

# CELEBRATING EXCELLENCE

1961-2021



UNIVERSITEIT VAN PRETORIA  
UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA

Faculty of Engineering,  
Built Environment and  
Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en  
Inligtingtegnologie / Lefapha la Boetšenere,  
Tikologo ya Kago le Theknolotši ya Tshedimošo



*Excellence in Mining  
Engineering Education*

*1961 - 2021 A Diamond Celebration*

Department of  
Mining Engineering

# *A jewel in the crown of mining engineering education in South Africa celebrates its diamond jubilee*

## 1961–2021

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The Department of Mining Engineering in the Faculty of Engineering, Built Environment and Information Technology (EBIT) at the University of Pretoria (UP) is proud to celebrate its diamond anniversary in 2021. With its history of 60 years of excellence in mining engineering education, the Department plays a significant role in mining teaching, learning and research at UP, and contributes new ways of innovating for the future.



## ***Our motto***

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*Educating and leading mining engineers to become “**imagineers**”*

## ***Our vision***

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*To be a leading research-intensive mining engineering department in Africa recognised internationally for its quality, relevance and impact, and for developing people, creating knowledge and making a difference locally and globally.*

## ***Our mission***

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*To educate and lead mining engineering students to become imagineers by empowering them with technical and non-technical skills through the use of world-class education, research, leadership and related technology interventions.*

# 1

## Establishment

Established in 1961 following the successful institution of the Faculty of Engineering at UP in 1956, the Mining Engineering programme had been hosted in the erstwhile Faculty of Mathematics and Natural Science since 1956. The institution of an independent department 60 years ago was necessitated by the recognition of mining engineering as an important discipline in South Africa.

The Department's first intake comprised five students who had come over from other departments. Its first students to enrol for the degree in Mining Engineering graduated in 1968. By this time, 25 students had graduated from the Department. It has since contributed greatly to the mining industry by providing world-class mining engineering leaders, and has delivered 963 graduates since its establishment. As a specialised discipline, it has grown steadily over the years into a leading department of mining engineering in South Africa, with many alumni serving the mining industry with distinction. Over the years, the Department has faced many challenges, with its strategic intent following the ebb and flow of the fortunes of the industry. However, it has proved to be resilient and ready to turn challenges into opportunities. This was demonstrated most recently in 2020 when the challenges posed by the COVID-19 pandemic caused it to embrace disruptive approaches to teaching and learning, and to emerge more agile and flexible than ever before. The change of its language of tuition to English in the late 1990s to facilitate access, the present strong emphasis on leadership skills grounded in sound technical skills, and contributions to inculcating a safety culture in mining operations serve as further examples through which it ensures the delivery of work-ready graduates.

## Our strategic goals

- To be a leading research-intensive department
- To pursue excellence in teaching and learning
- To be recognised continuously for the quality of graduates delivered
- To strengthen the Department's national and international profile through the establishment of sound sustainable business and other relationships
- To become financially independent in terms of the growth strategy of the Department

*The University of Pretoria is recognised as one of the top 50 universities in the world in minerals and mining engineering according to the QS World University Subject Rankings of 2021.*

## Our values

*The Department's values are rooted in heartfelt leadership, based on the principles of trust and care.*

- Respect
- Care
- Honesty
- Integrity
- Trust

Through its Mining Resilience Research Centre, the Department strives to enable the mining industry to transition from being reactive and compliant to becoming resilient in issues related to safety, health, environmental sustainability, social responsibility and community management through well-structured and committed undergraduate and postgraduate education and research. It is therefore dedicated to visibly aligning its educational and research objectives with industry needs. Its active involvement in the community includes the participation of its staff members in the activities of professional societies, as well as through expert consultation and community projects within the Faculty.

# 2

## Profile



### ACADEMIC OFFERING

Undergraduate students pursue the BEng Mining Engineering degree programme. Postgraduate students can pursue honours, master's and doctoral degree programmes in Mining Engineering and Applied Science in Mining.

