. At no time in the history of Australian minerals education has there been any real structuring of a true national system of minerals education. Instead, the formation and growth of departments offering minerals education has been governed by history, geography, individual university policies and economics. Generally speaking, minerals education has been structured to satisfy the needs of regional centres within the minerals industry. It has, therefore, been driven by individual concerns rather than by what is best for the industry as a whole.

The growth and development of minerals education may have been appropriate to the prevailing circumstances of the time. However, the Taskforce believes that this pattern of piecemeal growth and development has left minerals education with three fundamental weaknesses:

- available resources are spread inefficiently and too thinly;
- the focus of minerals education on supplying graduates only to the minerals industry makes it very difficult, if not impossible, for the system to deliver the flexible numbers and the diversity of skills that industry needs, and to maintain the financial support needed for long term viability; and
- the financial weakness of minerals education, and that of the wider university sector, limits its ability to attract and keep world class educators.

2.3.1. The fragmentation of minerals education is lowering education standards

No existing university has sufficient resources to offer a world class program.

Minerals education in Australia is not confined to a small group of universities.[4] There are six departments of undergraduate education for mining engineers, with three student 'centres of gravity' - University of Queensland, University of New South Wales and the Western Australian School of Mines at Curtin University. Metallurgical engineering and science has nine departments of undergraduate education and follows a similar pattern to mining engineering with a small number of 'centres of gravity'. In geoscience, there are 26 universities offering undergraduate degrees.

This fragmentation is mirrored at the postgraduate level where most departments offer a small range of coursework, which is structured according to their academic and research strengths and their assessment of industry demand.

Many of these departments have achieved high standards, even world class standards, in one or more particular aspects of the discipline. However, the size of the centres is such that none of them, even the biggest, can really be said to offer a comprehensive program that is world-class.[5]

There are few incentives for universities to combine to form more cost efficient centres.

Fragmentation in Australian minerals education is driven by history and reinforced by the current system of public funding to universities.[6] The system provides few, if any, incentives for universities to combine to form larger, more comprehensive and cost-effective centres of excellence. Indeed, the current Commonwealth system of allocating most university funding on the basis of student numbers is an active discouragement to such moves.

3. Appendix A Section 1.1 discusses the current directions of the West Committee's review of Australian higher education financing and policy. Appendix B further discusses the changes occurring within the higher education sector.
4. Appendix D Section 2 describes the fragmentation and diversity of minerals education in Australia, through selective examples.
5. Appendix C further discusses funding processes for minerals tertiary education.
6. Appendix B and C further discuss the funding framework of the higher education and minerals education systems.

Overall, the Taskforce considers that there are too many departments offering minerals courses. This prevents minerals education in Australia from reaching the educational standards that could be achieved and becoming an internationally recognised provider of minerals education.

In the geosciences, for example, 26 universities graduate between 400 and 500 people each year. There are up to four geoscience departments in a single capital city. With the exception of some well-functioning networks between geoscience departments, these departments are currently doing little in the way of sharing resources to assist each other in lifting their educational standards. This situation is even more acute in mining and metallurgy departments.

The Taskforce believes that the number of mining and metallurgy departments, which will be both economically sustainable and capable of providing long-term world-class minerals education, is about half of the current number. In geoscience, the sustainable number is probably half to two-thirds of the current number of departments.

2.3.2. Minerals education is too narrowly based, leading to financial weakness and a lack of diversity

Minerals education exists largely because there is a minerals industry. This means coursework is oriented almost exclusively to the minerals industry and that the existence of university departments is dependent on the students who choose to enter the industry. In the present environment this dependence creates three problems for the industry.

Minerals education is small and vulnerable to cyclical swings.

Firstly, minerals education is small and vulnerable to the cyclical swings in demand for graduates.[7] Indeed, there are few courses within the tertiary education system with so narrow an employment focus as minerals courses. The current class sizes of a minerals course are usually amongst the smallest of the engineering and science disciplines, even though the number of students are, in many cases, at an historical high.

The cyclical nature of the minerals industry[8], as shown in Figure 2.1, results in a cyclical demand for graduates. History suggests that the current number of graduates may be reaching a peak for the current cycle. The impact of this cycle is to severely weaken the financial and staffing base on which minerals courses can be built.

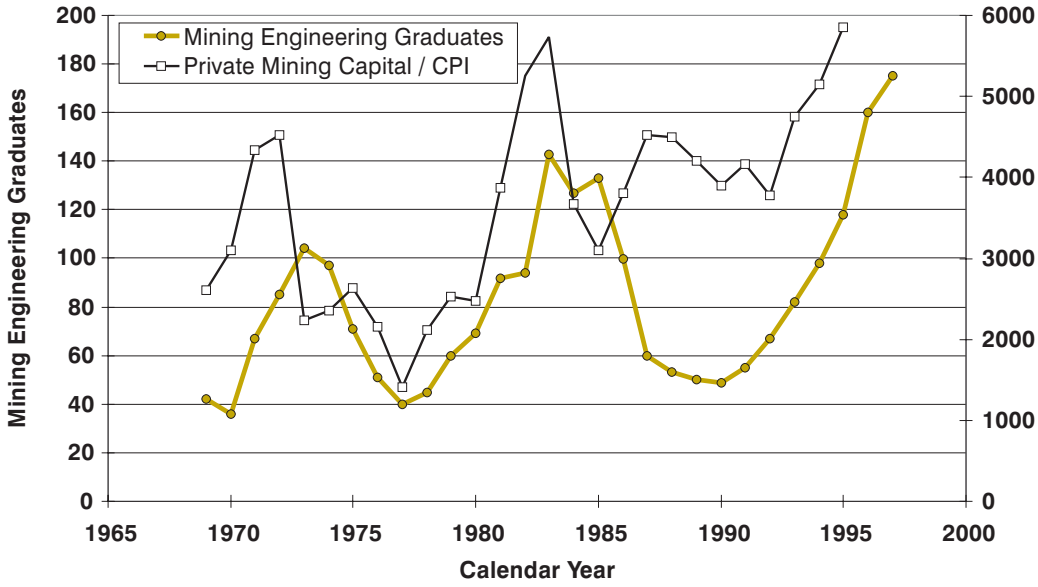
This vulnerability is exacerbated by the funding pressure on the tertiary education sector in recent years, with smaller courses having felt the greatest impact. Small, technically oriented minerals courses have been under great pressure to increase student numbers, to amalgamate with larger courses or to shut down.

Despite numerous offerings of courses, minerals education lacks a genuine diversity in graduate perspectives.

Secondly, the training of graduates takes years and so there is a time lag between the emergence of industry demand and an increase in the supply of graduates. This has caused frequent mismatches in graduate employment. In the past, drawing foreign professionals and graduates into the Australian industry has made up shortfalls in national numbers. However, as Brady (1997) [11&12] has described, this source is rapidly diminishing as minerals education in many countries continues to contract.

Thirdly, despite the wide range of different departments offering minerals education, the diversity of graduates is limited to the diversity available within minerals education. Arguably, the education available in minerals departments essentially provides variations on a theme, not genuinely different perspectives, which the industry now requires. In other words, minerals education is not currently oriented towards supplying a true diversity of graduates and professionals to the industry.

Figure 2.1 Australian Mining Engineering Graduates



Note: Private Mining Capital Expenditure is divided by CPI to develop expenditure in 'real' terms. CPI reference value of 100 in 1990[8].
Source: Derived from ABARE (1996)[8], Sen (1991)[9] & Lawson (1997)[10]

2.3.3. Minerals education is facing a shortage of high quality academics

The quality of university education is directly determined by the skills of individuals who design and deliver education. One negative outcome of the financial weakness caused by fragmentation and a narrow base, is that academic numbers are kept low and academic salaries remain uncompetitive. The Taskforce believes that this is the major factor limiting the current system of minerals education achieving truly world class standards.

New graduates sometimes earn as much as as senior lecturers.

The significant disparity between industry and academic salaries[13] is a major obstacle to attracting the highest quality people into university posts. Twenty-five years ago, professors and heads of departments enjoyed salaries reasonably equivalent to managers in industry, similarly for senior lecturers compared to superintendents. During this period, base salaries of academics and industry salaries in the minerals professions have diverged by as much as 100% of academics salaries. Furthermore, new graduates

7. Appendix C further discusses the impacts of the graduate cycles on the cash flow of minerals departments.
8. **ABARE** (1996), *'Australian Commodity Statistics 1996'* Australian Bureau of Agricultural and Resource Economics, Canberra.
9. **Sen GC** (1991), *'In Preparation for High Technology'*, Proceedings Reliability, Production and Control in Coal Mines, The AusIMM, Wollongong, 2-6 September, p323-325.
10. **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.
11. Appendix D Section 1.3.
12. Appendix F
13. Appendix C Section 1.3.3 and Appendix G Section 5 further discuss salary disparity.

are now earning as much, as if not more than, some senior lecturers. Academics' salaries have remained tied to the remuneration system within universities, while industry salaries have grown faster than the norm, (although some universities do provide a 'market-related loading' to partly offset the disparity).

A shortage of highly capable academics is becoming evident. Industry and academic salary disparity, combined with a declining status for the academic profession, is discouraging highly capable professionals from choosing to pursue academic careers.

The importance of salary levels in the departmental budget (60-70% of departmental costs) coupled with the marginal situations in most department's finances explains why the recent academic salary increases of 10-15% are causing so much concern in academia. These salary increases are unfunded by the Federal government and are one of several financial pressures which may result in the lowering of student entrance standards so as to increase enrolments.

2.3.4. A vulnerable system, unable to capitalise on opportunities

The quality of minerals education in Australia is being undermined by the combined effects of a fragmented system, government funding framework, salary disparity and staff numbers. Further, as a system, it is operating from a base which is too financially weak and narrow to give confidence in its ability to survive the major shifts now occurring in both the industry's needs and the tertiary education sector. Similarly, it lacks the ability to capitalise on the opportunity to become an international provider of world class minerals education.

2.4 A rapidly changing tertiary education system

There are significant sweeping changes occurring in the Australian and International higher education sectors.

The changes sweeping through the tertiary education system in Australia and the rest of the world will fundamentally reshape the structure and culture of tertiary education over the course of the next 10 or more years[14]. These changes are occurring in:

- society's requirements of education – reflected in an increased participation rate in tertiary education and a customer focus to student needs; and
- institutional structures and course delivery – reflected in the growing competition among institutions and rapidly changing methods of course delivery.

