"Educating Mining Engineers for a Sustainable Future"

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Objectives and Outline

- Educating Mining Engineers
  - Meeting the New Vision of Engineering Education
  - Integrating Trends and Needs of the Global Minerals Industry

- Minerals Education Challenges and Opportunities
  - Revitalization of the Education Infrastructure
  - Learning from “Best Practices”

- Conclusions

Note: A number of references were used to develop this presentation. A reference list can be provided by the author on request.
Meeting the New Vision of Engineering Education
The Role of the Modern Research University

- Preserve and maintain the basic knowledge
- Create new ideas, philosophies, arts and technologies
- Recruit and retain highly qualified teachers/researchers
- Educate post-baccalaureate and post-doctoral students
- Attract supplemental funds and other resources, equipment and facilities
- Transfer new concepts and technologies to industries and governmental agencies
- Foster the competitive position for national economies in the world marketplace
- Provide education in a “state-of-the-art” atmosphere
The New Engineering Frontiers: (Charles M. Vest, President Emeritus, MIT and President, NAE, 2006)

- The intersection of physical, life and information sciences – the so called bio, nano, info – "which offers stunning, unexplored possibilities"

- The macro world of energy, row materials, food, manufacturing, communications, which presents "daunting challenges of the future"
The Engineering Graduates
(Source: Charles M. Vest, 2006)

- "The kind of students who will explore these new frontiers should reflect a diverse society, write and communicate well, think about ethics and social responsibility, conceive and operate systems of great complexity within a framework of sustainable development and be prepared to live and work as global citizens"

- "We must ensure the best and brightest become engineers of 2020 and beyond. We can't afford to fail"
The Engineering Schools (Source: Charles M. Vest, 2006)

- Engineering schools should focus on
  - Creating an environment that provides inspiration
  - Offering "exciting, creative, adventures, rigorous, demanding and empowering milieus is more important than specifying details of the curriculum"

- Students are "driven by passion, curiosity, engagement and dreams." They deserve opportunities to discover, participate in research teams, perform challenging work in industry and gain professional experience in other countries.
An increasing global population with aspirations for a higher standard of living is significantly altering natural systems, affecting the quality and quantity of life on earth.

Technology is both partially the cause and a critical component of a future solution.

Have engineering schools incorporated the topic of sustainability in meaningful ways? Below are findings based on published literature and two questionnaires:

- Faculty believes that teaching principles of sustainability is important, even though many are generally ill informed.
- Graduates should have a basic understanding, but they don't.
- Although many colleges offer courses, only a few appear to be seriously incorporating sustainability concepts.
“Renaissance Engineers!”
(Source: A. Akay, 2003)

- Engineering must go beyond pure technology in order to consider how engineering can address matters that are often embedded in the social and economic fabric of society.
- Engineers must go beyond being technical experts who understand and consider social, financial and political factors by becoming leaders in all arenas of society.
- “These expectations call for renaissance engineers and the need for a renaissance in engineering education.”
What all this Means in Educating Mining Engineers?

- Minerals educational programs must ensure engineering competency for the graduates by aiming at a reasonable balance between depth and breadth.
- A greater exposure on emerging technologies, health and safety issues and management/economics subjects will enhance the curriculum and contribute to an improved positioning of the graduates in the market place.
- The increasing global demand for raw materials and the need to engage the sector in sustainable development practices, dictate the development of integrated educational concepts that consider the entire mine life-cycle, from exploration to mine closure and post-mine land use.
- In short, the mining educational process should **promote a balanced curriculum** of technical, environmental, ethical, social, business and global aspects of the profession.
Integrating Trends and Needs of the Global Minerals Industry
The Status of the Global Minerals Industry

- Minerals Supply v. Demand
  - Robust Prices, Output and Demand
  - Exploration/Financing of New Projects

- Changing Industry Structure
  - Industrial Minerals, Aggregates and Construction Materials
  - Privatization/Concentration/Globalization of the Sector
  - Large Producers v. Small/Artisanal Mines

- Environmental Demands and SD
  - Environmental Pressures and Demands
  - Transition to Sustainable Development (SD)

- Technical and Professional Needs
  - A Multi-Disciplinary Approach to Mining
  - Lack of Investing in Minerals R&D
  - Man Power Crisis in the Minerals Industry
## Comparison of World Prices