# 3

## Industry footprint

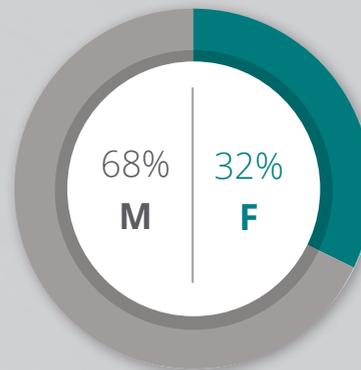
As an important role-player in the South African economy, the country's mining industry is optimally positioned to embrace the disruptive technologies that characterise the Fourth Industrial Revolution (4IR). In this regard, the Department partners with industry by supplying it with between 15 and 20% of its mining engineering graduates. The Department's innovative teaching practices and relevant research are highly regarded by industry.

### DEMOGRAPHIC PROFILE

The Department's racial and gender profiles are fully representative of the South African population.



- 01 **Black (80%)**
- 02 **White (8%)**
- 03 **International (8%)**
- 04 **Indian (3%)**
- 05 **Coloured (1%)**



The Department collaborates with various stakeholders such as the Minerals Council South Africa (MCSA), the Mandela Mining Precinct (MMP) as part of the South African Mining Extraction Research Development and Innovation (SAMERDI) strategy and the Mine Health and Safety Council (MHSC), which makes it a key participant in future innovations in the mining industry.

Through the generous financial support of its industry partners, the Department has been able to develop world-class teaching and research facilities, such as the Kumba Virtual Reality Centre for Mine Design, the infrastructure development that included new offices for the Department on the fifth floor of the Mineral Sciences Building and a new mining exhibition centre, as well as industry-supported research chairs.

It is able to support students financially through the provision of industry-sponsored bursaries, which have also been rolled over to full-time postgraduate students in the Department over the last 10 years to build capacity and capability in terms of future researchers and potential academic lecturers. Industry support has contributed to the development of a robust continuing education programme. The presentation of short courses in conjunction with Enterprises University of Pretoria (E at UP) forms an important part of the Department's third-stream funding strategy. The Department furthermore benefits from the expertise of leaders from industry and academia, who serve on the Mining Engineering Advisory Board.



*“The Department’s alumni serve in the leadership ranks of prominent organisations.”*

# 4

## Alumni footprint

The Department’s alumni are among the country’s leaders in mining and other industries, such as oil and gas, as well as water purification, locally and abroad, and include a significant number of individuals who serve in the leadership ranks of prominent organisations and on their boards of directors, and are recognised for the role they play in the development of the country’s economy.

The Department’s many alumni who are employed at senior executive level in the mining industry are a true testament to the quality of graduates that the Department has produced over the last 60 years, and will continue to produce. These individuals are champions for the University of Pretoria, and enhance its image through their exceptional achievements as the chief executive officers, chief operating officers, managing directors and executive heads of various mining companies.

The Department also enjoys the active support of its alumni through the Mining Alumni Society of the University of Pretoria (MASUP). Through this platform, alumni support the Department by raising sponsorships, and ensuring that a high level of skills and educational standards are maintained. This society also serves as a social network for mining engineers in industry.

### **The following are among the Department’s most prominent alumni:**

- Dr Con Fauconnier, former CEO of Kumba Resources and Exxaro Resources
- Mr Chris Griffith, CEO of Gold Fields
- Mr André Joubert, CEO of African Rainbow Minerals’ Ferrous Division
- Mr Pierre Joubert, CEO of Ivanhoe Mines
- Mr Henry Laas, Group CEO of Murray & Roberts Holdings
- Mr Nico Muller, CEO of Impala Platinum
- Mr Peter Steenkamp, CEO of Harmony Gold
- Mr Francois Uys, CEO of Siyanda Resources

# 5

## International footprint

The University of Pretoria is recognised as one of the top 50 universities in the world in minerals and mining engineering according to the QS World University Subject Rankings of 2021.

It is one of only two departments in South Africa to educate professional graduate mining engineers. Its graduates are well accepted in the market, and its racial and gender profiles are fully representative of the South African landscape. It follows a balanced scorecard management system approach in terms of its responsibilities related to internal business processes, finances, learning and growth, and accountability to customers and clients.

The Department's prime resource is its teaching staff, which has more than 100 years of combined industry experience. The active participation of industry experts as part-time lecturers forms an important part of its teaching strategy. The financial contribution of the Minerals Education Trust Fund (METF), in the form of a staff salary subvention, has enabled the Department to attract high-quality lecturers from industry. The additional involvement of guest lecturers keeps its staff and students up to date with the latest industry trends. Its postgraduate research programme has benefitted from the involvement of Prof Con Fauconnier as honorary professor and Prof Bharath Belle, Prof Jan du Plessis, Prof John Napier and Prof William Spiteri as extraordinary professors.