2.4.1. Society's requirements of tertiary education are changing

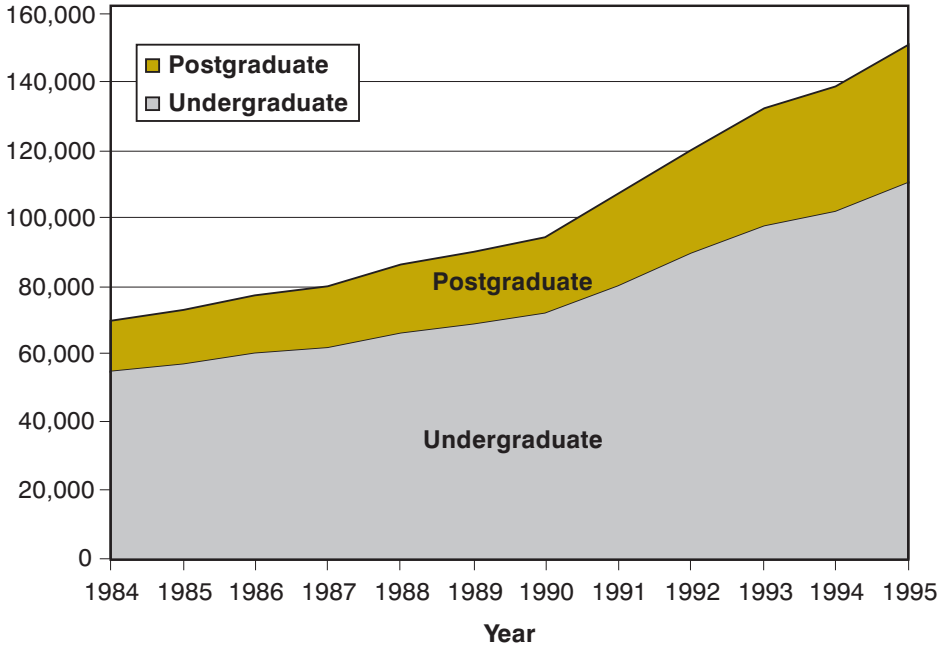
Participation in tertiary education[15] has been growing for many years. Since 1983, annual new enrolments in higher education have almost doubled. The Industry Commission[16] quotes a rise, between 1987 and 1996, from 3.17% to 4.60% of the population.

This increase has occurred in both undergraduate and postgraduate courses. Between 1984 and 1996, the number of students in postgraduate studies has increased by 178%. In the same period, the numbers of students enrolled in undergraduate studies has increased by 100%, Figure 2.2.

The rise in postgraduate studies and double degrees is significant. An undergraduate degree is becoming, for many professionals, only the first step in a lifetime of tertiary education. Similarly, career expectations and increasing competition for professional employment are requiring a broader education to deal with the challenges of the modern career.

Undergraduate numbers have doubled and postgraduate numbers nearly trebled in a decade.

Figure 2.2 Course Completions by Level in Higher Education: 1984-1995



Note: Original Sources: Higher Education Series, Report No.13, 1992 and Selected Higher Education Statistics 1995
1995 Figures projected.
Source: DEETYA (1996) [17]

Students are looking for qualification which allow career flexibility.

This position 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.

Students are now tending to look for qualifications which will allow them career flexibility in the expectation that their jobs will change over time - possibly in quite unexpected directions. Universities are having to respond by undertaking a fundamental reassessment of what their courses provide.

The increasing level of student fees is also creating a generation of more demanding students.[18] To quote Senator Vanstone, *"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'"*.[19] The introduction of full fees to a large proportion of local students in 1998 is likely to magnify a student customer focus.

14. Appendix B and Appendix A Section 1.2 further discuss the impact of these changes. Appendix G discusses the historical trends within higher education.
15. Appendix B Section 1.2 further discusses this issue.
16. **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
17. **Department of Employment, Education, Training and Youth Affairs** (1996), *'Annual Report 1995-96'*, Commonwealth of Australia, Australian Government Publishing Service, Canberra.
18. Further discussed in Appendix B Section 1.1.1 and Appendix B Section 1.4.
19. **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.

2.4.2. Institutional structures and course delivery methods will undergo major change [20]

In this new environment, major changes in modes of educational delivery and course design are inevitable. One area, which appears to have major growth potential is the 'out-sourcing' of tertiary education design and delivery. This recognises that the traditional approach of 'in-house' designing and presenting of all the coursework for a particular degree is no longer necessary and may be both inefficient and result in poorer quality courses.

While still in its infancy, there are many signs calling for this shift to occur. For example, in the recent review, *Changing the Culture* it is argued that: *"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."*[21]

Economics will demand greater university cooperation and resources sharing which information technology will make possible.

The influence of technology, deregulation and changing requirements of education from both students and employers will inevitably break the traditional institutional structures. Traditionally, universities operated in isolation from each other. The Taskforce sees a far greater degree of strategic cooperation between universities in years to come with resource sharing made necessary by economics and demand, and made possible by information technology.

2.4.3. Minerals education is not well-positioned to take advantage of these changes

Minerals education in Australia is in danger of being irretrievably damaged.

If the system of minerals education were founded on a strong financial base and were more broadly based in the diversity and number of students, the Taskforce would have less concern about the impact of the coming changes in tertiary education. Indeed, there are enormous opportunities, of which those that are well positioned could take advantage. However, the financial vulnerability of the current minerals education system places it in danger of being irretrievably damaged by these changes. After all, minerals education - despite its importance to the Australian economy - is only a very small part of the entire tertiary education system (less than 1% of the total students enrolled).

20. Appendix B Section 1.3 Appendix B and Section 1.4 further discuss university structures as well as course design and delivery.
21. **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 Technicalogical Sciences and Engineering, Canberra.

3. A model for minerals tertiary education into the future

Key points

The Taskforce proposes a new structure for minerals education in Australia which draws on the best attributes of available systems.

The aim is to establish the world's leading minerals education system by:

- fostering minerals technical excellence;
- using innovative approaches to education delivery;
- making better use of available resources to provide long-term financial stability for Australian minerals education; and
- expanding the diversity and number of graduates available to the industry.

Creating the system involves three core initiatives:

- establishing a 'network of centres' by strengthening the best present centres of undergraduate minerals education; these will continue to produce first class minerals graduates in their own right but will 'export' minerals education to each other and to the wider tertiary undergraduate and postgraduate education system;
- developing a system of 'alternative pathways' which recognises and takes advantage of the fact that there are many undergraduate degree courses which are sound preparation for work in the minerals industry; and
- establishing an Australian School of Mineral Resources to offer the best available postgraduate minerals courses from a wide range of education providers through a virtual campus.

3.1 Options for minerals tertiary education

The Taskforce examined a number of scenarios for the future of minerals education. Four were considered in detail and the cases for and against them are summarised below.

1. *Mainstream Engineering and Science education* - this model abandons traditional, minerals-specific education in favour of a 'generalist' approach, based on one of the 'mainstream' engineering or science disciplines supplemented by postgraduate specialist study and training. This 'mainstream' approach:
   - takes full advantage of the broader capabilities of the tertiary education system and it guides the industry away from preconceived restricted ideas of what is proper professional undergraduate education;
   - deals with the system-wide issues of diversity and flexibility of numbers; **but**,
   - underestimates the value of undergraduate minerals-specific education; and
   - is unrealistic in expecting that all minerals-specific education would occur at the postgraduate level.

Generalist versus specialist.

2. *Regional Schools of Mines* - this model follows the philosophy that tertiary education will coalesce, in the future, into industry-focused geographic groupings. The regional schools approach:
   - fully recognises the importance of world class minerals education and provides a previously tried mechanism to provide this education; **but**,
   - does not take advantage of the alternative pathways into the minerals field and the wide pool of capable people available from broader engineering and science disciplines;
   - does not take sufficient account of cyclicity, the small size of many classes and the resulting financial pressures; and
   - ignores student trends away from such a narrow educational preparation and inflexible career options.

A national school with a virtual campus.

3. *A National School of Mines* - this model involves a radical shift from existing models of tertiary education to a 'virtual' national school. This national school:
   - has much to recommend it at the postgraduate and continuing further education level; **but**,
   - underestimates the real need for campus-based undergraduate education; and
   - it shares the weakness of the Regional Schools model in its failure to exploit the wider pool of potential graduates.

Minerals education centres once lost, are difficult, if not impossible, to recover.

4. *Laissez Faire* - this model contends that there is no crisis in minerals education and, given the rapidity of changes, that any cure may be worse than the disease. Consequently, the matter should be left to the education 'marketplace'. The *laissez faire* approach:
   - is high-risk and hands-off. It depends upon the workings of the market to provide the right outcomes;
   - despite the size of the minerals industry and its contribution to research, the industry's 'market power' at undergraduate level is weak; and
   - in a fiercely competitive market, leaving minerals education to the vagaries of such a market will prove to be a mistake. Centres of specialist education, once lost, are difficult, if not impossible, to recover.

3.2 The preferred model

No model is entirely satisfactory.

The Taskforce's conclusions from this analysis of the above options are twofold:
- the industry should consciously adopt a 'model' for minerals education and a concerted approach to achieving it. In other words, the Taskforce rejects the *Laissez Faire* approach; and
- none of the models described above is fully suitable to meeting the needs of the industry. Instead, the 'preferred model' should draw on the strengths of each of the models discussed.

The Taskforce has, therefore, developed the preferred model outlined below (and described it) in detail in the next section for undergraduate and postgraduate education.

A hybrid of the regional schools model and mainstream engineering and science.

Undergraduate Level: should be a combination of the Mainstream Engineering and Science model and the Regional Schools of Minerals model. Minerals departments within the mainstream engineering and science faculties will provide the foundation of technical excellence for undergraduate minerals education. These departments should be linked together and perform two essential functions:

- they will produce first class minerals graduates in their own right; and
- they will 'export' minerals education to each other and to the wider tertiary undergraduate and postgraduate education system.

The second function ensures that minerals technical excellence will be exploited in the wider tertiary education system to encourage flexibility and diversity of graduates suited to careers in the specialist minerals professional roles. It fosters continued minerals technical excellence at the undergraduate level and enables the industry to develop recruitment methods that draw new graduates from a larger group of talented people.

A national school for postgraduates, with a virtual campus.

Postgraduate Level: The Taskforce recommends the National School model, providing the highest standards of technical education in a comprehensive and readily accessible way. Minerals postgraduate coursework will be delivered by a 'virtual' school that brokers courses between institutions to create a national curriculum. This system fosters the development of course material.

The minerals departments described in the undergraduate level of this preferred model will be the main supporting pillars of the National postgraduate school. However, it is also expected that there would be a very wide range of providers and deliverers of coursework, particularly from the numerous minerals-related private companies, research institutions and undergraduate departments around Australia and internationally.

The proposed system of postgraduate education will create minerals technical excellence at the postgraduate level. This will meet two needs identified by the Taskforce:

- development of purpose-designed conversion courses for graduates with little minerals-specific knowledge, who are entering the minerals industry; and
- development of a full curricula of minerals specific postgraduate education for Continuing Professional Development (CPD) at the individual subject, graduate diploma and masters levels, using innovative design and delivery eg. computer-based learning, distance education and short courses.

The preferred model capitalises on the strengths of the existing system but in a more systematic, efficient and focused way than at present. It can take advantage of the opportunities and withstand the threats of any adverse developments.

3.3 Undergraduate education

The model at undergraduate level would consist of:

- a select network of 'centres' throughout Australia. These centres will be linked via telecommunications and, more importantly, by a culture of sharing resources; and
- a broader network of courses which are recognised as producing graduates suitable for employment in one of the three 'core' technical roles in a minerals company.

3.3.1. A network of centres

Historically, minerals departments or 'Schools of Mines' have covered the disciplines of mining engineering, minerals processing and often geological engineering or science. On the other hand, geoscience applied to minerals exploration has been successfully taught in departments with and without any linkage to other minerals departments.

