



On-campus mine surveying practicals: their contribution in training mining engineering students in an open distance learning context

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Synopsis

The University of South Africa (UNISA) is the only South African university offering mine surveying by open distance learning (ODL). Initially intended to service mining engineering practitioners in search of formal training, the university has seen a growing enrolment of private students. Because this cohort of students has had little contact with the mining environment, there is a need to supplement the theoretical training by ODL with practical sessions on campus.

In order to investigate this concern, historical data pertaining to the performance of students over the last five years was collected. Six mine surveying modules forming part of the national diplomas in Mining Engineering and in Mine Surveying offered at UNISA were considered: Mine Survey II and III, Mine Valuation II and III (Mine Surveyors subjects), and Mine Survey and Valuation II and III (Mine Engineering subjects).

A roster was then designed for mine surveying practicals for implementation over one year, with students' attendance being optional. The students who accepted the invitation were monitored for the duration of the research.

From the initial findings, a noticeable improvement in pass rate was observed for students who attended the practical sessions compared with those who did not. This can be regarded as an incentive to make the mine surveying practicals compulsory in future while integrating them with the current learning and assessment. One consequence of this would be the training of well-rounded technicians with sought-after skills for the South African mining industry.

Keywords

mine surveying, open distance learning, on-campus practicals, mining engineering education.

Introduction

The University of South Africa (UNISA) is the only South African university offering mine surveying by open distance learning (ODL). The set-up was intended to primarily offer flexible training to mine practitioners in search of formal qualifications without affecting their professional lives. However, over time, professional students employed in or by the mining industry have been outnumbered by private students. These students are freshly graduated from high school with little to no prior industrial experience.

It is clear that the current curriculum needs to be rethought considering the changing profile of students enrolling for mining-related qualifications. That is why the Department of Mining Engineering at UNISA has introduced on-campus practical sessions. The programme

is initially aimed at supplementing students' formal training with relevant mine surveying exercises.

In order to assess the impact of the programme, historical data pertaining to the performance of students over the last five years was extracted from the University database. Six mine surveying modules forming part of the National Diploma in Mining Engineering and National Diploma in Mine Surveying offered at UNISA were considered. Mine surveying subjects include Mine Survey II and III and Mine Valuation II and III; while mining engineering subjects include Mine Survey and Valuation II and III. A roster was designed for mine surveying practicals for implementation over one year, with students' attendance being optional. The students who accepted the invitation were monitored for the duration of the research. Statistical analysis centred on the hypothesis was performed to determine the change in status before and after the inception of the programme. Finally, recommendations for future work are proposed and conceivable changes to tuition policies evoked.

The National Diploma in Mining Engineering and Mine Surveying

The National Diploma in Mining Engineering and in Mine Surveying are two of the formal engineering qualifications offered by UNISA's Department of Electrical and Mining Engineering, which is based on the Science Campus in Florida, Roodepoort. The Department of Electrical and Mining Engineering forms part of the School of Engineering, which itself forms part of the College of Science, Engineering and Technology (CSET), as shown in Figure 1.

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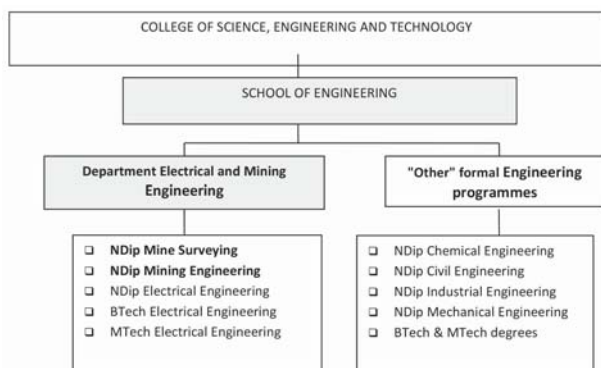


Figure 1—Engineering qualifications offered by CSET at UNISA (source: Self-Evaluation Report-National Diploma in Mine Surveying, internal unpublished document)

The National Diploma in Mining Engineering

The purpose of this qualification is to produce competent mining technicians whose responsibilities would include the selection and managing of the optimal mining process for the mineral deposit in question. A qualified person with sufficient experience will be able to register with the Engineering Council of South Africa (ECSA) as a Professional Technician in this field of engineering. This programme is a prerequisite for the BTech Mining Engineering offered by the University of Johannesburg.

The NDip Mining Engineering programme helps candidates to obtain a Mine Manager's Certificate of Competency (MMCoC) since it covers the syllabus of Part A as well as sections of Part B. Students who completed the diploma may apply to the Department of Mineral Resources (DMR) for exemption from Part A of the MMCoC.

The curriculum of the programme is presented in Table I.

The National Diploma in Mine Surveying

The main purpose of the National Diploma in Mine Surveying is to produce competent mine surveyors whose responsibilities would include taking measurements on and under the surface of the earth in a horizontal and vertical plane, showing the results in the form of a map, plan, or 3D computer model after certain calculations have been done.