One of the Department's key strategic initiatives is to ensure that its research is recognised internationally for its high standards. The intention is to increase the collaboration potential among international researchers with similar technical subject knowledge and skills, and to foster international co-publication. The Department is a member of the global academic community through its representation of the University of Pretoria on the International Society of Mining Professors (SOMP). This body represents mining academics all over the world, and is committed to making a significant contribution to the future of the minerals discipline internationally. All of the Department's lecturers are members of this organisation.

The Department also intends approaching the Colorado School of Mines in Denver, Colorado, the top-ranked mining school in the world. The knowledge gained from the proposed visit to Colorado will be used as a benchmark to further improve the Department's ranking. The effect of COVID-19 and the ban on international travel have postponed this initiative, however.

# 6

## Facilities

The Department's excellent relationships with its industry partners led to the establishment of the Kumba Virtual Reality Centre for Mine Design (VR Centre), which was made possible through an R18.8 million investment over three years by Kumba Iron Ore in 2013. This was the first centre of its kind in Africa to be housed at a university, and enables the Department to realistically simulate a range of mining functions in a low-risk, high-impact learning environment.

The facilities comprise a wall-to-wall 3D theatre, as well as an immersive mine simulation theatre, which casts 360° images against dark surrounding panels with cinematic clarity and highly realistic sound effects. The infrastructure development, which was completed in 2015, included new offices for the Department on the fifth floor of the Mineral Sciences Building, while African Rainbow Minerals provided funding for a new mining laboratory and exhibition centre.

In 2019, the METF made a substantial sum available to the Department to acquire new laboratory equipment for mining modules. This new equipment has added to the Department's virtual reality theatre and 360° cylinder, and will ensure that it can cater for new needs in terms of technology transfer to enhance students' learning experience and understanding. The support of the METF is graciously acknowledged and appreciated.



# 7

## Research excellence

The Department is concentrating its efforts on growing research capacity in four key research areas, which will have an impact on the future of mining and the sustainability of the industry: mechanisation and automation, rock-breaking and explosives engineering, management and leadership, and rock engineering. This will, in turn, stimulate economic development and impact on the contribution of mining to the country's gross domestic product (GDP).

The strategic intent of the Department to increase its postgraduate student numbers has a direct impact on its research output. It is increasing its publications in national peer-reviewed journals and at conferences, and has a healthy research pipeline. The challenge that it is embracing is to increase publications in accredited international journals and cement its relationships with international mining schools. The appointment of extraordinary lecturers with PhDs in future to fill the gap in research areas that the Department wants to explore will become more important and, in this way, increase its research capacity and capabilities.

Prof Francois Malan, the Department's Research Coordinator, has a B2 rating as a researcher from the National Research Foundation (NRF), which signifies an internationally acclaimed researcher. Prof Malan has also been elected to serve on the editorial board of the Southern African Institute of Mining and Metallurgy (SAIMM), in this way increasing the Department's visibility in terms of professional support.

The Department's postgraduate teaching and research is supported by three industry chairs, as well as the Mining Resilience Research Centre (MRRC) and a widely recognised research group in rock engineering. It also hosts the SAMERDI Research Centre for Mechanised Mining Systems.

### **AEL INTELLIGENT BLASTING CHAIR FOR INNOVATIVE ROCK-BREAKING TECHNOLOGY**

The AEL Intelligent Blasting Chair for Innovative Rock-breaking Technology was established in 2018 to establish the University as a centre of excellence for emerging rock-breaking technologies. It focuses on developing postgraduate students in this field, and makes use of the VR Centre to demonstrate three-dimensional blast simulation and the visualisation of new research. In partnership with the Department of Electric, Electronic and Computer Engineering, this Chair has succeeded in exploiting the Department's virtual reality (VR) and augmented reality (AR) expertise and facilities to strengthen the funder's market and technology leadership position. It also supports groundbreaking projects to resolve pressing issues in the mining industry. Negotiations are underway to extend this support until 2023. The Chairholder is Prof William Spiteri.