The historical separation of education for minerals 'exploration' and education for minerals 'exploitation' is understandable. However, it also has unfortunate aspects, in that:

- it has led to a separation of excellence in the teaching of exploration geoscience and the teaching of mining and metallurgy; and
- the linkages between the two streams are not as highly developed as is desirable.

Not all components of a sound minerals education need to be developed by each centre.

The Taskforce believes that an Australia-wide network that caters for a wide variety of course options can maintain the strengths of separate focuses, as well as drawing the geosciences and mining and processing aspects of education closer together. This approach would broaden the scope of minerals education, without the fragmentation of the current system. It is based on the philosophy that not all components of a sound minerals education need to be developed from within one centre.

The centres will each develop a unique character because they will not develop courses to cover all areas of minerals education. Rather, all centres should develop coursework in their respective areas of competence and cooperatively deliver this education throughout the network. This will enable all students in the network to have access to world class education in a broad selection of topics.

Where courses are provided in the same location, they should form a single centre. A centre may well be multi-institutional and involve two or more university departments in the same city or region. Each individual centre, however, would have one common curriculum. The multi-campus arrangement would cater for the fact that different subjects may be best offered at different campuses because of the existing distribution of facilities and teaching staff. The different campuses also add to the quality of the university experience by exposing the student to a range of environments.

Such multi-campus networks informally exist among some of the geoscience departments. The Taskforce sees great value in such arrangements and encourages the formation of multi-institution centres that reduce duplication of resources.

There is no need for the centres to have a common undergradiuate curriculum.

A national network of minerals centres does not demand a 'common' undergraduate curriculum. Each individual centre must have sufficient resources to develop its own basic course, with its own flavour. A common, uniform curriculum across all centres would result in a loss of diversity in graduates that may well be to the detriment of the industry. It would also lose the advantages that different university settings can contribute to an undergraduate education. In this sense, the Taskforce agrees with Senator Vanstone: *"An undergraduate experience which is rich and formative must have an intellectually challenging and broadening curriculum. It also requires a lively campus culture, a physical environment on and around the campus which encourages study and social interaction and an ethos of openness, tolerance and excellence …"*[1]

Close communication between the centres will be critical to their success. It could be that undergraduate minerals education may, in time, take the form of a national 'virtual' school. However, the Taskforce believes that the campus-based nature and the purpose of an undergraduate education will require a relatively loose network of centres rather than a more formally structured organisation, which the word 'school' implies.

The network would form close links with the national minerals industry. The aim would be to ensure that, across the whole system, the outcomes of minerals education are regularly reviewed and students are given plenty of opportunity for structured practical application of the principles of their disciplines.

3.3.2. Characteristics of an individual centre

Each centre would be at world's best standard in their specialties.

The centres are the foundation of the new education system and so the Taskforce has put considerable effort into defining their role and function. Each centre would operate by:

- drawing on the resources of the host university to deliver high-quality teaching and learning in the non-specialist minerals areas of the undergraduate curriculum eg. mathematics, chemistry and physics as well as broader subjects;
- having one or more speciality areas of research excellence and would assume responsibility for achieving world's best standards in these areas of the undergraduate curriculum in geoscience, mining engineering or metallurgical engineering;
- working with other centres to enable each centre to deliver all components of the undergraduate minerals program to world's best standards; and
- developing coursework and delivery methods in its specialities which would allow those courses to be delivered in other minerals and non-minerals courses around the country and overseas.

Each centre would have the capacity and competency to:

a) offer a world class minerals program and be able to deliver truly effective and, where appropriate, innovative **course content**;

b) offer significant **practical experience** in the industrial or field environment;

c) have an **academic staff** mix which is able to offer first class teaching and research skills in one or more significant areas of the minerals field;

d) have the commitment and ability to attract **first class students**;

e) be located **close to a research facility**;

f) have long-term **support from their parent university**; and

g) be able to deliver courses beyond its boundaries, **attracting international fee-paying students**.

Each of these features is discussed in more detail in the following sub-sections.

1. **Senator the Hon Amanda Vanstone** (1996), *"University of the Year Award"*, Speech, Royal Pines Resort, Gold Coast, Queensland, 24 July 1996, DEETYA. http://www.deetya.gov.au /minwn/vanstone/vs03_7.htm

(a) Course content

Course content is the responsibility of the centre concerned.

The Taskforce takes the view that establishing the right balance of course content must remain the responsibility of the specific centre. It is likely that the core subjects of each program will be the same, but no single course formula is necessarily the best. Indeed, diversity should be encouraged. Rather than defining course content, the core commitment sought from each centre as part of the network will be that it regularly reviews its coursework, overall course design and its delivery methods, to ensure that the course efficiently and effectively meets the requirements established in Chapter 1.

The Taskforce recognises that such course reviews have been a priority in undergraduate education for most of the 1990s. However, most course reviews have resulted in only incremental change in course design. With some notable exceptions, undergraduate coursework essentially remains dominated by traditional subject matter and delivery methods. The Taskforce endorses the judgements of the recent Organisation for Economic and Co-operative Development (OECD) review which noted that although there had been *"substantial achievements* [in improving the quality of teaching, this] *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."* [2]

For example, more fundamental review of course structure and content is needed to address:

a. an overemphasis on specific applications of a discipline. These applications are often out-of-date and are, in reality, 'number crunching' exercises, with little content of lasting use to students;

b. the inability of most departments to provide first class education across the whole range of subjects offered. The sharing of resources between different universities is still the exception rather than the rule at undergraduate level.

To address the issues raised in these examples a centre will regularly ask two fundamental questions about its course:

- Do individual subjects and the overall course-mix successfully achieve the goals established in the 'undergraduate outcomes'[3]? How does each component contribute?
- Does each component of the course reach a 'world class' standard? If not, why not and how can it be improved?

The process of coursework review must facilitate the sharing of lecturers between different centres and the use of industry practitioners in the education process.

The centres will also seek active input from industry in framing their curriculum and this can be expected to evolve over time. In the course of its work, the Taskforce identified three initial changes to course content for immediate action by centres.

Students' awareness of safety, their critical thinking and their understanding of the chain of minerals activities are priorities for improvement.

First, in 1996/97 the minerals industry incurred 33 fatalities.[4] Improvement in safety is the number one priority challenge for the national minerals industry. Thorough and relevant occupational health and safety education for minerals specialist professionals is one of the essential steps towards improving the safety performance of the minerals industry in Australia. The teaching of process safety and risk analysis as in chemical engineering courses is considered to be a good role model for minerals courses and should be coupled with other aspects of occupational health and safety including the statutory obligations imposed on employers and mine officials.

Second, all technical disciplines should develop skills in applying scientific method. This would lead them, as a matter of course, to question the validity of data and the assumptions underlying any scientific/engineering argument. Education delivering critical thinking is of more lasting value than many of the more specific technical subjects offered in most courses.

Third, students need an overview of the entire chain of activities from minerals exploration through to refining. They should see minerals exploitation as a process - not as a series of discrete steps. While specialisation is needed, all graduates should have some understanding of orebody geology, mining, minerals processing and downstream processing techniques, and of the impact of these activities on the environment. These five areas of knowledge are typically structured around separate undergraduate degrees.

Professional demarcartions need to be broken down.

The unfortunate outcome of this is that industry management has further developed this separation into 'professional demarcations' between aspects of the same fundamental process. Anyone who has worked on a minesite will be well aware of the differing goals and approaches often held by the mining manager and the plant manager. Worse still, mine geologists are often to one side and not seen as integral contributors to mine management. These differing goals are, at least partly, an outcome of the education system.

For the future success of the industry, these professional demarcations need to be broken down. This demands that specialist professionals take a 'whole process' view – viewing the sequence of steps involved in successfully exploiting an orebody, while having a particularly strong technical understanding of one aspect of the sequence of steps.

For example, it is accepted that it is cheaper and more effective to design into the mining process the building of waste dumps and rehabilitation programs, than it is to undertake these activities after the event. The linkages between geology, mining and processing are even more important. The education for exploration and mining geoscientist roles should encompass a broad and deep understanding of the many aspects of geoscientific theory and technology and place them in the context of the entire minerals extraction process.

Good role models can be found in the course design for the mining engineering and minerals engineering degrees at some universities in Australia. These approaches, with three common years for all disciplines, attempt to provide both mining and minerals processing graduates with a sound understanding of the entire mining, minerals processing and extraction process.

2. **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
3. Described in Chapter 1.
4. **Minerals Council of Australia** (1997), '*Australian Minerals Industry Safety and Health - Safety Survey Report for 1 July 1997 - 30 September 1997*', Quarterly Report.

(b) Practical experience

Practical experience is an essential part of minerals education.

The Taskforce believes that practical experience is an integral and vitally important part of minerals undergraduate education. It reinforces and brings to life the fundamental principles being taught during the undergraduate course. Another important purpose is to give the student an understanding of the limitations of the discipline when it comes to practical application. It also helps achieve a number of other industry-oriented goals, giving students:

- an understanding of what professional work entails;
- an understanding of company decision making processes;
- better interactive people skills, communication and teamwork;
- better knowledge of the industry and the issues facing it; and
- an understanding of the lifestyle in remote areas.

The Taskforce believes practical experience should be given greater emphasis than at present. This does not imply that the course must be, or is inevitably, 'vocational' in flavour. The Taskforce believes through imaginative course design, minerals education can effectively use both the classroom and the field/minesite/industrial environment to instil a first class understanding of the fundamental principles of a discipline and the broad context in which they are applied.

Within the current ad-hoc system of industry-university practical experience there are three main delivery methods:

- *Short term or field sites visits*: which range in specialisation from an overall site visit (eg. an overview of mining methods) to specific aspects of a subject (eg. roof bolting at the Wyee Colliery on-site teaching facility).
- *Longer term site visits*: employment during the university semester (eg. Flinders University Industrial Affiliates Program) or a period of employment during the student vacation.
- *Course project work*: a thesis or major design project dealing with a real industry situation, with intermittent contact between a student and a sponsoring company.

Industry wants graduates with experience - it must provide opportunities for them to get it.

Discussions with academics indicated that providing practical experience is one of the more difficult-to-manage tasks of undergraduate education. It is also an area of concern to many in industry. Vacation work is the most problematic. Even when students do find vacation work, they often gain little structured experience that applies the main principles of their course.

The Taskforce recommends that a centre will have a program of structured practical coursework both during and out of the undergraduate calendar. This program would be based on, but not limited to, achieving strength in all of the above forms of delivery.

For these programs to be effective in achieving their objectives, there are a number of fundamental requirements:

- they must consist of well structured assignments, which meet multiple graduate outcomes and especially demonstrate the linkages between theory and practical application;
- practical experience should be structured for an efficient use of time to achieve the learning of fundamental concepts within an industry environment;

- they must be sufficiently resourced by universities and especially industry. They will require a greater commitment of resources, more than the current 'hit and miss' system of 'vocational' student vacation experience; and
- there must be a high level of commitment from both universities and industry to ensure continuing coordination of these programs.

There should emerge 'teaching minesites and processing plants' and 'teaching field locations' in the same way as 'teaching hospitals' have developed in the medical field.

