

## 120 Years of Education for Mine Surveyors in South Africa

### A Framework for the Mine Survey Profession

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#### Abstract

*The first formalised training for Mining Engineers and Mine Surveyors offered in South Africa was introduced in 1895 at the Kimberley school of Mines. This means that the education of Mining engineers and Mine Surveyors in South Africa has continued uninterrupted for 120 years. History indicates that the University of Witwatersrand, University of Pretoria and the University of Johannesburg has a common origin in the Kimberly School of Mines. The Institute of Mine Surveyors of South Africa (IMSSA) celebrated its 90<sup>th</sup> Annual General Meeting during September 2012. Mine Surveying is a well-established but little known profession in South Africa. The profession has seen a number of changes brought about by war, political changes and changes in the mining industry during this period. This paper provides a short history of the development of the three institutions involved with undergraduate teaching in the field of mining engineering and Mine Surveying. The paper continues to outline the progression of education models in the field of mine surveying since the establishment of the original School of Mines to the current date. The paper concludes by discussing how the legacy of these education models can be transformed into a set of qualifications that will benefit all those who choose to pursue Mine Surveying as a profession.*

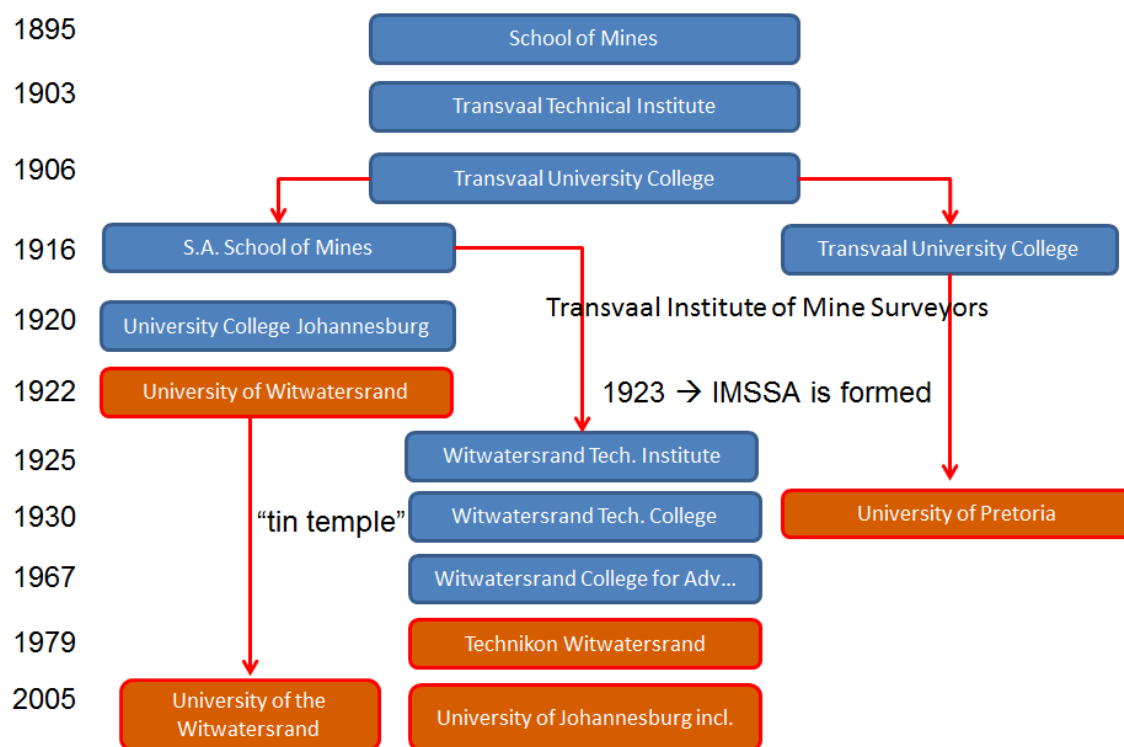
#### 1. A Timeline of the Last 120 Years