### **HARMONY GOLD CHAIR IN ROCK ENGINEERING AND NUMERICAL MODELLING**

The Harmony Gold Chair in Rock Engineering and Numerical Modelling was established in 2013 with support over three years to conduct research on a safer working environment in the hard-rock mining industry. It focuses on directed research into specific rock engineering problems and associated solutions, and has developed techniques to simulate rock mass behaviour in South African deep-level gold mines. Harmony Gold extended its initial sponsorship of the research chair by a further three years in 2016, and again in 2019, enabling the Department to become a recognised leader in rock engineering and numerical modelling. The research conducted in this Chair forms part of individual postgraduate study programmes under the leadership of Prof Francois Malan (Chairholder) and Prof John Napier, renowned specialists in rock engineering, with Prof Napier dealing specifically with numerical modelling.

### **MURRAY & ROBERTS CHAIR IN INDUSTRY LEADERSHIP 4.0**

The Murray & Roberts Chair in Industry Leadership 4.0 focuses on providing specialised skills and capacity building that are essential to the implementation of optimised systems related to the 4IR through defined leadership strategies. It also conducts research on leadership and the adoption of new technologies in the mining industry. Some of the key interventions in which this Chair will be involved are leadership workshops, research on the adoption of new technology and related research publications, in particular, involving postgraduate student researchers. Prof Ronny Webber-Youngman is the Chairholder, and Dr Johann Uys is a senior researcher in this Chair.

## MINING RESILIENCE RESEARCH CENTRE

In recognition of the fact that a resilient mining industry is of particular relevance to Africa, the Department launched the Mining Resilience Research Centre in 2017. This multidisciplinary research centre draws on the resources within the University's nine faculties, matching the right skills sets to any mining problem. It contributes to finding practical solutions to complex mining problems related to productivity, safety, health, environment, social responsibility and community management challenges. It does this through well-structured and committed postgraduate education and rigorous, integrated, scientific research initiatives. It pursues practically implementable solutions, educates graduates who are equipped with relevant skills and conducts collaborative contract research for industry. In the process, it contributes to strengthening the University's mining footprint, as well as its national and international minerals research profile.

This forms part of the Department's long-term strategy to become a world leader in mining research for practical implementation, and is well supported by Enterprises University of Pretoria with regard to the contractual and administrative arrangements associated with applied research in particular. The activities of the MRRC have enhanced the Department's capabilities by utilising research capacity from other departments in various faculties at the University to actively participate in mining research. It also supports the MHSC with research projects.

## ROCK ENGINEERING RESEARCH GROUP

The Department emphasises rock engineering research, which is undertaken by four key researchers in this area, supported by a number of postgraduate students. A key aspect of this research is to develop new design criteria and layouts for hard-rock mines to ensure their sustainability. Improved formulae and methods for designing hard-rock pillars are also investigated.

Close collaboration has been established with the mining industry, especially with Northam Platinum, Impala Platinum and Harmony Gold. Various topics related to pillar behaviour and design criteria are currently under investigation at postgraduate level.

*“Collaboration is key”*

## SAMERDI RESEARCH CENTRE FOR MECHANISED MINING SYSTEMS

The Mandela Mining Precinct, an initiative of the Department of Science and Innovation, approved the establishment of the SAMERDI Research Centre for Mechanised Mining Systems (MMS) at the University of Pretoria. This centre will establish research expertise in automated condition and performance assessment of the rock and equipment in mechanical parameters obtained during drilling and blasting operations. Its research activities relate to continuous rock drill condition assessment; an estimation of rock strength properties using selected mechanical parameters obtained during drilling; and the predictive maintenance management of mechanised mining equipment. Preliminary research has already been conducted at the MRRC.

The SAMERDI Research Centre for MMS will also support the development of historically disadvantaged institutes of higher education by identifying potentially suitable universities to participate in a twinning project. The appointment of a Research Competence Leader will supervise and develop postgraduate students in the identified areas. In addition, the research centre will support four enrolled master's degree students for the duration of their programme.

The Department of Mining Engineering, the Council for Scientific and Industrial Research (CSIR), the University of the Witwatersrand and the University of Johannesburg are participating as partners in the Mandela Mining Precinct initiative.

# 8

## Teaching and learning

The Department has developed innovative teaching and learning initiatives. These are aimed at supporting undergraduate students and enhancing the Department's throughput and success rates, while ensuring that it delivers well-rounded mining engineers to the workforce.