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<tbody>
<tr>
<td>Oil Brent</td>
<td>$/barrel</td>
<td>19,90</td>
<td>28,70</td>
<td>30,17</td>
<td>40,37</td>
<td>60,39</td>
<td>58,64</td>
<td>194%</td>
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<td>Natural Gas</td>
<td>$/MMBtu</td>
<td>2,55</td>
<td>4,79</td>
<td>6,19</td>
<td>5,76</td>
<td>6,34</td>
<td>7,91</td>
<td>128%</td>
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<tr>
<td>Copper</td>
<td>$/tonne</td>
<td>1462</td>
<td>1536</td>
<td>2321</td>
<td>3280</td>
<td>6201</td>
<td>5225</td>
<td>225%</td>
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<tr>
<td>Nickel</td>
<td>$/tonne</td>
<td>5680</td>
<td>7100</td>
<td>1665</td>
<td>1520</td>
<td>1338</td>
<td>37900</td>
<td>228%</td>
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<tr>
<td>Steel</td>
<td>$/tonne</td>
<td>504</td>
<td>422</td>
<td>740</td>
<td>1056</td>
<td>1725</td>
<td>1575</td>
<td>213%</td>
</tr>
<tr>
<td>Zinc</td>
<td>$/tonne</td>
<td>768</td>
<td>750</td>
<td>1008</td>
<td>1270</td>
<td>4259</td>
<td>3045</td>
<td>302%</td>
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<tr>
<td>Gold</td>
<td>$/ozt</td>
<td>276</td>
<td>343</td>
<td>417</td>
<td>427</td>
<td>640</td>
<td>668</td>
<td>160%</td>
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<tr>
<td>Silver</td>
<td>$/ozt</td>
<td>4,52</td>
<td>4,67</td>
<td>5,97</td>
<td>6,39</td>
<td>13,01</td>
<td>13,93</td>
<td>233%</td>
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<tr>
<td>Platinum</td>
<td>$/ozt</td>
<td>477</td>
<td>598</td>
<td>814</td>
<td>861</td>
<td>1135</td>
<td>1199</td>
<td>147%</td>
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Aggregates and Growth
(U.S.G.S.)

- More than 50% of the aggregates produced in the US, during the 20th Century, were produced and consumed in the last 25 years.

- An aggregate production of over 40 B tons is projected for the first 25 years of the 21st Century. This equals the entire output of the 20th Century.
Global Exploration 2007

Billion USD

Sources: RMG, MEG.
Announced Global Mining Investments

Mine Investments by Region 2006

MINING COMPANIES

Total 4,100 companies

149

957

3067

CONTROL OF MINING

Metals total 250 billion USD

Issue No. 1: Man Power Needs of the Minerals Industry/Community - A Crisis?

A topic deserving an entire presentation!

- Shortage at all Levels
- Demographics v. Regional/Sectoral Trends
- Aging Work Force and Retirements
- Human Resources Development
- Need for improved Training and Upskilling
Need for Advanced Training Methods!
Impacts of the Workforce

“OLD” Workforce: Great Success

- Operational and Productivity Improvements
- Outstanding Health and Safety Performance

The “NEW” Workforce: Impacts?

- Can the industry maintain current levels of productivity and safety assuming an infusion of a new, inexperienced, workforce?
- Will an uncontrolled replacement of the workforce threaten productivity, safety and profitability?
- Is there a pool for this new workforce? Where?
Issue No. 2: The Energy Impacts and Footprint of the Minerals Sector - Energy at What Price?

Another topic deserving an entire presentation!

- Understanding the Energy Impacts on Minerals and Processing Operations, Systems and Performance
- Appreciating Sectoral and Regional Interests/Conflicts
- Establishing an Energy-Based R&D Agenda
- Surviving Carbon-Limited Legislation and Treaties – Is there a plan?
Evidence of Global Warming!
**Issue No. 3: Minerals Operations are Highly Dependent on Continued Technological Progress - Are We Investing in R&D?**

- Research must be continuously undertaken to meet the future technology needs of the industry. This was recognized in the MMSD (2002) process and the subsequent Toronto Declaration:
  
  *Research and technology are vital to this initiative [i.e. SD] if the mining industry is to keep or be granted a “social license” to operate*

- R&D programmes will have to be accomplished largely through cooperative efforts between government, industry, research organizations and the global mineral schools

- This requires viewing the traditional mining universities both as educational resources and as centers of excellence for the development of new technologies
Technology Barriers

- Emphasis on Revolutionary v. Evolutionary Changes
- Needs Significant Infusion of Public/Private Funds

Mining Industry R&D Investment (% sales)

N.B. BHP-Billiton reported on Australian Financial Years - i.e. Yr Ends Jun04, 03, 02, 01
Designing the “Mine of the Future” (per Rio Tinto)

- Economic evaluation, mine design, operation and closure are integrated, taking into account local community and ecology before, during and after mining.
- Mining is conducted on large scale and extraction rates, with high levels of automation and technology.
- Mining and processing requires limited use of land, with minimal surface disturbance and the mine site is returned promptly to sustainable and beneficial use.
- Efficient use of energy and water is in the core of all processes.
- Operation are safe for employees and neighbours.
- Low to zero impact on other natural resources.