According to Lurie, the South African School of Mines was established in Kimberly in 1895. During the South African war this institution was transferred to Johannesburg which was identified as the new centre of gravity of mining activities, where in 1903, it was renamed as the Transvaal Technical Institute. The Pretoria branch of the Transvaal University College was established in 1906, which later became the University of Pretoria while the Johannesburg branch became SA School of Mines and Technology 1910. From this institution the

Johannesburg University College and the Wits University developed. What remained of these institutions was consolidated and became the Wits Technical Institute in 1925 which in turn evolved into Witwatersrand college for advanced technical education 1967 and finally into the Technikon Witwatersrand. Lurie concluded that “...thus Pretoria University, University of the Witwatersrand, and Technikon Witwatersrand (now part of the University of Johannesburg) have a common origin” (Lurie, 1989).

The University of South Africa developed separately from this process. UNISA originated from the University of the Cape of Good Hope which was established in 1873. It was then incorporated into UNISA to become the South African University in 1918. The Universities of Witwatersrand, Pretoria, Natal, Free State, Rhodes and Potchefstroom “...broke away between 1921-1952 to become the independent universities...” (UNISA, 2016). The distance learning institution of the Technikon Witwatersrand called the Technikon South Africa (RSA), was established on the 1<sup>st</sup> of April 1980. In August 1993, the Technikon launched its new name, Technikon SA (TSA) (UNISA, 2016). This institution continues to provide distance learning courses in Mining Engineering and Mine Surveying after its incorporation into UNISA in 2004.

Table 1. Timeline of events



## **2. The Current Education Model Available to Mine Surveyors**

Three distinct routes of qualifications have been developed since the original establishment of the School of Mines in Kimberley and continue to be used by all mine surveyors wishing to further their education. These forms of qualifications are the Chamber of Mines- , the National Diploma- and Bachelor degree qualifications. These models are discussed individually.

### **2.1 Chamber of Mines Certificates**

The Chamber of Mines vocational certificates are sometimes referred to as the “Practical route”. These qualifications allow the student to study and write examinations while employed full-time in the mining industry. These certificates are the result of the consolidation of the certificates that were developed by individual mining houses during the 1970s and 80s to develop skills “in-house”. In order to ensure a commonality between the various mine specific certificates structures, the Chamber of Mines developed three certificates that accommodated the three stages of qualification required by a surveyor to progress to a point where he or she could be promoted to a senior position and become a candidate to the Government Certificate of Competency (GCC) examinations.

The Mine Health and Safety Act, Chapter 17.(1).(b).(i). defines a competent person on mines where no blasting takes place, as a person who is in possession of an Advanced Certificate in Mine Surveying issued by the Chamber of Mines of South Africa (COM) with specific restrictions and requirements. The six COM certificates in surveying and mine valuation are:

- **Basic Survey-and Sampling Certificates.** These two certificates are issued on mine and is therefore considered to be a Chamber of Mines qualification. It is required that each candidate registering for the Elementary Certificates provide proof of the Basic Certificate before being accepted. These certificates are approximately<sup>1</sup> on an NQF Level 4 standard.
- **Elementary Survey- and Sampling Certificates.** These certificates prepare the candidate for a wider range of elementary survey and sampling techniques on approximately NQF Level 5 standard.

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<sup>1</sup>The NQF level is stated as an approximate value as these qualifications have never been officially evaluated by SAQA for the appropriate NQF levels.

- Advanced Survey- and Valuation Certificates. The certificate in surveying will provide the holder with access to the Government Certificate of Competency examinations. The valuation certificate is not required for GCC candidacy but it is seen as preparation for the Mine Economics paper. This certificate is an “exit” level qualification for persons preferring a career in mine sampling and is considered to be between a NQF level 5 and 6 standard.