The Taskforce stresses the critical need for an industry-wide commitment to underwrite and support these programs. This should be done in a structured and formal way, if industry is serious about wanting new graduates to have had practical experience. Similarly, it is highly desirable for all companies within the minerals industry to establish structured graduate training programs which build on the limited practical experience that is gained at the undergraduate level. These programs should not only assess and develop further practical experience and extend to further technical education.

(c) Academic profile

As with course content, the Taskforce believes that there should be minimal prescription of the academic profile within a department. Individual academic staff and the staff mix will be a unique part of the culture of any particular centre. It is up to the director of the centre to create and sustain the most suitable academic profile.

Academic staff must include those at the forefront of technical expertise . . .

The academic staff must include people who are at the forefront of their field of technical expertise. A centre must be able to achieve world class academic strength in at least one significant area of the undergraduate curriculum. For example, a 'significant area' in geoscience might be geophysics, economic geology or exploration geology.

Technical expertise alone, however, is insufficient. Academic staff must be committed to providing first class education - both for their own students and in 'service' teaching. The Taskforce considers that there is an urgent need for departments to develop a higher level of 'teaching skills'. Academics must have the capability to design, develop and deliver truly effective coursework.

. . . and with a higher level of teaching skills.

To achieve this, it is likely that a minerals department will have a mix of staff with recent and relevant industry experience as well as staff who have enhanced experience within the teaching and learning and research areas. The Taskforce also believes that industry secondments for academics and for secondments of industry professionals into academia should be increased. There is no expectation that a geoscientist or engineer from industry could merely walk into a department and become an instant expert on the teaching of minerals subjects. However, there is a need to bring more industry experience into the learning environment. Similarly, many companies could benefit from input from an academic to their technical processes and to their management and development of graduates.

Importantly, a centre will have a clear strategy for, and commitment to, attracting first class staff, reviewing their performance and rewarding it as appropriate. Attracting good people will require extra resources to bring academic remuneration to levels more competitive with industry. A centre will also have mechanisms to allow poor performing staff to be 'let go'.

(d) Attracting the right students[5]

Quality students need to be attracted to minerals education.

The Taskforce recognises that the quality of incoming students is a major factor in producing world's best graduates. It believes the most effective way of attracting the best students into a minerals career will be mainly through the quality of the education and the prospects of a rewarding and challenging career. The reputations of the department and of the minerals industry are also critical.

A centre, nevertheless, can still be proactive in attracting highly capable students, and those students who are most suited to the industry. There are many factors in such a strategy. These include:

- targeting first/second year students with information sessions, introductory coursework, field trips, student vacation employment and social events which raise awareness and increase interest in the minerals disciplines;
- participation in programs aimed at achieving similar ends at the high school level (eg. the Australian Schools Minerals Venture programs arranged by The AusIMM); and
- targeting talented students with scholarships and co-op programs.

A centre needs good links with industry and scholarship providers.

Scholarships are a vital element in attracting the best students, particularly now that students' financial contributions for their education are higher than they have been for decades. A centre must facilitate good connections with industry and other scholarship providers. Programs such as The AusIMM Education Endowment Fund and the Industry Co-op scheme at the University of New South Wales are excellent examples of these relationships. Not all scholarship schemes have been effective and the Taskforce believes that some rationalisation may be warranted.

(e) Proximity to research

The Taskforce takes the view that there are strong reasons for locating minerals education and research together. Firstly, the sector is not large enough for separate 'research' and 'teaching' centres. The number of undergraduate centres in minerals education is, and will continue to be, small. This argues for an association of education centres with research facilities as part of the process of reducing fragmentation (particularly as postgraduate education is associated with research centres as much as with undergraduate departments).

Centres must be attractive to academics for both research and teaching.

Secondly, the shortage of first rate academics in minerals education makes it necessary to build and maintain centres of research and education which are attractive to academics, both from a research and a teaching point of view. Such centres may also prove more attractive to those from the private sector who wish to take part in research for a period and who also have much to offer in the teaching field.

Finally, links to research and the most up-to-date technical advances are necessary to maintain undergraduate courses technically at world's best practice. Education links with research should also provide graduates with an understanding of the benefits research can achieve and the methods by which it is employed.

(f) Long-term support from parent university

A centre must have long-term support from its parent university. This will manifest itself in internal resource allocation policies[6] which are designed to foster technical strength, especially in the minerals area. The university, with industry, must also be prepared to sustain its minerals courses through cyclical downturns.

University policies should commit to:

- encouraging and facilitating cooperation with other universities;
- rewarding academic staff competitively with alternative occupations, including a significant merit component;
- achieving the highest standards of academic teaching performance; and
- targeting funds towards strong engineering and science programs.

(g) Attracting international students

The network of centres should aim to be the world leader in minerals education, becoming heir to the role once played by leading overseas schools which have declined or disappeared. Centres of minerals education should collaboratively work towards building an internationally recognised reputation which will attract full-fee paying students to Australia, integrated with distance education coursework to overseas students. In this way, centres of minerals education in Australia can move towards greater financial sustainability, with revenue from fee-paying students. This will also increase and diversify student numbers, and help attract quality international academics.

3.3.3. Taking the initiative

The Taskforce believes that establishing a select network of centres is the most effective way to achieve world class undergraduate minerals education in Australia. The number of institutions able to attain the status of 'centre', is only a subset of the current number of departments offering minerals education. Even so, those departments which can achieve excellence will need some assistance to do so. The Taskforce therefore recommends that concerted action be taken to:

Initiative 1

Create a select network of centres and link this with industry. Each member-centre within the network should:

a) collaborate where desirable with other members to offer a world class minerals program and be able to deliver truly effective and, where necessary, innovative coursework;

b) have a structured practical experience program;

c) have an academic staff mix which is able to provide, as a priority, first class teaching, while also maintaining research skills in at least one significant area of the minerals field;

d) have the commitment and ability to attract talented students;

e) be located close to a research facility;

f) have long-term support from their parent university; and

g) have the willingness and capability to deliver education to (full-fee paying) international students.

5. Appendix E discusses the issue of student attraction in greater detail.
6. Appendix B Section 1.1.2 and Appendix B Section 1.3(d) and Appendix C Section 1.1 and Appendix C Section 1.2.2 discuss this in further detail.

3.4 An effective system of alternative pathways

The centres will not be the only source of graduates for the minerals industry.

The network of centres is expected to continue to produce the majority of the specialist graduates needed by the industry to fill roles as mining and metallurgical engineers and geoscientists. The rest of the new graduates will come through other minerals departments not connected with the centres, and through 'alternative educational pathways'.

This diversity is necessary to reduce the impact of industry cycles on the centres, and desirable because of the diverse backgrounds of graduates that this will provide the industry.

Given the nature of geoscience and its status as a fundamental discipline, most graduates recruited into geoscientist roles will have studied geoscience. The same is not true for graduates entering the roles of mining and metallurgical engineer. Already it is commonplace for mining and metallurgical engineers to have come through the alternative pathways of civil and chemical engineering or even other engineering streams.

Despite this practical reality, alternative pathways are not fully accepted by the minerals industry.

Industry must accept that alternative pathways are legitimate and help bring new perspectives.

To encourage and legitimise the alternative pathways, three steps should be taken:

- define the broad educational preparation necessary for graduates filling the roles of mining engineers, metallurgical engineers or geoscientists;
- establish a road map of alternative pathways into the three minerals roles; and
- create a network of 'service' courses to support, where necessary, the alternative pathways.

3.4.1. The necessary education for graduates entering 'minerals' roles

The first aspect of legitimising alternative pathways is to 'recognise' a range of undergraduate courses as being a sound preparation for one of the core 'minerals' roles.

An understanding of basic science and engineering principles, the ability to apply them . . .

The elements of a sound undergraduate education (established in Chapter 1) are:

- an understanding of the basic science and engineering principles and the fundamental concepts of a technical discipline appropriate to a role as a geoscientist, mining engineer or metallurgist;
- the ability to apply these concepts to practical problems, preferably, but not limited to mineral problems - both in the classroom and in the field;
- an understanding of the linkages with other technical disciplines and the need for leadership, teamwork and different perspectives when addressing complex problems;
- an appreciation of the limitations of the knowledge provided at the undergraduate level and the need for lifelong learning; and

An awareness of broader industry issues.

- an understanding of broader issues such as economic evaluation, human relations, professional ethics, occupational health and safety and community expectations, and the relative importance of these issues when applying the concepts of the technical discipline in the workplace.

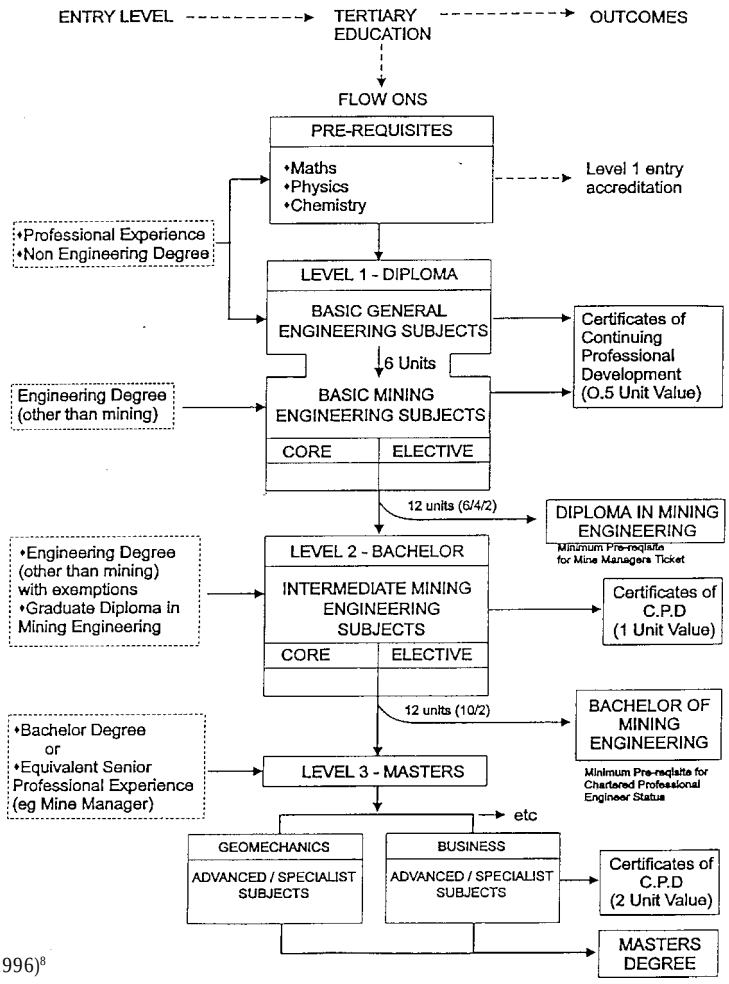
These elements form the basis for developing 'course recognition criteria' for use in assessing whether a particular undergraduate course is a sound preparation for graduates seeking to enter minerals roles.

A set of course-recognition criteria is already in use - The AusIMM 'graduate outcomes'.[7] These are effectively an application of the above five elements to minerals-specific courses. The AusIMM graduate outcomes would apply to the minerals-specific courses offered in the centres and elsewhere. However, they will need review and broadening if they are to be used to support an effective system of alternative pathways.