### LEADERSHIP DEVELOPMENT

The development of its students as future managers and technical specialists remains a priority and the development of life skills and responsible leadership through participation in student activities is continuously encouraged. As a result, graduates from the Department are employed in a wide range of companies both locally and internationally. According to the latest available statistics, approximately 95% of the Department's graduates from 2018 and 2019 are employed in various fields in the minerals sector, as well as in consultancies and financial institutions.

Prospective mining engineers need to be able to deal with up to five different generations of workers in the workforce, and this requires special skills. To address this challenge, the Department is grooming its students for the modern workplace by equipping them with various non-technical skills that promote creative and innovative thinking to enable them to deal with the complexities in the mining industry.

This initiative, known as the Murray & Roberts Mining Engineering Leadership Academy (M&R MELA), forms part of the Murray & Roberts Chair in Industry Leadership 4.0. It focuses on the development of leadership and communication skills, as well as conflict resolution, problem-solving and stress management skills. It also plays an important role in addressing the challenges pertaining to the next generation of mining, which need to be dealt with in a very different way than has been done in the past.

When one considers that we are in the midst of the 4IR, disruptions are part of the everyday working environment of leaders worldwide. A leadership academy such as the M&R MELA is therefore critical in exposing final-year mining students to the associated challenges.

### INDUSTRY VISITS

Industry visits form part of the Department's curricula. Each year, the Department's third-year class visits mining operations in industry. During these visits, students are exposed to real-life mining activities before completing their studies.

### INDUSTRY CAPACITY-BUILDING

The Department presents in-house leadership development short courses to the staff of leading mining companies on their own premises.

### ENGLISH LITERACY SUPPORT DRIVE

Another initiative to support students to succeed academically is the English literacy training drive, which was launched in the Department in 2014. This was developed following the identification of students' mastery of the English language as one of the challenges that affects their academic performance, since only 9% of the Department's students have English as their first language. The fact that English is the language in which they have to study can become a hurdle to adequately understand and communicate their understanding of complex concepts. The Department's dedicated English support staff give presentations, conduct testing, present writing workshops and offer private consultations that are aimed at providing students with individualised solutions for their language skills improvement.

## STUDENT WELLBEING

An important focus of the Department is the wellbeing of its students. Its interaction with its students takes place according to a value-driven framework, in which the principle of heartfelt leadership features prominently. The values it entrenches in its students are those of respect, care, honesty, integrity and trust.

In accordance with these values, it has established a Student Wellbeing Committee, which offers emotional and other support to students. Where possible, the Department also lends support to avert any anxiety students may experience during their studies, especially students who are in need. Confidentiality is guaranteed and all cases are handled on merit.

In the extraordinary circumstances brought about by the nationwide lockdown and related COVID-19 prevention regulations in 2020, several challenges had to be overcome. These included the availability of data for students, access to laptops and the narrated recording of lectures. In addition, it was found that a real level of uncertainty and anxiety was prevalent among students regarding the resources available to support their online needs.

In this regard, both the Faculty and the University as a whole were instrumental in their efforts to make free data available, supply laptops to students on a loan basis, accommodate students in the University's residences and issue travel permits. Without these support initiatives, an effective roll-out of the online approach to teaching, learning and assessment would not have been possible.

Under normal circumstances, students are assisted in other ways as well, including the provision of prescription glasses, daily meals, accommodation and registration fees. The Department also receives financial assistance from industry for student support, including annual donations from MASUP and other industry partners. The Southern African Institute of Mining and Metallurgy also supports students in their early years of tertiary education on a year-by-year basis through its Scholarship Trust Fund.

## NETWORKING AND MENTORSHIP

Mining engineering students are given the opportunity to network and socialise with other students and staff of the Department outside lecture halls through the Tuks Mining Society, a student organisation that supports the Department's students on a holistic level. A mentorship programme is in place where junior students are assigned senior students to assist them with academic issues and provide guidance based on personal experience.

# 9

## Enrolment strategy

In 2015, following a slump in mining student numbers worldwide, the Department took a strategic decision to reduce its first-year intake. This is in alignment with the decreasing need for mining engineers worldwide, supported by current employment trends in the South African mining industry, which has a direct impact on the number of students who display an interest in pursuing mining engineering as a career. It therefore decided to cap its undergraduate student capacity at 150 students, which would include 40 final-year students.