The Chamber of Mines also provide certificates for the Mining Environmental Control and Rock Mechanics disciplines. The Mine Environmental Control qualification is required by the Mine Health and Safety Act (Act 29 of 1996) for persons who are responsible for the environmental control of the mine. Regulation 22.15(5)(a) of the Act defines that a competent person referred to in regulations 5.1(1), 9.2(3) and 16.1(1), depending on the nature of the mine, should be in possession of a *Certificate in Mine Environmental Control or the Intermediate Certificate in Mine Environmental Control, issued by the Chamber of Mines of South Africa.*

The Rock Mechanics qualification is required by the Mine Health and Safety Act (Act 29 of 1996) section 14.1 (8). This competent person is defined in section 22.14.1(8) of the regulations as “*a person who is at least in possession of either the Chamber of Mines Certificate in Rock Mechanics [Metalliferous Mines], or the Chamber of Mines Certificate in Rock Mechanics [Coal Mines], whichever is appropriate for the type of mine concerned.*” The Rock Mechanics qualification is preceded by the Strata Control certificates for Hard rock and Coal mining. Following on these qualifications, a candidate can complete Certificate of Competency examinations in either Hard rock, Coal-, Massive- or Surface mining, administered by the Chamber of Mines.

The entire “suite” of COM qualifications continue to enjoy strong industry support and have been entrenched in the Mine Health and Safety Act. The COM examinations are offered twice a year with approximately 120 persons per certificate registering for each of the survey and valuation examinations. A summary of the average number of registrations per examination for each of the certificates is supplied here (Anderson, 2016).

Table 2. Summary of average number of registrations per examination for each of the certificates

	2009-2015
Mine Survey Elementary Survey	159
Mine Survey Advanced Survey	119
Mine Survey Advanced Valation	97
Mine Survey Draughting	15
Mine Environmental Intermediate	112
Mine Environmental CoC	71
Strata Control Hard Rock	149
Strata Control Coal	14
Rock Engineering Hard Rock	47
Rock Engineering Coal	7
Rock Engineering Massive	3
Rock Engineering Surface	4

Unfortunately the Chamber of Mines certificates were never evaluated for equivalency in the National Qualification Framework (NQF) or SAQA system and therefore enjoy no tertiary recognition when a person wishes to enter the main-stream university education.

## 2.2 National Diploma for Technicians (Mine Surveying)

Lurie observed that, since 1926, “*Sandwich courses*” were offered at the Witwatersrand Technical Institute. Such a “sandwich course” consisted of afternoon classes for two days and one Saturday per week. Mines that sent students on these courses were expected to allow students to leave work early on these days. The curriculum from 1938 described the inclusion of physical training for one hour every morning, and included four workshops, one of which was compulsory to be attended, in either Carpentry, Boilermaking, “Electrical” or “Fitting”. The “sandwich course model” of training continued until 1976 when the first full-time diploma course in Mine Surveying was offered to supplement the distance learning courses offered Meyer observed that “...among un-certificated surveyors there are many who have studied and failed to obtain their certificates of competency....it would be in the interest of mine surveying to provide a second chance for these men by introducing a Mine Survey diploma...in this way these “second best men” could obtain recognition...”(Meyer, 1964)

A part-time National Certificate for Technicians (NCT) in Mine Surveying was introduced at the Witwatersrand Technical College in 1967 but it was phased out in 1980. It was replaced with a four-year, full-time (three years of which two years academic plus two years Work Integrated Learning) course in 1979. This four year National Diploma for Technicians was

later reduced to a 3 year National Diploma in Mine Surveying. (Lurie, 1982) This qualification incorporates a strong Work Integrated Learning (WIL or Practical training) component that originally required 24 months (four semesters of six months each) of practical industry related work in the workings of a mine. The WIL component has been in later years reduced to 12 months (two semesters of six months each). The WIL component is compulsory and a student is not allowed to graduate until the specific outcomes have been met. The WIL component of the qualification is considered to give a “competitive edge” to diplomats over graduates. The full time National Higher Diploma (three years) is still offered by the University of Johannesburg but it is planned to be phased out from 2016. In addition to the “full-time” diploma, a further distance-learning course was offered by the then Technikon South Africa which was later incorporated in UNISA. This option remains a favourite of persons already working on the mines, but requires a lot dedication to complete the studies after working hours.