3.4.2. A road map of alternative pathways

The second aspect of legitimising alternative pathways is to create a 'road map' of the pathways, to prepare a graduate for a particular role. Figure 3.1 is a sample 'road map' for the educational pathways of a mining engineer. This covers only those pathways which include formal undergraduate education in mining engineering. Other pathways in a complete road map may not include any formal minerals-related undergraduate education. All pathways may involve postgraduate education in minerals-specific areas.

Figure 3.1 UNSW Example of Entry and Exit Options for Industry Personnel



Source: Galvin (1996)[8]

7. Appendix I.
8. **Galvin JM and Roxborough FF** (1996), '*UNSW Mining Engineering Education for the 21st Century*', Annual General Meeting, Sydney Branch, The AusIMM, 21 October.

3.4.3. A national network of service courses

Effective alternative pathways will require minerals-related coursework to be available for a wide range of undergraduate engineering and science courses. Consequently, the third aspect of an effective system of alternative pathways will be the design and provision of coursework, which is suitable for use in the broader tertiary system. An example might be the design of a hydrometallurgy course, which is suitable for use in chemical and chemical engineering courses.

The key to successfully providing such 'service' courses will lie in the course design and the cost at which it can be provided. The design and provision of this coursework will be one function of the centres.

3.4.4. Taking the initiative

The Taskforce believes that a system of alternative pathways towards a 'minerals' qualification is both necessary and inevitable. Broadening the base from which to draw people into the industry will increase diversity and overcome the recurrent shortages of professionals, which have bedevilled the industry.

The minerals industry can no longer ignore the social changes that are driving higher education towards much greater flexibility in all its institutions. Market forces in higher education and in the industry are driving in this direction.

To ensure that industry makes the most of this opportunity the Taskforce recommends that concerted action be taken to:

Initiative 2

Create a system of alternative educational pathways which ensure that the industry benefits from the great strength and depth of graduates in the wider tertiary education system. Three steps are required:

a) describe the broad educational preparation necessary for graduates filling the roles of mining engineers, metallurgists and geoscientists;

b) define a 'road map' of educational pathways into the minerals industry and how they might be followed; and

c) establish a national network of 'service' courses to support the alternative pathways.

3.5 Postgraduate education

A national school is needed for postgraduate coursework.

At the postgraduate coursework level, the key initiative needed is to establish a national program of world class technical minerals education. To achieve this, the Taskforce believes that a national postgraduate school is required to create, shape and drive improvement in a suite of comprehensive and coordinated technical postgraduate education curricula. Currently, the education curriculum at postgraduate level is poorly thought through, unlike the curriculum at the undergraduate level. Each university has tended to create coursework in its own various areas of expertise. Little attention has been given to the creation of a comprehensive curriculum for each field. Even less attention has been given to maintaining the curriculum at the highest standards and to intergrate those curricula into the industry environment via innovative coursework and education delivery techniques.

Curricula need to be driven into the industry environment via innovative coursework and education delivery.

For some years, the Australian Minerals Foundation (AMF) has been developing such curricula at the short course level. However, the Taskforce believes that a truly world's best curriculum, which is dynamic and at the forefront of educational technology, can only be achieved if providers combine their efforts and strengths on a nationwide basis.

The Taskforce recommends calling this school the Australian School of Mineral Resources (ASMR). The aim of the School, as opposed to the network proposed at the undergraduate level, is to create a distinct institution which is recognised around the world as the leader in postgraduate minerals education.

The ASMR will offer the best minerals postgraduate program in the world.

3.5.1. The Australian School of Mineral Resources

The ASMR will be a 'virtual' institution (minimal infrastructure) focusing on the creation of a postgraduate curriculum, which offers the best minerals postgraduate program available in the world. No single centre should take responsibility for the advancement of minerals education and as no particular university focuses specifically on minerals education, so the ASMR would be the vanguard for postgraduate minerals education in Australia.

The curriculum of the School needs to provide:

- specialist courses at graduate diploma and masters level, to cater for the industry professionals' need to specialise;
- short courses for minerals professionals seeking to upgrade their skills in a particular area; and
- purpose-designed conversion courses for graduates, with little minerals-specific knowledge, who are entering the minerals industry.

Innovative course design and delivery would be as much a part of the School's charter as to maintain the highest standards of quality in the technical content. Delivery methods would include traditional classroom-based lectures, tele-conferencing and computer-based learning. For the latter two, particularly computer-based learning, effective course design for the minerals industry is in its very early stages. The ASMR would be playing something of a pioneering role in this area.

Taking metallurgy as an example, a national curriculum could be constructed as follows:[9]

Process control	-	offered by JKMRC/Mining, Metallurgy and Materials, University of Queensland
Hydrometallurgy	-	offered by AJ Parker Centre/Minerals Science, Murdoch
Pyrometallurgy	-	offered by GK Williams Centre/Chemical Engineering, Royal Melbourne Institute of Technology
Flotation	-	offered by Ian Wark Research Institute/Metallurgical Engineering, University of South Australia

9. Adapted from **May JR and Lynch AJ** (1995), '*The Education Factor*', Proceedings from the World's Best Practice in Mining and Processing Conference, The AusIMM, Sydney, 17-18 May, p1-3. A model of minerals tertiary education into the future

The coursework offered would be predominantly technical, covering the fields of:

- mining engineering;
- primary and extractive metallurgy;
- minerals exploration and mine geology;
- environmental engineering;
- mine equipment design;
- minerals safety management; and
- minerals economics.

The ASMR will also attract international students.

Research and undergraduate departments at individual universities would collaborate in the design of much of the ASMR coursework. However, the provider of the coursework for any particular subject may be in the private sector (a consultancy, for example) or may be a consortium of universities working with one or two private sector parties.

The ASMR will become a national 'brand'.

In addition to Australian students, the ASMR would have as its market students from the rest of the world, and would have an important role as an exporter of education. Australia has the beginnings of this reputation in the minerals field and it has the technical strength. There is a real opportunity to lead the world in minerals education.

Indeed, one of the benefits which will flow from the School is the creation of a recognisable 'brand', both nationally and internationally. There are currently only a few 'brand names' that are recognisable in minerals education - the Julius Kruttschnitt Mineral Research Centre (JKMRC) is certainly one. Other overseas institutions, such as the Royal School of Mines, which did have the reputation, are no more. The proposed ASMR provides the best means of capitalising on the opportunity created by the closure of such schools and capture significant direct benefits for the local Australian minerals industry.

While there are no specific models for the structure of such a School, there are some precedents that provide guidance. One example is the Centre for Oil and Gas, based at the University of Western Australia. This Centre offers postgraduate masters coursework and short courses covering a range of topics. The course curriculum draws from three Western Australian universities - University of Western Australia, Curtin and Murdoch - as well as from the University of New South Wales.

There is also Engineering Education Australia (EEA). Formed in 1990, this organisation is owned by the Institution of Engineers, Australia. Its purpose is to provide award and non-award programs for engineers. Twenty tertiary institutions offer degrees through the EEA curriculum. It offers a range of coursework from masters degrees through to undergraduate degrees and TAFE diplomas. It also offers 'do-it-yourself learning packages', including short courses. EEA is, with the assistance of the Deakin University's distance learning expertise, at the forefront of developments in educational delivery.

Lastly, there is the model provided by the Australian Minerals Foundation. The AMF plays a similar role for the minerals industry, as does the EEA for the wider engineering community. The AMF is currently in the short course area, and in the near future will move to the masters level of education.

No obvious models for the national school but there are some that point the way.

3.5.2. Taking the initiative

The ASMR will drive innovation in postgraduate education via a single well-recognised institution. The Taskforce recommends:

Initiative 3

Establish the Australian School of Mineral Resources (ASMR) in order to create a world class centre of postgraduate minerals education. Coursework will cover:

a) conversion courses for non-minerals graduates to support Initiative 2;

b) masters coursework in advanced technical areas; and

c) short courses for continuing professional development.

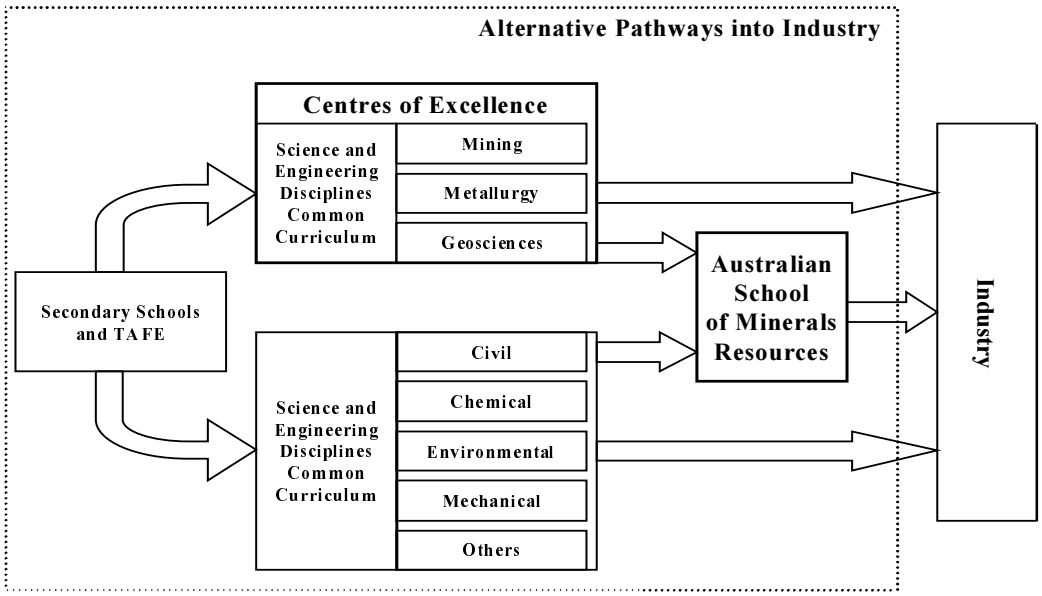
These courses must be readily accessible to industry through the innovative coursework design and delivery.

3.6 An integrated system

The individual components of the Taskforce's model have also been chosen to come together to form an integrated system.

Figure 3.2 illustrates the model of minerals education which will emerge from the recommendations. Most of the elements of the proposed system currently exist. The main difference will lie in the strengthened ability of each of the elements to cooperatively deliver quality education for the minerals industry.

Figure 3.2 Preferred Model for Minerals Education in Australia



4. Delivering change

Key points

- Cultural change on the part of industry, academia and the Federal government will be necessary if the proposed new structures, institutions and funding are to deliver the desired educational outcomes.
- The Minerals Council of Australia with the collaboration of the universities and government should establish and fund the Minerals Education Council (MEC); the MEC should be a body with enough influence to accelerate change from an incremental series of steps to a rapid reorientation.
- The budget of the Minerals Education Council and its secretariat should be $2.5 million over five years.
- The Minerals Education Council should call for submissions from interested institutions to form the network of centres; these submissions should be made in conjunction with other university departments and minerals companies or industry bodies.
- The additional resources needed to implement initiatives such as new courses, increased salaries and practical training will not be known until after these submissions, but could be of the order of $20 million over five years.

4.1 The nature of change

Structural change won't work without appropriate changes in behaviour and beliefs.