At the same time, it increased its focus on postgraduate enrolments, with the aim of having 100 postgraduate students by 2025. By the end of 2020, it had 137 undergraduate and 57 postgraduate students (39 honours, 10 master's and eight PhD candidates). In terms of its 2025 action plan, the Department aims to have 30% full-time postgraduate students active in research in the Department at any time. The support of African Rainbow Minerals, through its Postgraduate Bursary Initiative, will support postgraduate students from diverse backgrounds to study towards honours and master's degrees in mining engineering.



# 10 Curriculum innovation

## REDESIGNING THE CURRICULUM TO ADDRESS THE FUTURE CHALLENGES OF MINING ENGINEERING

Like many other mining schools around the world, the Department has gone through an extensive redesign of its mine design curriculum over the last few years. This was aimed at aligning the Department's activities with the challenges that will be faced in the next generation of mining. In the process, it contemplated the future of mining, specifically what the mining engineering profession will look like in years to come.

The new mine design curriculum includes exposure to aspects such as leadership, the social context of business, rectifying the imbalances of the past, and international economic systems, striving to create a more equal, yet productive society that can effectively tackle the societal challenges of poverty, unemployment and inequality.

The most important aspects that have been incorporated into the new mine design curriculum include improved employee safety, increased productivity, lower energy consumption and reduced environmental impact; none of which would be possible without the adoption of appropriate disruptive technologies.

*“The critical skills required for the 4IR include analytical thinking and innovation.”*

### INSTRUCTIONAL DESIGN

All Mining Engineering modules are designed in a format where the one-dimensional script is enhanced through the inclusion of high-quality pictures and illustrations that make it possible for students to comprehend the theory without needing to go underground (as even then they would find the content difficult to grasp). Animations are used to show difficult concepts in mining, making them more understandable for the inexperienced mining student, and video material is used to make images come alive. A databank of mining industry videos has been collected as part-time viewing material to enhance students' understanding of difficult mining concepts and procedures, including reconstructions of typical mine incidents with 3D animations, incident reconstruction simulations and geology features.

As much as 80% of the Department's modules has been instructionally designed following an approach that incorporates analysis (what are the outcomes, and where can the content be enriched with media elements for better understanding), design of the content (applying for copyright when reference is made to journal articles), development (building the design in an electronic format, creating the links to the media and journal files, and testing all the links), implementation (students' use of the material and feedback) and evaluation (what worked, what did not work, and where is improvement necessary for the next offering).



## INTERACTIVE IMMERSIVE TECHNOLOGY

Building on the success of the VR Centre in presenting real-world scenarios for immersive experiences by means of VR, the Department recognised the potential of expanding this facility to offer innovative teaching and learning experiences through its interactive immersive technology (IIT) drive. This is an innovative resource that brings real-world scenarios to students to enhance their exposure to their chosen industry, and enables technical and other practitioners to simulate plans and designs in a risk-free environment, with minimal time and resource allocation.

One of the initiatives that the Department has launched utilising the facilities of the VR Centre is the blast wall, which provides training in a “practical” environment through the use of VR. This exercise involves projecting the blast wall onto a screen, after which learners mark grade lines, direction lines and grid lines onto a virtual wall. They then use virtual tools to design the blast, mark the blast holes and timing sequences, and execute the blast. This has the advantage over teaching in a traditional classroom environment, as the learners are able to visualise and fully comprehend the concepts being taught, while gaining practical experience in a user-friendly, safe and erasable environment, where mistakes can be made without consequences.

The Multimedia programme in the Department of Information Science is collaborating with the Department of Mining Engineering in research related to VR and user interaction. By introducing this level of innovation into the educational space, the Department can offer unique learning opportunities.

The Rock Engineering module is already exploring IIT in a risk identification exercise, which adds another dimension to the Department’s strategy of delivering quality education. In 2019, the Department acquired IntelliShot™ control equipment through a donation from the METF. This equipment will be used for the initiation of dummy electronic detonators to illustrate single-hole sequential firing by third-year students in the Rock-breaking module.

## GAMEFICATION

Yet another innovative technique that the Department is exploring is the “gamefication” of education and training. This has – at its core – the use of game design elements in a non-gaming context. The Department is convinced that the future of education (knowledge transfer) and training (applying knowledge) lies in this space.