### **2.3 Degree Courses**

The University of the Witwatersrand, for a brief period of time, offered a B.Sc. in Mine Surveying. This qualification was offered from 1982 only to be discontinued in 1988. Currently this university has a Master- and Doctor Degree option available to Mine Surveyors. The University of Johannesburg started offering the Bachelor of Technology: Mineral Resource Management in 2006. The B.Tech degree course received accreditation from PLATO in October 2009 as a professional degree.

## **3. The Higher Education Qualification Framework of 2007**

A new National higher education framework was introduced in South Africa in 2010. The framework outlined by the HEQF was seen as an opportunity to align and update the current qualification routes for mine surveyors to ensure vertical and horizontal integration of the previous somewhat misaligned qualification types.

### **3.1 The NQF Levels 1 to 4 Qualifications**

The NQF Levels 1 to 4 qualifications did not exist previously but it was hoped that these would be addressed by “Chamber of Mines type” of qualifications. With the introduction of the HEQF, the Chamber of Mines may no longer offer these qualifications, as the Chamber is not a recognised provider of higher education according to the act. A concerted effort is currently underway to replace all of these certificates with SAQA recognised equivalents that will enable students to articulate these qualifications with the courses offered at higher

education institutions. A further complication is that the COM qualifications for the Mine Surveyors, Mine Environmental specialists and Rock Engineers are defined in the MHSA act. In the case of the Mine Environmental- and Rock Engineering disciplines these certificates are the certificates of competency used to appoint these competent persons on a mine. In the case of Mine Surveying, provision has been made in the act for a “MQA recognised” qualification.

Since the current COM qualification does not have a NQF level it could not be used by a person wishing to obtain credits towards formal tertiary qualifications. The new level 1 to 4 qualifications are seen as *occupational qualifications* linked to specific occupations classified according to the Organizing Framework Occupations (OFO) codes. These qualifications consists of three components namely: theoretical, skills and practical (portfolio). Currently two NQF Level 4 Qualifications for mine surveying has been developed, the two qualifications are:

- SAQA 94870 Occupational Certificate: Mining Technician (Mining Sampler: Hardrock) and;
- SAQA 94876 Occupational Certificate: Mining Technician (Mining Surveyor)

As part of the Quality Council for Trades and Occupations (QCTO) process a number of requirements are still being addressed. One of the most important requirements is the appointment of an Assessment Quality Partner (AQP) for each of the qualifications. Through the MHSA Chapter 4 Section 41(3), a Mining Qualifications Authority (MQA) was established to advise the Minister on qualifications, standards, assessments, examinations, quality assurance and accreditation of mining qualifications. The role of the MQA is to advise the Minister on the registration of qualifications on the National Qualification Framework (NQF). (DMR, 2011). In schedule 7(g) (GNR 612 of 24 June 1998) it is determined that the Authority must “*assure the quality of education and training...,without itself being provider of education...*” It is therefore argued that the MQA is ideally positioned to be appointed as the AQP for the new qualifications in partnership with the IMSSA, SANIRE and Mine Ventilation Society.

### **3.2 The National Diploma as an NQF Level 6 Qualification**

The NQF Levels 5 to 10 qualifications have as their primary purpose the provision of a well-rounded, broad education. The Higher Certificate on a NQF Level 5 and the Advanced Certificate on a NQF Level 6 defined in the HEQF were identified as the best suited

qualifications to replace the Chamber of Mines certificates. During the initial strategic planning, UNISA was identified as being ideally positioned to be the provider of these qualifications as a distance learning offering. Extensive work was undertaken to update and modify the National Diploma content, which consists of two years of academic study, into two separate, 12 month certificates. Unfortunately it was decided at an accreditation visit, upon recommendation from PLATO, not to continue with the development of these two qualifications. The current three year national diploma has therefore been reworked and will now be offered as a revised two-year National diploma offering. The current National Diploma: Mine Surveying offered by UJ and UNISA will be phased out from 2016.