In minerals tertiary education there is no one particular stakeholder with the power or the ability to shape the system. Change, therefore, must be embraced by all the various stakeholders. The Taskforce has proposed new funding, structures and institutions for minerals education that can deliver the outcomes industry desires. However, the impact of these will be limited unless stakeholders make the institutions work to their benefit. Without this commitment, the structural changes - including extra funding - could be short-term and short-lived.

The fundamental problems arise from:

- industry's historically ad-hoc demands from tertiary education and a lack of leadership;
- the resistance to change by the conservative and fiercely autonomous culture within universities; and
- an inappropriate system of Federal Government funding, lacking incentives to pursue the common good.

4.1.1. Minerals industry

Many in industry assume their professional are keeping at the forefront of technical advances.

Above all else, the minerals industry must acknowledge that there are limitations to the outcomes that can be achieved in an undergraduate degree course, and accept the need for the continuing further education of its professionals. This means recognising the fundamental role which continuing professional development (CPD) plays in the effectiveness of a company's professionals and in a company's continued success. This role will only become more important in the future.

To quote from Galvin and Roxborough: "*The concept of Continuing Professional Development (CPD) is not new. It has, however, come to the fore over recent years in*

most professions, stimulated by the exponential growth of knowledge and information. Prior to that, certainly in mining, it was fondly assumed that if the employing company did not provide CPD then people were keeping themselves up-to-date through private reading, involvement in professional societies and the like." [1]

The Taskforce believes many in industry still 'fondly assume' their professionals are keeping at the forefront of technical and other advances. Industry rewards are also biased towards time spent at work rather than continual professional education (CPE), further impeding the development of a strong CPD culture.

One cause of this has been the lack of good education support but this will only change when industry demands, drives and backs it with resources. This means providing work time for professionals to undertake training and giving a higher priority to this activity. For this to be effective, companies need properly conceived development programs. It should not be merely a reward for some good work.

The lack of strong CPD culture causes other problems. For example, the recurrent shortage of experienced professionals is partly a result of beliefs that general work facilities are unsuitable for training professionals who have experience in other fields and who wish to move into the minerals industry. Similarly, the current CPD approach lacks the capability to establish educational programs for the conversion of professionals from other disciplines. Further, it is driving employers to demand increasingly specific skills training from the undergraduate degree. This is pushing many in industry, and some in academia, towards an increasingly vocational view of undergraduate education, which will be to the longer-term detriment of both the industry and the graduates from these courses.

Graduates tailored to the needs of an individual company is an unrealistic expectation.

Following from this, industry must recognise that a system of minerals education will never deliver graduates with skills tailored to the needs of individual companies. The industry must develop systems which identify the specific skills needed and implement on-the-job training and structured graduate orientation programs to develop these 'generic' graduates to best suit the individual employer's needs.

The minerals industry also needs to change its behaviour in another way. This review has made much of the impact of the industry's investment cycles on recruitment patterns. These cycles will remain a characteristic of the industry. It is not necessary, however, for this to have such a dramatic cyclical impact on professional recruitment. For their own commercial advantage, as well as for the health of the wider system, minerals companies should adopt steadier recruiting patterns for professionals - certainly more than the mere 16%[2] of employers who are currently prepared to employ new graduates. In practice, this means companies adopting a recruitment pattern which is relatively stable from year to year. While this may not be practical for some smaller companies or companies focused on capital projects, it is well within the capability of most in the industry.

Companies should adopt steadier recruiting pattern and provide work experience for undergraduates.

Similarly, for a majority of minerals companies the provision of undergraduate employment must be relatively constant from year to year and in the same magnitude of numbers as forecast for future employment. For example, a company requiring two graduates a year to fill mining engineering roles should provide industry experience and undergraduate employment for eight students per annum. Support in this area

1. **Galvin JM and Roxborough FF** (1997), *'Mining Engineering Education in the 21st Century - Will Universities Still be Relevant?'*, The AusIMM Annual Conference, Ballarat, 12-15 March, p301-307.
2. **Western Australian Tertiary Education Taskforce** (1996), '*Discussion Paper*', the Chamber of Minerals and Energy of Western Australia Inc., July.

includes sponsorship of student site visits, project work and structured student employment. Industry is vociferous in its call for more practical experience in the undergraduate degree. However, there seems little matching willingness, with notable exceptions, to provide opportunities for students to gain this practical experience.

Lastly, the minerals industry must broaden its view of the skills and training relevant to a career as a mining engineer, metallurgist or geoscientist. There remains a strong view that the only genuine minerals professional has been educated in a minerals-specific course. This, combined with cyclic recruitment, place unattainable demands on the minerals tertiary education system. More importantly, it tends to blind the industry to the great depth of talent available within the wider community.

Industry must change by:

- accepting there are limitations to the outcomes that can be delivered in an undergraduate degree course;
- accepting its own need for genuine continuing professional development (CPD) among its employees by establishing structured company CPD programs;
- identifying skills requirements needed from new graduates and implementing the necessary graduate orientation programs to deliver them;
- lessening the cycle of demand for newly graduated professionals by adopting more stable recruitment patterns;
- taking a greater role in the provision of undergraduate practical experience;
- increasing the percentage of companies being prepared to employ new graduates; and
- broadening its view of what constitutes a graduate suitable for a minerals industry career and rethinking recruitment efforts to reflect this.

4.1.2. Universities

The major change required from universities is a shift away from a fiercely maintained academic autonomy, towards a culture of sensible sharing of resources and capabilities with other departments (both within the same university and with other universities).

Academic autonomy is desirable, but sometimes leads to empire building and senseless duplication.

The current funding policies for tertiary education are responsible for some of the barriers preventing greater cooperation between universities, but they are not the only obstacles. While a degree of autonomy is both necessary and desirable, the Taskforce believes that autonomy has taken too great a prominence in driving behaviour within universities. This is probably a natural outcome of any system where there is no central authority and no real common organisational goals. The lack of such central authority only serves to underline the need for academics to change their own beliefs and behaviours.

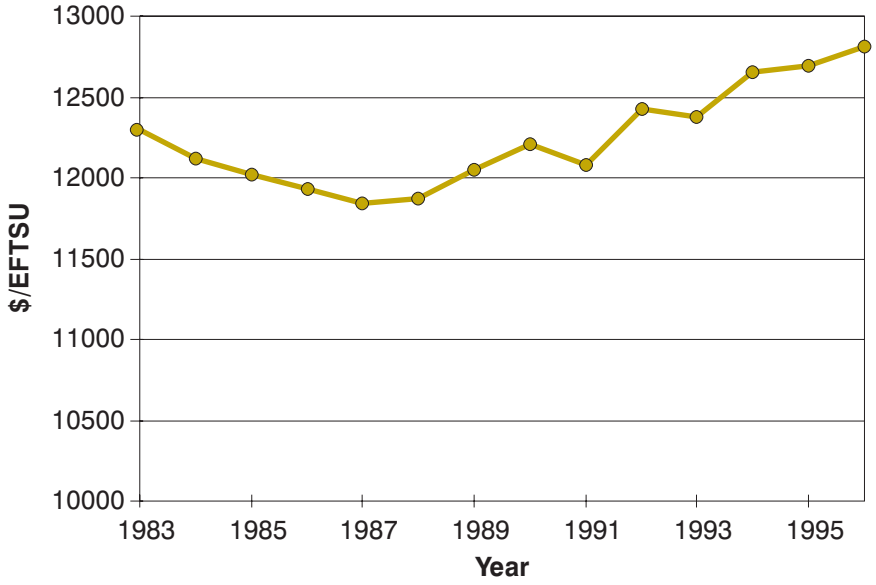
This independence finds its worst expression in competitive 'empire building'. This has serious negative impact on the quality of tertiary education, because all universities (indeed, all university departments) are attempting to offer all aspects of tertiary education under the one roof. The geographical spread of students and their reluctance to travel to access courses has also contributed to this duplication and waste of resources.

Much has been said about the severity of funding cutbacks within the university sector. However, Figure 4.1 shows that the overall funding per student in real terms has actually increased since 1987.[3] The increase in funding is going into the expansion

Overall funding per student in universities has actually risen since 1987.

of a range of programs offered by universities. This is inefficient and duplicates a wide range of under-resourced programs. The Taskforce believes that better cooperation between universities and departments and rationalisation of course providers would deliver improved educational outcomes, reducing the need for further resources.

Figure 4.1 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)[4]

This suggestion reflects a growing view within tertiary education. This view has been expressed by Amanda Vanstone,[5] thus: universities *"are seeking to cooperate and concentrate their resources to offer higher quality education, or to support disciplines which do not attract large numbers of students. Their aim, obviously enough, is to create economies of scale to ensure the viability of the courses and the services associated with the courses."*

Change and innvoation in minerals education is the exception rather than the norm.

A second area of needed cultural change within universities is in their preparedness to challenge traditional ways of doing things. This is a not a universal criticism. There are recent examples of initiatives within minerals education and wider engineering and science education, such as *Changing the Culture*. Nevertheless, these initiatives remain the exception rather than the rule. There is a long way to go before the general directions of universities are towards innovative approaches to the design and delivery of education.

As outlined in Appendix B, this behaviour is partly a result of the reward system within universities. Research success has traditionally been the road to promotion, recognition and higher rewards within the university system. In turn, this comes from a time when the university system tended to be the preserve of an elite rather than the large-scale education industry that exists today. To some extent, teaching became seen as the price to be paid for the autonomy to pursue research interests. While

3. Appendix C discusses the funding issue in more detail.
4. **Department of Employment, Education, Training and Youth Affairs** (1996), '*Annual Report 1995-96*', Commonwealth of Australia, Australian Government Publishing Service, Canberra.
5. **Senator the Hon Amanda Vanstone** (1996), '*A catalyst for change? Higher education and the 1996-97 Budget*', Address to The University of Adelaide, 11 November. http://www.deetya.gov.au/minwn/vanstone/vs11_11.htm

many academics do put serious effort into teaching, and their numbers are increasing, the evidence suggests that much more change is needed.

Universities must change by rewarding behaviour aimed at:

- encouraging cooperation between individual departments both within universities and between universities, to share resources and to develop and deliver world class minerals eduction;
- encouraging innovation and regular examination of the traditional design and delivery of tertiary education; and
- placing a priority on the development of teaching excellence in tertiary education.

4.1.3. Federal government [6]

The Taskforce believes it is essential for the Federal government to fund minerals education at optimum levels. The Taskforce recognises that education policy is currently the topic of fierce debate in the community and minerals education cannot be seen in isolation from these broader issues. However, the Taskforce believes that there is real opportunity to move higher education onto a higher quality, more efficient base in key areas of national interest, such as minerals education. This can be achieved through significant targeted funding.

In addition to providing optimum funding levels, there are four areas where the Federal government can assist in creating a new university culture that supports the aims of this review.

Encourage cooperation and reward teaching excellence.

The first two areas the government can assist change are by encouraging universities to move toward greater cooperation and to develop a priority for the development of teaching excellence. Both of these points have been discussed above in the nature of change required by universities.