Many previously disadvantaged students are enrolled for mining programmes at UNISA. Statistics collected from the Institutional Information Portal (Directorate: Information and Analysis, 'HEDA' (Unisa, 2016a)) reveal that they represent about 95% of all mining-related students over the last five years. UNISA thereby assists mining companies to meet the requirements of the Mining Charter. Health and safety in the minerals industry continues to be a priority. UNISA wants to better equip future graduates with regard to mine health and safety in particular.

The curriculum of the National Diploma in Mine Surveying is outlined in Table II. It is important to point out that UNISA and the University of Johannesburg are the only two universities in South Africa offering a diploma in mine/minerals surveying. UNISA is the only university that offers such a programme by distance learning.

ODL context of learning

Methodologies used in distance learning differ from those

used in residential universities. In ODL, students are issued with a study package upon registration, consisting of study guides, tutorial letters, and course notes. Textbooks are prescribed where course notes are not provided by UNISA. The assignments are included in tutorial letters. Students do not attend classes, but limited discussion classes and lecture consultation sessions are offered in some cases. Discussion classes are not compulsory and are not offered to remote students in South Africa, Africa, and the rest of the world. To compensate for this, UNISA uses e-learning technologies to a large extent. The UNISA learning management system (LMS), called myUnisa, is the UNISA online student portal and the university's most important study tool (UNISA, 2016b). Students can download all course material, as well as additional resources. myUnisa is also called the 'virtual campus for distant learners'. It constitutes a platform where students can interact with fellow students, lecturers, and tutors.

Through self-study the students work through the study guides in their own time, complete the assignments (two or three), and submit them for assessment. Tutorial letters are used by lecturers to provide feedback on assignments and to discuss general problems regarding the subject content. Some lecturers provide such feedback individually when they mark student assignments. Lecturers, and in some cases also tutors, are appointed for each subject to offer academic support to the students via telephone, e-mail, MyUnisa (internet), and personal sessions where required.

A year mark is calculated from assignment marks. The year mark has a weight of 20% when the final mark is calculated; the examination (summative assessment) has a weight of 80%. There are three examination periods, namely January/February, May/June, and October/November. All semester modules have examinations in May/June and October/November respectively for students registered in semester 1 or semester 2. Examinations for full-year modules are held in October/November, and in January/February of the following year for students who qualified to write a supplementary examination (*i.e.* students who have failed with a minimum of 40%). The supplementary examination for semester modules is granted on the same condition but is written in the following session of examination.

At a residential institution a student will typically register for all level 1 subjects in a semester. At UNISA a student may register for subjects from levels 1, 2, and 3 simultaneously provided that the prerequisites are fulfilled. As indicated in Tables I and II, nearly all subjects/modules are offered over a period of a semester, while a few are offered over a full year. The remaining full-year modules are in the process of being semesterized. Certain subjects, for example work integrated-learning (WIL) subjects, remain full-year subjects.

The experiential learning components of the programmes, also called work-integrated learning (WIL) are divided into separate modules covering the required levels of the programmes as shown in Tables I and II. These subjects are administered as individual modules. UNISA staff monitor the experiential learning of students continuously through feedback from students and mentors, completion of assignments and logbooks, and visits to the workplace where possible.

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Table I

Curriculum of the National Diploma in Mining Engineering

National Diploma: Mining Engineering			
Qualification code: NDMIN	NQF Exit level: 6	Total credits: 360	
<p><i>Admission requirements:</i> A National Senior Certificate (Diploma endorsement) with at least 50% in the language of teaching and learning and with at least 50% in Mathematics and Physical Science. Students who do not meet the additional requirements may follow Unisa's alternative pathway.</p> <p><i>Purpose statement:</i> To produce competent mining engineers whose responsibilities would include the selection and managing of the optimal mining process applicable to the relevant mineral deposit to be mined. A qualified person with sufficient experience will be able to register with the Engineering Council of South Africa (ECSA) as a Professional Technician in this field of Engineering.</p>			
Module Code	Module name	Prerequisite/Co-requisite	Semester/Year
First level: Group A. Compulsory			
ENN103F	English for Academic Purposes		Semester
EUP1501	Ethical Information and Communication Technologies for Development Solutions		Semester
MAT1581	Mathematics I (Engineering)		Semester
MEP171X	Mineral Exploitation I		Semester
SMI181Q	Science: Mining I		Semester
STA1510	Basic Statistics		Semester
Second level: Group A. Compulsory			
CAD161S	Computer Aided Draughting I	Co-requisite: MED161Q	Semester
ENV301E	Environmental Management		Semester
EWS121Q	Engineering Work Study I		Semester
FAC1501	Introductory Financial Accounting		Semester
MAT2691	Mathematics II (Engineering)	Prerequisite: MAT1581	Semester
MED161Q	Mechanical Engineering Drawing I		
MPR101E	Mining Engineering Practice I		Year (WIL)
MPR201E	Mining Engineering Practice II		Year (WIL)
Third level: Group A. Compulsory			
EMA2601	Engineering Management II (Module A)		Semester
EMA2602	Engineering Management II (Module B)		Semester
MBE2601	Mineral Beneficiation II	Prerequisite: MEP171X	Semester
MEN2601	Mine Engineering II	Prerequisite: SMI181Q	Semester
MGY2601	Mining Geology II	Prerequisite: MEP171X	Semester
MIN2601	Mining II	Prerequisite: MEP171X	Semester
SAV2601	Mine Survey and Valuation II	Prerequisite: MEP171X	Semester
Fourth level Group A. Compulsory			
EMA3601	Engineering Management III	Prerequisite: EMA2601 or EMA2M1E & EMA2602 or EMA2M2E	Semester
GMI3601	Geology: Mining III	Prerequisite: MGY2601 or MGY291S	Semester
MIE3601	Mine Engineering III	Prerequisite: MEN2601 or MEN251W	Semester
MIN3601	Mining III	Prerequisite: MIN2601 or MIN201E	Semester
MTS351X	Mining Technical Services III	Prerequisite: MEP171X	Semester
SAV3601	Mine Survey and Valuation III	Prerequisite: SAV2601 or SAV231Y	Semester