### **3.3 The Bachelor degree as an NQF Level 7 Qualification**

The current Bachelor of Technology: Mineral Resource Management professional degree has a well-developed curriculum, which was used as the foundation for the new degree. This degree will be upgraded and replaced with a Bachelors degree in Mine Surveying (NQF Level 7) with the first registration of a new student cohort planned for 2017. It was decided to move away from the term “Mineral Resource Management” as the descriptor for the degree and replace it with the descriptor “Mine Surveying” as defined by the International Society of Mine Surveyors as: “...[*Mine surveying is a] branch of mining science and technology which includes all measurements, calculations and mapping which serve the purpose of ascertaining and documenting information at all stages, from prospecting to exploitation, and utilising mineral deposits by both surface and underground workings...*” (IMSSA & ISM). Common areas with other surveying degrees are to be exploited to the maximum in order to ensure a greater articulation between different surveying degrees. This new degree will share a common first year with the Mining Engineering degree. This new degree will address a requirement (discussed a number of years ago within the mine surveying industry) that proposed that “...*the statutory certificate is the hallmark of a professional surveyor, then, in the opinion of the authors, the profession will continue in its gradual loss of status and esteem...every effort, it is urged, should be made to establish mine surveying on equal footing with other branches within the institution (mining?) and with other professions...a suggested full-time course of study of three years either at University or appropriate college, ...followed by two years of approved practical training..*”(Unknown, 1961). This new three year degree will enable graduates to register at the level of technician with PLATO or its replacement the South African Geomatics Council. The new professional degree will be a three year degree plus a further one year honours degree (NQF level 8).The honours degree will allow a certain amount of specialisation



in geostatistics, mine planning, GIS, deformation monitoring or advanced mine surveying and will include a significant research component. This honours degree will allow graduates not only to register as professional mine surveyors and allow them access to a Masters degree programme.

### **3.4 Work Integrated Learning**

Willows-Munro remarked at an AGM of IMSSA in 1948 that “...*the theory of surveying can be learnt, but the art can only be acquired by long and patient experience, ...success is usually associated more with **training and judgement** of the surveyor than theoretical knowledge, ... the suggested outline of practical work is 12 months in the sampling department, 6 months learner miner, 6 months in the study (mine planning) department followed by work in the survey department, ...after obtaining his mine surveyors certificate, he should serve a period of shift bossing and eventually obtain his mine manager’s certificate*”( Willows-Munro, 1948). The phasing out of compulsory WIL in the curriculum of the National Diploma has led to concerns being raised about the quality of students being released into industry with the minimal amount of WIL. One of the niche areas of the current National Diploma is the ability of diplomats to be immediately serviceable when entering industry as they are by then already familiar with the culture of the industry they are entering. Meyer observed in 1964 that the average surveyor that has not had the privilege of a tertiary education also has a remarkably low understanding of fundamental survey principles. Meyer registered his distress in observing “...*how little they know even about tasks done daily.*”, arguing that this distressing trend was the result of poor mentorship by survey managers leading to less qualified individuals teaching new trainees their own poor practices and thereby perpetuating the low levels of experience.(Meyer, 1964). The importance of a second tier qualification during which the graduate or diplomat is guided through a structured process of work experience is essential to ground theoretical knowledge with “hands-on” experience, both for day to day work efficiency as well as to prepare candidates for the next stage of qualification, the Government Certificate of Competency.