Third, the public funding policies must be directed towards rewarding excellence in education and towards encouraging cost-efficient provision of courses by making universities work together. This relies on creating awareness amongst students of educational quality and value for money. Australia can learn from the USA where extensive, well-informed and objective surveys are regularly published on different types of courses. To encourage further cost-efficient provision and improved quality, the design of public funding should support students in following up their choice. For this to be fully effective, public funding of education and student support should also help overcome any major financial barriers to the mobility of Australian undergraduate students.

Lastly, the discussions the Taskforce has held with academics and with those in industry familiar with university operations, have led it to conclude that bureaucracy is consuming too much of the resources that should go to minerals education departments. While accountability in funding allocation is essential, some of the bureaucracy is an avoidable distraction and can have pernicious effects well beyond its immediate impact on the time of academics and administrators. Government policy should shift towards less onerous reporting requirements and focus on funding based on the quality of educational outcomes.

Federal government should assist change by changing the funding framework for higher education to place greater emphasis on:

- improving educational quality by encouraging cooperation and sharing between universities to efficiently utilise public and private resources;
- developing teaching excellence in tertiary education;
- encouraging and supporting student mobility to pursue cost effective and superior quality courses; and
- reducing the administrative burden on universities and rewarding the quality of educational outcomes.

4.1.4. Professional associations

The professional associations closest to the minerals industry are the Australasian Institute of Mining and Metallurgy (The AusIMM) and the Australian Institute of Geoscientists (AIG).

These associations are already moving in the direction necessary to support the aims of this review. The AusIMM introduced Chartered Practising Status (CPS) in 1995, and the AIG has developed a similar system. This initiative establishes a formal requirement for professionals to pursue structured further education. By not stipulating what this education must be, The AusIMM recognises the diversity of further education that will be necessary for the individual careers of its members.

To be meaningful, industry, The AusIMM and the AIG will have to drive the CPS. The CPS must be regularly reviewed to ensure it is contributing to effective, continuous learning and this learning actually improves organisational profitability.

Professional associations should embrace alternative pathways into the minerals professions.

The Taskforce believes, in particular, The AusIMM should embrace the concept of alternative pathways into the specialised minerals professions. It should also adopt a broader view of tertiary qualifications and the professional experience necessary for roles in the minerals industry. The AusIMM graduate outcomes criteria for course recognition will need review and broadening if they are to be used to support an effective system of alternative pathways.

Generally, closer relationships between the professional associations are an important step towards establishing a truly viable system of alternative educational pathways into the industry. Educational pathways can only be enhanced by establishing the minerals professions as part of, rather than apart from, the wider group of engineering and science professions.

Further, there could be advantages in the amalgamation of professional associations representing minerals industry professions. The Taskforce encourages the associations to explore opportunities to optimise resources and better align their efforts to represent the interests of the minerals professionals.

6. Appendix B and Appendix C discuss the current government funding framework for higher education and the issues that have led to these recommendtions. Appendix A discusses the status of the Review of Higher Education Financing and Policy.

Professional associations must continue to:

- work together to adopt a broader view of the tertiary qualifications and professional experience necessary for roles in the minerals industry;
- focus on systems for continuing professional development management which encourage strong continuous learning beliefs and behaviour; and
- consider whether consolidation or amalgamation of organisations might be in the best interests of minerals professionals and the industry.

4.1.5. Students and professionals

Students and professionals will contribute to improving minerals education by actively exercising choice within the tertiary education system. Students and professionals are ultimately responsible for their own careers, and for their own continuing development. Mobile, inquiring and quality-focused professionals gain better personal outcomes than those who are willing to follow a path fixed for them by their companies or the nearest university. Such students also contribute to the quality of the system, by challenging its norms and forcing it to respond to current needs.

4.2 Driving and facilitating the change

In this review, the need for cooperation has emerged as a recurrent theme. Genuine working together will not be easy and simply understanding the common interest in tertiary education is not enough. There is a need for a forum and mechanism for bringing together those interests.

To provide this mechanism, the Taskforce proposes that the Minerals Council of Australia establish the Minerals Education Council (MEC) with the collaboration of universities and government. MEC will represent a fundamental change in the dynamics of the minerals education system. It will be the body with enough influence, in both a leadership and a resourcing sense, to accelerate the stakeholder change process from an incremental series of steps to a rapid reorientation.

4.2.1. The Minerals Education Council

A forum for bringing stakeholders together and to catalyse action.

The Minerals Education Council would be charged with leading and facilitating the necessary changes in minerals education. The Council should encourage industry to place more emphasis and priority on the education of its professionals and demand more of the universities and of government in helping it to do this.

Broadly, MEC would have the responsibility:

- to lead and facilitate the achievement of the recommendations contained in this review;
- to assemble and direct resources as appropriate towards achieving the recommendations;
- to ensure that, across the whole system, the outcomes of minerals education are regularly reviewed;
- to provide representation at and input into the tertiary education policy-making processes at Federal, State and university/industry level;
- to foster close links between the national minerals industry, the network of centres and the ASMR; and
- to ensure opportunities are available for students to obtain structured practical experience.

The Council would be permanent.

The MEC would be directed by a council with, perhaps, eleven representatives drawn from industry, academia and government. Selection of the Council chair and membership would rest with the Minerals Council of Australia. One possible composition of the Council would be five representatives from industry (at least one from a smaller company and one who is an AusIMM councillor), five from academia and one from the Federal government.

The MEC would appoint and resource a Secretariat, led by an Executive Director. The role of the Secretariat would be to develop a collaborative coherent strategy and plan for implementing MEC's charter and to drive the implementation process.

The Secretariat's role implies a finite life.

The Minerals Education Council would be established on a permanent basis to maintain a structured relationship between all minerals education stakeholders. The Secretariat for the Council would be established initially for a period of five years. After this, the Council would perform a full review of the Secretariat functions and its continued existence.

This review is needed because the Secretariat's primary role in the first instance is to drive and facilitate change. This implies a finite life. Ideally, in a five-year period there would be a change within minerals education towards a culture of working together within both industry and academia. This new culture should be self-sustaining and self-managing. While the Council would continue on an ongoing basis, the need for the Secretariat to drive and facilitate change may well have disappeared. Alternatively, the needs of the time might demand another approach. Another reason for review is to avoid creating another body, which becomes yet another bureaucracy in an already over-crowded field. The Secretariat must remain a vital force in improving the quality of minerals education or it should be wound-up.

The MEC and its Secretariat should also develop concrete plans of action to pursue the initiatives proposed in Chapter 3. The following sections describe, in broad terms, the process, which might be followed in establishing each of the action plans.

(a) Initiative 1 – creating a network of centres

Invite submissions to create centres and create a collaborative strategic plan between the centres chosen.

The MEC should first establish a preliminary plan for the network of centres and the criteria for judging whether a particular minerals department is capable of becoming a centre of minerals education. The framework for these criteria was outlined in Chapter 3. Submissions should be called from institutions to become part of the select network of centres, and should include details of the timetable and additional resources (human, infrastructure and funding) considered necessary to progress these initiatives. MEC should require all submissions to be done jointly with other university departments and companies or industry bodies.

After the submission stage is complete, the MEC should lead and facilitate the process of developing a collaborative strategic plan for the structure and resourcing of the network of centres. This would be an inclusive process with all parties being involved in consultations. Further, the process needs to determine whether there are significant resource shortfalls and the MEC should negotiate and establish funding participation from universities and governments, prior to final approval by industry.

The outcome of this process would be a series of formal 'business plans', outlining how their combined strategies for achieving this excellence will unfold. These business plans would be contractually agreed to between respective centres and the MEC.

Inevitably, this process will lead to the rationalisation of providers within the Australian

minerals education sector. The MEC must play an essential role in bringing together industry, universities and government to ensure that the rationalisation is structured and benefits the minerals industry and its professionals. Further, the MEC and government should ensure that the cost savings gained in the rationalisation are re-invested in the new system of minerals education, thus limiting the need for additional resources.

(b) Initiative 2 – establishing a system of alternative pathways

This must also be an inclusive process, involving industry representatives, The AusIMM and the AIG as well as academics. The intention is to establish a recognised and viable system of alternative educational pathways into the industry. MEC will drive and co-ordinate the process.

A recognised and viable system of alternative educational pathways into the industry.

The first step will be a review of course recognition criteria. The review will focus on facilitating recognition of broader based, or undergraduate/postgraduate combinations of courses. The second step will involve drawing up a system of alternative pathways, which will be recognised by industry and professional associations.

Lastly, a network of service courses to support these different pathways must be proposed. This proposed network would be taken up in the development of the curriculum for the Australian School of Mineral Resources.

(c) Initiative 3 – establishing the Australian School of Mineral Resources

The establishment of the Australian School of Mineral Resources will follow a similar planning process as for the formation of the network of centres.

The MEC should firstly establish a preliminary plan for the ASMR and the criteria for judging the capability of possible contenders. A significant criterion for judging the contenders will be the talent and leadership ability of the individual charged with directing the ASMR. Submissions would be called from selected parties and would include the timetable and additional resources (human, infrastructure and funding) considered necessary to progress this initiative. These submissions would form the basis of a tendering process.

Call for submissions to establish the ASMR in a competitive tender.

After the submission stage is complete, the MEC and the successful party would develop a collaborative strategic plan for the structure and resourcing of the ASMR.

The successful tender would then follow a process along the following lines:

- the Director would establish the requirements of a national curriculum. Inputs to this process would come from industry, the proposed national network of service courses and from all of the undergraduate departments and postgraduate / research centres which offer minerals postgraduate coursework;
- having established the required national curriculum, the Director would then assess the quality of courses, and the appropriateness of delivery methods currently available to support the curriculum. In doing so, the Director would work very closely with the private providers, universities and industry; and
- the Director would then develop a 5-year strategy for bringing the national curriculum to world's best standards. In doing so, the Director would identify resourcing requirements and commercial arrangements to achieve the 5-year plan and to ensure that the School is commercially viable after 5 years.

The outcomes of this development and strategy process would be brought to MEC for discussion, review and approval. Any set-up funding requirements would have to be approved and provided by the Minerals Council of Australia and other stakeholders.

ASMR would not be a degree-granting institution.

Following this, the ASMR would develop a process for commissioning coursework and offering a national postgraduate curriculum.

It is unlikely that the ASMR would be a degree-granting institution. Exactly what would be the powers of the ASMR in this respect would require discussion and negotiation with relevant universities. The MEC should undertake these negotiations.

The continued funding of the ASMR could follow similar lines as that of the Australian Minerals Foundation (AMF). The AMF's corporate experience, knowledge and expertise in establishing a national program of postgraduate minerals education would be invaluable when establishing the ASMR.

4.3 Resourcing the change

Significant extra resourcing will be required to implement this strategy. Two areas which will require resources are:

- to manage change: plan and administer the initiatives; and
- to implement and operate the new minerals education system.

4.3.1. Managing the initiatives

To achieve the improvements it wants, industry must take the lead.

The role of management, planning and administration of the three initiatives will lie initially with the Minerals Council of Australia. To achieve the improvements that industry wants from minerals education, industry will have to take the lead.

To provide this lead, the Taskforce recommends that the Minerals Council of Australia approve, in conjunction with the government and universities, funding for two initial steps:

- the establishment of the Minerals Education Council and its charter, initially as a sub-committee of the Minerals Council of Australia; and
- the appointment of an Executive Director and staff for a period of five years - to plan the staff, structure, implementation and administration required for the initiatives proposed for undergraduate and postgraduate education.