# 11 Industry 4.0: the future of mining in the 4IR

**With commodity prices picking up, and the fact that nothing that is happening in the 4IR would be possible without mining, it is clear that mining will remain a major contributor to the country’s GDP for many years to come. The many challenges associated with Mining 4.0 (next-generation mining) form an integral part of the Department’s teaching, learning and research activities.**

Although not many new mines are being opened in South Africa, it is becoming increasingly important to enhance the productivity of the country’s existing mines. By adopting new technology interventions and mining methods, as well as focusing on the health and safety of our workforce, mine management is realising that it is no longer a question of *whether* one should embrace technology, but *when* one should do so. An essential element in our quest for increased productivity is mine management’s awareness of its social responsibility.

According to Dr Gordon Smith, a member of the Department’s Advisory Board, “mining engineers who are strongly grounded in Industry 4.0-enabling technologies and systems engineering, as well as in change management and innovation, will be integral to the success of mining operations in the future”.

In a recent report by Swan Global Investments on addressing the mining skills gap, the authors mention that, for the next 25 years, there will be a high demand for metals in the world to meet the requirements pertaining to the 4IR. The report amplifies the pressing skills shortage that needs to be addressed as students' interest in mining declines, and the industry becomes increasingly characterised by an ageing workforce that needs to be replenished. It furthermore highlights five key areas for the lack of interest in mining: a lack of information pertaining to mining, climate change, resistance to coal-fired power stations, which are detrimental to a healthy lifestyle, uncertainty in job opportunities due to the cyclical nature of mining, and politics.

From this, it is evident that mining schools across the world are looking at different ways of attracting students. What the mining engineer of the future should look like is a very important topic that is being debated worldwide. Different ways can be explored to increase the attractiveness of mining as a career option, including collaboration with other engineering disciplines. In this way, mining engineers can be equipped with new skills that are not only appropriate for the present, but also for the future beyond the 4IR, in the era that is starting to become known as the Fifth Industrial Revolution.

## SKILLS REQUIRED IN THE 4IR

In 2016, the World Economic Forum (WEF) published an article that revealed the ten critical skills that are required for the 4IR. According to this article, the first, second and third industrial revolutions were based on mechanical production driven by water and steam power, on mass production enabled by the division of labour and the use of electrical energy, and on the use of electronics and information technology to further automate production, respectively. The 4IR represents a fundamental change in the way we live, work and relate to one another. It refers to the blurring of boundaries between the physical, digital and biological worlds. In 2020, the WEF updated this skills list in its "Future of Jobs" report, and identified the following skills as being critical for the modern workforce:

1. Analytical thinking and innovation
2. Active learning and learning strategies
3. Complex problem-solving
4. Critical thinking and analysis
5. Creativity, originality and initiative
6. Leadership and social influence
7. Technology use, monitoring and control
8. Technology design and programming
9. Resilience, stress tolerance and flexibility
10. Reasoning, problem-solving and ideation

These critical skills find clear resonance in the redesigned curriculum of the Department of Mining Engineering, particularly its emphasis on leadership development and promoting creative and innovative thinking so that graduates are prepared to deal with the expected complexities in the mining industry once they enter the job market.

According to the WEF, the world is in many ways unprepared to meet the challenges ahead. It is estimated that 65% of learners who entered schools in 2016 will end up in careers that did not even exist then. This is due to the impact and rapid advancements of the 4IR.

# 12 *The Fifth Industrial Revolution*

**We are standing on the threshold of the Fifth Industrial Revolution. This new era is set to highlight the significance of humanity in the workplace. This future era will build on the 4IR and it is foreseen that it will be an artificial intelligence (AI) revolution, with the potential of quantum computing, which will draw humans and machines together in the workplace.**

It will be about harnessing the unique attributes of AI by recruiters and employers who, in effect, will be more equipped to make even better and more informed decisions. The importance placed on human intelligence will be greater than ever before.

The Department of Mining Engineering is already starting to think beyond the 4IR, and to prepare its students for the Fifth

Industrial Revolution. This future era may need an entirely new set of skills to cope, but in many ways, should complement the skills identified to thrive in the 4IR.

It is clear that industries and related work have changed forever, and the mining industry is no exception. This further amplifies the need for a specific leadership approach that can accommodate the various complexities and deal with them accordingly.



Mining Engineering at  
University of Pretoria



Department of Mining Engineering,  
University of Pretoria



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#UPMiningMatters  
#60YearsUPMining

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