The new HEQF suite of qualifications will move away from the conventional work-integrated-model for mine surveyors and as a result, more emphasis will be placed on realistic on-campus training and simulations. Grobler observed that the challenges in the new suite of qualifications would be the identification of relevant components of WIL. These components will have to be incorporated into vacation, laboratory and practical field work as well as the

“second stage qualification” for graduates. This second stage qualification should ideally be registered at the appropriate NQF level and be considered a pre-requisite to the Government Certificate of Competency examinations (Grobler, 2015)

### **3.5 Government Certificate of Competency: Mine Surveying**

The current GCC is seen as a *“licence to practice”* by the Director of Mineral Resources and will not in the foreseeable future be replaced by a purely tertiary professional qualification. In order for a surveyor to be appointed as the responsible surveyor on a mine, he or she requires a GCC for such appointment. The South African Mine Health and Safety Act (MHSA) defines a competent person as a person who is qualified by virtue of knowledge, training, skills and experience to be familiar with the provisions of the MHSA and Regulations and have been trained to recognise potential hazards. Such a competent person must be in possession of an appropriate certificate of competency. (DMR, 2011) Identifying the common denominators from these definitions, the term “competency” within the reference framework of this paper can be defined as *“The ability by virtue of Education, Skills, Knowledge and Experience to identify potential hazards and deal with situations successfully.”*(Grobler, 2016).

According to Rae *“The certificates started in 1905 just after the Anglo-Boer War and 202 “Mine Surveying Certificates of Competency” were issued. After 1910 “Union” Certificates of Competency were issued, starting again from No 1. To date we are on number 1946, that means that in total 2148 GCCs have been issued for mine surveyors in South Africa.”*, That is an average of 20 “tickets” per year since 1905.(Rae, 2011). What is not clear from these numbers is the rate of attrition due to natural reasons and emigration or lateral movement into related fields such as head office positions, immigration, consulting, education, mine planning or Mineral Resource Management. Some of these persons migrate to the Mine Manager certificates or may end up leaving the mine industry entirely. The number of Mine Surveyors carrying multiple appointments have been noted with concern. It has been determined that the average age of the holders of the GCC is around 45 years. On average at least five GCCs are lost yearly through surveyors retiring from the profession.

The GCC is widely considered as the most difficult “ticket” examination with a 6% pass rate noted in 1964 (Morton 1964) to succeed in as Meyer observed *“looking at the results on a per subject basis, we find that it takes an average of 4.2 attempts per subjects to pass one subject”* (Maritz, 1990), Meyer remarks that the respective ratio for Mine Captains, Mine Managers and Mine Surveyors is **roughly 5:2:1**, and the yearly results so far give no indication

*that this state of imbalance is likely to improve.*” (Meyer, 1964). This pass rate has not improved in the past 50 years with the average pass rate still hovering around 5%.

A new model of competency examination is currently under investigation. The purpose of this investigation is to provide a model that will ensure competency in an outcomes based model rather than by examination only. A number of registration models used to define the competency of eligible persons have been evaluated. In South Africa, three models namely the PLATO registration process, the ECSA model and the DMR examination process were considered. Internationally the Western Australian-, New South Wales- and Queensland models were compared to the German registration process and United Kingdom model were investigated (Grobler, 2016).

#### **4. Concluding Remarks**

Mining education in South Africa has a long history starting with the Kimberly School of Mines in 1895. With the establishment of IMSSA in 1923, the institute has taken an active interest in developing education opportunities for all levels of mine surveyors. The Institute has always played an active role by reacting and predicting the impact of new technologies and industry challenges on the discipline. After 120 years the development of recognised qualifications within the national qualification framework and registered with SAQA, have finally succeeded in providing a comprehensive choice of qualifications to all levels of mine surveyors.

The GCC in South Africa has been issued for the past 110 years. In this time precious little could be done to improve the throughput rate. The conflicting requirements of throughput, or supplying sufficient certificates to industry, and the absolute non-negotiable of competency places a great responsibility on government, tertiary institutions and industry alike. If “competency” is defined as the culmination of education and skills by developing knowledge through appropriate experiences, it is essential for a graduate to be guided through this process by a competent and engaged mentor.

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