The cost of these two initial steps is estimated to be $2.5 million for a period of five years. This comprises salary and support costs for an Executive Director and the MEC Councillors. This funding will be necessary to start the process of achieving the initiatives recommended in this review.

Recommendation 1

Minerals Council of Australia should establish and fund a new body, the Minerals Education Council (MEC) in order to progress the initiatives recommended in this review. This would include the following steps:

a) the Minerals Council of Australia develop the charter for MEC and appoint a Chair and Board; and

b) the MEC to appoint an Executive Director to plan the strategy and resources required to progress the initiatives.

This is to be done within a budget of $2.5 million over five years.

4.3.2. Implementing and operating the initiatives

Additional funding will be needed for course development, teaching and academic salary supplementation. Other in-kind resources will be needed in the form of facilities to allow practical education on-site (such as on-site accommodation and teaching facilities) and people, from industry and elsewhere, to teach and advise students and academics. Some examples:[7]

- innovative coursework development for the ASMR;
- salary supplementation for selected academic staff;
- additional academics;
- installation of computer and telecommunications facilities to enable computer-based learning and distance education; and
- infrastructure requirements, on campus and on-site.

Recommendation 2

The Minerals Education Council (MEC) should call for submissions from interested institutions to form a network of centres. These submissions should be made in conjunction with other university departments and minerals companies or industry bodies. The submissions would form the basis of a tendering process, and will result in a collaborative business plan which will be contractually agreed by all stakeholders. Submissions should detail:

a) how the criteria in Initiative 1 will be met by the proposal;

b) how they will support the alternative pathways of Initiative 2;

c) how these centres will contribute to the curriculum of the Australian School of Mineral Resources (Initiative 3);

d) the timetable for implementation;

e) the resources universities will commit; and

f) the resources required from the MEC and a proposal for accessing these resources.

(a) Estimated order of magnitude for costs required to implement initiatives

A budget of around $20 million over five years may be needed.

The Taskforce believes that to implement the strategy fully, the minerals industry, governments and universities will have to contribute substantial funds. These will be required to fund the network of centres and the ASMR in designing, developing and delivering innovative coursework. The extent of the necessary extra funding cannot be known until detailed submissions are made by parties wishing to participate in achieving the initiatives (see Recommendation 2). However, through an informed estimation, the total is expected to be in the vicinity of $20 million over five years.

The Taskforce acknowledges that industry and government already commit significant funding to minerals education. The rationalisation and efficient redistribution of this funding will be a significant contributor to the resources needed to progress the initiatives. However, additional funding will be required to facilitate change and implement the initiatives. The industry (including its service companies) can expect to have to provide a significant proportion of these funds together with the universities and government. The extent of participation by universities and government will

need to be established before industry's contribution is finalised.

The additional funding required by the minerals geosciences sector should be less than that needed for mining and metallurgical science and engineering, because the resources available within all the geoscience departments, taken together, are substantial. The dispersion of these resources is one of the biggest barriers to improving the quality of minerals geoscience education.

There is no doubt that minerals education is substantially underfunded. However, the Taskforce does not wish to commit to any specific funding estimates until the submissions detailed in Recommendation 2 are received and considered.

(b) Possible sources of funding

Government, industry and universities need to consider a redistribution of existing funding as well as additional funding.

Given the need for significant funding, the obvious question is: 'where could this funding come from?' There are three main beneficiaries of a national system of minerals education: the industry, universities and Australians through the Government. These stakeholders should form a partnership in providing the needed resources.

Additional support from the Federal and State governments will be required and should be related to the amount of support that the industry is prepared to contribute.

Part of the Federal government support should come from a redistribution of existing funds and other additional sources. For example, redistribution of funds could happen by:

- the new system of minerals education receiving a significant proportion of the extra government funds, made available from the efficiency gains of the rationalisation of the current minerals education system; and
- a change in the funding framework resulting in an increase in the level of funding directed to the departmental level of specific universities.

Government and universities must not see possible industry funding as a windfall.

State government funding will essentially be additional funding (in 1994 the total level of State government funding for the higher education system was only 1.9%). The minerals industry provides a major contribution to State government funding. State governments should consider the benefits that minerals education centres of excellence can bring to their economies. They should actively support university submissions to MEC.

Similarly, the Taskforce would expect participating universities to contribute commensurate financial support for minerals education and not to regard additional industry funding as a windfall gain. To enable this, universities should change their funding distribution policies to free up additional funds for minerals education departments.

7. Appendix C has more detail on these points.

Definitions

Throughout this review, there are several terms that are used many times:

1. minerals industry;
2. minerals tertiary education;
3. minerals disciplines; and
4. undergraduate and postgraduate education.

For clarity it is necessary to define and discuss these terms.

(1) Minerals Industry

For the purposes of this discussion paper the definition of the minerals industry implies all companies that are regular employers of the graduating professionals from mining, metallurgical and geoscience engineering and science courses. These companies and organisations are involved in the exploration for orebodies and the mining and processing of ore to primary metal, and are seen as the main beneficiaries of an improved system of minerals education in Australia. This includes a wide range of companies from large mining houses through to small mining companies, contractors, service companies, technical consultants, financial analysts and regulatory agencies.

This review has not included discussion of the petroleum industry, despite the close links in education - particularly in the education of geoscientists. The recommendations from this review will relate specifically to minerals education.

(2) Minerals Tertiary Education

The Taskforce defines minerals tertiary education as that education which purposefully prepares, or further educates, people for the role of mining engineer, metallurgist or geoscientist in minerals-related employment.

The rationale for choosing this admittedly circumscribed definition of minerals education is that these roles are all closely linked to the core technical business of the minerals industry. The minerals industry is almost alone in having an interest in maintaining standards of education for those roles.

(3) Minerals Disciplines

The phrase 'minerals disciplines' will be referred to frequently throughout this review. Minerals disciplines are defined as the degree qualifications of mining, metallurgy and geology.

In focussing on these three disciplines, it is recognised that there are significant differences between them. The differences can perhaps be best described by saying that mining and metallurgy are specific to the minerals industry and have reasonable substitutes in civil and chemical engineering. Geoscience is considerably less tied to the minerals industry[1] and it has no real substitutes. Nevertheless, all three disciplines share two characteristics: together they form the 'core' technical disciplines of the minerals industry and they are all largely dependent on the industry for their viability as disciplines, at least in their current form.

(4) Education System - Undergraduate and Postgraduate

While, the undergraduate and postgraduate stages of education can be considered to be part of a single continuum, in practice they are different in many ways. Throughout this review, undergraduate and postgraduate education will be discussed as having different roles in the education process.

(a) Undergraduate Education

Undergraduate education is the first stage of the education process where a systematic effort is made to establish basic principles of a discipline and ways of approaching and solving problems. These frameworks can be quite pervasive and come to typify a profession. For example, the framework that a graduate from an economics course will use to approach a problem will be different from that used by a scientist, which in turn will be different from that of an engineer or a lawyer.

Undergraduate education also introduces the student to a range ways of thinking and techniques for analysis.

(b) Postgraduate Education

At the postgraduate level, the student already has a 'dominant paradigm' through which problems are approached and modelled. The purpose of postgraduate study is for the student to apply the broader thinking models developed in undergraduate education to the gaining of new knowledge in one or several, relatively narrow and particular areas.

Postgraduate education encompasses both research and coursework components. Throughout this review, postgraduate education is implied only in the coursework sense. This review has not considered education at the research level, other than to indicate the importance of a research capability in ensuring effective and relevant teaching.

(c) Summary of differences between Undergraduate and Postgraduate Education

Table 1 summarises the differences between undergraduate and postgraduate education.

Table 1 Comparison of undergraduate and postgraduate education

Feature	Undergraduate - U/G	Postgraduate - P/G	Difference
Funding	Majority public, some students pay	Mostly student pays	P/G more market oriented
Learning Style	Campus-based, face to face	Often external, distance learning	P/G flexible delivery distance learning are more acceptable to students
Diversity, stability	Focused on common frameworks & principles, course content tends to be stable with incremental change	Focused on wide variety of specialist content, course content will change with technological advances	P/G more rapid change in content
Providers	Undergraduate departments	Wide variety of providers	P/G more numerous providers, including non university

1. Recent statistics indicate that 62% of 1996 graduates were employed by the minerals industry. Graduate employment is further discussed in Appendix D, Section 1.1.

Abbreviations

AATSE/ATSE .. Australian Academy of Technological Sciences and Engineering
ABARE ..... Australian Bureau of Agricultural and Resource Economics
ABS ..... Australian Bureau of Statistics
ACED ..... Australian Council of Engineering Deans
ACIRL ..... Australian Coal Industries Research Laboratories
ACT ..... Australian Capital Territory
AGC ..... Australian Geoscience Council
AGPS ..... Australian Government Publishing Service
AGSO ..... Australian Geological Survey Organisation
AIG ..... Australian Institute of Geoscientists
AMF ..... Australian Minerals Foundation
AMIRA ..... Australian Mining Industries Research Association
ARC ..... Australian Research Council
ASEE ..... American Society for Engineering Education
ASMV ..... Australian Student Mineral Venture
ASTEC ..... Australian Science, Technology and Engineering Council
AVCC ..... Australian Vice-Chancellors' Committee

BE ..... Bachelor of Engineering
BOG ..... Base Operating Grant
BSc ..... Bachelor of Science

CAE ..... College of Advanced Education
CAUT ..... Committee for Advancement of University Teaching
CPD ..... Continuing Professional Development
CPE ..... Continuing Professional Education
CPI ..... Consumer Price Index
CPS ..... Chartered Practising Status
CRC ..... Cooperative Research Centre
CSIRO ..... Commonwealth Scientific and Industrial Research Organisation

DEETYA ..... Department of Employment, Education, Training and Youth Affairs

EEA ..... Engineering Education Australia
EFTSU ..... Effective Full-Time Student Unit
EU ..... European Union

FT ..... Full Time

GCCA ..... Graduate Careers Council of Australia

HECS ..... Higher Education Contribution Scheme

IEAust ..... The Institution of Engineers, Australia

JKMRC ..... Julius Kruttschnitt Mineral Research Centre

MSc ..... Master of Science

ME ..... Master of Engineering
M.I.M. ..... Mount Isa Mines
MP ..... Member of Parliament
NESTC ..... National Earth Science and Technology Centre
NEP ..... National Education Program
NZ ..... New Zealand
NSW ..... New South Wales

OPEC ..... Organisation of the Petroleum Exporting Countries
OECD ..... Organisation for Economic Co-operation and Development

PhD ..... Doctor of Philosophy
P/G ..... Postgraduate
PT ..... Part Time

RIEFP ..... Research Infrastructure (Equipment & Facilities) Program
R & D ..... Research and Development

TAFE ..... Technical and Further Education
TES/TER ..... Tertiary Entrance Scores/Tertiary Entrance Requirement
The AusIM .... Australasian Institute of Mining and Metallurgy
TIAC ..... Technology and Industry Advisory Council

U/G ..... Undergraduate
UK ..... United Kingdom
USA ..... United States of America

VET ..... Vocational Education and Training

WA ..... Western Australia