Remote Mining  Invisible Mining  Urban Mining
Minerals Education Challenges and Opportunities:

Revitalization of the Education Infrastructure
“Community” Goal and Priorities

- The minerals community must be committed to encourage and support university-based education, at the highest level.
- Research of the scientific and engineering knowledge in areas relevant to the provision of mineral products should be recognized and adequately supported.
- The community must establish global academic networks that can work jointly and co-operatively.
- The academic minerals community must pursue new ways of learning, attracting non-traditional students and participating in distributed educational schemes.
- The community must embrace and encourage active engagement with SD concepts and processes.
- The minerals community must place priority in addressing the issue of public image of the minerals-producing industries and fostering pride in the minerals disciplines.
Emphasis in Minerals Education

- Geosensing/Geospatial Data/Visualization
- Geomechanics
- Optimization of Mine Planning
- Orebody to Mill Integration
- Production Control
  - Loading
  - Hauling
  - Spatial Measurement
  - Equipment Reliability
  - Fragmentation
- Ventilation/Mine Environment
- Health and Safety: Engineering/Legislative/Behavioural Controls/Emergency Response
- Energy Systems: Conservation/Efficiency/C-Footprint
- SD: Life-Cycle, Capacity Building and Community Engagement
Promote “Sustainable Engineering”

- “Sustainable Engineering” in the minerals industry should be based on an educational process that promotes an understanding of the environmental, ethical, social and business aspects of the profession.
- Sustainable education incorporates a global and geopolitical understanding of the industry.
- An educational process that motivates students, instills a desire to pursue learning and emphasizes individual, as well as interdisciplinary learning.
Minerals Education Challenges and Opportunities:

Learning from “Best Practices”
What is the Current Status of Minerals Education?

- A minerals education crisis, or at least serious concern
- Some historic mining schools have terminated minerals programs
- The “survivors”, in both developed and developing countries, are under pressure and scrutiny
- Globally, minerals engineering programs represent a sub-critical mass of effort that, without adequate support, may deny the industry and the community technical and professional manpower within a few years.

Numerous factors have contributed to this decline:
At the Department Level
International Mining Program Closures
(after Knights (2003)

Change in Number of University Mining Programs 1985-2003

USA United Kingdom Canada Australia South Africa Chile
Educational Institutions with a Component of Mining/Minerals Education in the USA:

- Virginia Tech
- Colorado School of Mines
- University of Utah
- Montana Tech
- University of Nevada, Reno
- University of Missouri, Rolla
- New Mexico Tech

- University of Arizona
- University of Kentucky
- Southern Illinois University
- University of Alaska, Fairbanks
- University of West Virginia
- South Dakota School of Mines
- Penn State University

Reduced from 24 to 14 (!) in 25 years
At the Undergraduate Level:

- Student recruitment and retention

According to a survey, students offered the following reasons for lack of interest in the field:
  - Image (a sunset industry!)
  - Lack of technical innovations
  - Size and academic reputation of the discipline
  - Job location
  - Starting salaries
  - Lack of career development interest by employers

Students are “seeking a career not a job”
Long Term Trends – Australia, USA, UK, S. Africa, CA (Davison, Rio Tinto, 2004)

Long term trends - Australia, USA, UK, South Africa, Canada

- BSc Australia
- BSc UK
- BSc USA
- BSc South Africa
- BSC Canada
- Total
CYCLICAL NATURE IN DEMAND AND SUPPLY FOR MINING ENGINEERS
R&D Funding Impacts

- The decline in research funding by industry and government is a serious threat to the sustainability of the minerals engineering education.

- This is, dramatically, illustrated by the current crunch in attracting and developing mining faculty at mining schools around the world, a crisis that is expected to reach even more alarming proportions during the next five years.
At the Post-Graduate Level:

- The limited research funding by industry and government has been a serious threat to the development of post-graduate programs.
- Recruitment and support of qualified post-graduate students is competitive across fields.
- Related disciplines with broader appeal, better funding and, possibly, more rewarding careers are successfully recruiting from the same pool.
- The opposite is not happening!
At the Faculty Level:

- The continuous decline of minerals education had a significant impact in the recruitment, retention and development of the “professorate”
- The faculty issue becomes even more critical when looking at the demographics of the profession
- The vast majority of the academic staff in minerals programs is at the senior level, posing serious succession and continuity problems
- Since the post-graduate pipeline is also decreasing, a serious crisis is developing

Who will be teaching in the minerals schools in the next decade?
Education... Min Eng Faculty Demographics-USA

- 14 (remaining programs)
- 86 tenured or tenure track faculty members
- Average age +52 years (+26% are over 60 years)
- 10% expect to retire in next 2 years and in total 40% for the next 5 years (approx time for current freshmen to graduate)
- Assuming a rate of 10 Ph.D. per year and 50% entering academia (current rate) will lead to a tremendous faculty shortage
Visibility and Prominence:

- The fact that the established research community (i.e. NSF in USA) has ignored technical issues related to minerals, raises questions as to whether nations are willing, or even interested, to invest in this field.

- Serious questions are often asked, in academic administration, regarding the need of sustaining or preserving such programs. And most definitely, on the need of investing new resources in this discipline.

- Within the academic system, where performance measures and outcomes are based on peer rankings and national visibility, the absence of any recognition of the minerals engineering field can eventually lead to a lack of interest in sustaining such programs.
Learning from “Best Practices”

- Minerals programs have been forced to become more innovative, seek new partnerships, develop joint educational and research efforts and expand to new areas and disciplines.

- A number of global educational developments and initiatives can be highlighted as “best practices” in minerals research (Australia: CRC; Europe: ETP SMR) and education (EMC; EGEC; MEA).

- Role of the Society of Mining Professors (SOMP) - *Societät der Bergbaukunde*
Examples

Reference: 2005 SME Annual Meeting, Salt Lake City, Utah, March 2005

Session: Global Minerals Education: Issues, Trends and "Best Practices"

A CD of the presented papers can be requested directly from SME
The Attraction & Retention of Professional Staff – An Australian Perspective

Kevin Tuckwell
Executive Director
Minerals Tertiary Education Council

MTEC MINING ENGINEERING EDUCATION INITIATIVES IN AUSTRALIA

Bruce Hebblewhite
School of Mining Engineering
The University of New South Wales (UNSW), Australia

SME2005 Conference, Salt Lake City, Utah, USA
Monday 28th February, 2005

Educational Programs and Partnerships in Mineral Engineering

Hans de Ruiter & Wijnand Dalmijn (FEMP)

SME Annual Meeting 2005
Salt Lake City, 28 February
USA: SME Mineral Education Sustainability Task Force: Recommendations for Industry

- Select one or more mining schools to support and address sustainability issues
- Provide senior employees to school “Advisory Boards,” offer scholarships, internships and identify mentors
- Supply resources to mining schools to help them recruit new students
- Lobby State and Federal legislators, Regents, and University Administrators on the importance of keeping the remaining mining schools funded
- Use company lobbyists to explore Federal funding for mining schools as “strategic” to US Security
European Mining Course (EMC)

- Helsinki University of Technology
  - Helsinki, Finland
- RWTH
  - Aachen, Germany
- Camborne School of Mines
  - Cornwall, United Kingdom
- TU Delft
  - Delft, Netherlands
Mining Education Australia (MEA)

- A national, collaborative education joint venture between:
  - Curtin University (WA School of Mines)
  - University of New South Wales
  - University of Queensland

- MEA JV into effect on July, 2006; Commenced Implementation on February of 2007
The "Societät der Bergbaukunde" (Society of Mining Sciences) was established in Schemnitz by Ignaz Von Born in 1786.

The first international professional/scientific society with an impressive Membership list (Sir Humphrey Davy).

The Society developed branches and offices in 15 countries and, at its peak, listed 154 members.

After the death of Von Born in 1791, the Society begun to fold.

Revitalized in 1990, the Society has now 145 active senior academic members from mining education institutions representing 40 countries.
The Objectives of the Revitalized Society of Mining Professors

- To ensure that university-based education at the highest level, in the minerals disciplines, can be sustained.
- To ensure that advancement through research, of the scientific and engineering knowledge in the areas of relevance to the provision of mineral resources continues.
- To establish a network of academics involved in achieving the above goals.
- To enhance the image of the minerals-producing industries, promote development of educational courses within these disciplines and foster pride in the disciplines.
- To establish and maintain ongoing contacts with the global mineral industry.
- To promote co-operation in education and research and identify co-operative opportunities.
Conclusion

- It is a time of a unique opportunity for revitalizing, if not reinventing, the old paradigm of minerals education.
- In cooperation with scientific and professional organizations, mining programs/institutions must pursue a new global vision, revitalize traditional goals and objectives and ensure that education in the minerals disciplines is sustained.
- Innovative programs must now be developed exploring new ways of learning, attracting non-traditional students and participating in distributed educational schemes.
- The educational community must integrate SD concepts, processes and practices into the curriculum and research agenda and foster pride in the mineral disciplines.
- Diverse international partnership opportunities in research and education are now needed that can provide a vital link for establishing and implementing global partnerships in the minerals field.
Mining Engineering:

"... the art is one the most ancient, the most necessary and the most profitable to mankind."

Georgius Agricola in *De Re Metallica*