The need for mine surveying practical sessions on campus

Mine surveying practicals on campus were developed to support the theoretical study of mine surveying subjects, since these subjects have been found to be challenging to the majority of students. This is particularly true of private students, since they have never had the opportunity to visit or undergo training in a mine survey department.

Table III shows the pass rates and the number of students enrolled in 2012, indicating the difference between private and professional students. The challenge faced by private students transpires through their poor performance compared with professional students. For 2012 used as baseline, the

average pass rate of private students is only 10%, against 26% for professional students.

Data collection

In this section, the structure of the programme for on-campus practicals is presented. Student performance is also reviewed in order to form a baseline for comparison before and after implementation of the on-campus programme.

Structure of on-campus practicals

Mine surveying practicals were implemented from 22 February 2016 on the Science Campus of UNISA. The Mining Engineering laboratory and the vicinity of the campus were

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Table II

Curriculum of the National Diploma in Mine Surveying

National Diploma: Mine Surveying			
Qualification code: NDMSR	NQF Exit level: 6	Total credits: 360	
<i>Admission requirements:</i> A National Senior Certificate (Diploma endorsement) with at least 50% in the language of teaching and learning and with at least 50% in Mathematics and Physical Science. Students who do not meet the additional requirements may follow Unisa's alternative pathway.			
<i>Purpose statement:</i> To produce competent mine surveyors whose responsibilities (simplified) would include taking measurements upon and under the surface of the earth either in a horizontal or vertical plane and showing the results in the form of a map or plan applicable to the relevant mineral deposit to be mined.			
First level: Group A. Compulsory			
ENN103F	English for Academic Purposes		Semester
MAT1581	Mathematics I (Engineering)		Semester
MEP171X	Mineral Exploitation I		Semester
MSP101R	Mine Survey Practice I		Year (WIL)
SMI181Q	Science: Mining I		Semester
STA1510	Basic Statistics		Semester
Second level: Group A. Compulsory			
EMA2601	Engineering Management II (Module A)		Semester
EMA2602	Engineering Management II (Module B)		Semester
EUC1501	End-User Computing I (Theory)		Semester
EUP1501	Ethical Information and Communication Technologies for Development Solutions		Semester
MAT2691	Mathematics II (Engineering)	Prerequisite: MAT1581	Semester
MGY2601	Mining Geology II	Prerequisite: MEP171X	Semester
MSG211Q	Mine Survey II	Prerequisite: MEP171X	Semester
MSP242S	Mine Survey Practice II		Year (WIL)
MVA231Q	Mine Valuation II	Prerequisite: MEP171X	Semester
Third level: Group A. Compulsory			
EMA3601	Engineering Management III	Prerequisite: EMA2601 or EMA2M1E & EMA2602 or EMA2M2E	Semester
MSG3601	Mine Survey III	Prerequisite: MSG211Q	Year
MSP352T	Mine Survey Practice III		Year (WIL)
MVA3601	Mine Valuation III	Prerequisite: MVA231Q & STA1510	Year
STG381S	Structural Geology III	Prerequisite: MGY291S	Year

Table III

Number of students enrolled in 2012 and their pass rate per subject and category

	Number of students enrolled in 2012			Pass rates per subject/category		
	Private	Professional	Total	Private	Professional	Total
Mine Survey II	45	12	57	12%	26%	39%
Mine Valuation II	68	19	87	13%	21%	33%
Mine Survey III	18	12	30	27%	47%	73%
Mine Valuation III	10	14	24	13%	21%	33%
Mine Survey and Valuation II	90	39	129	2%	6%	8%
Mine Survey and Valuation III	38	58	96	15%	38%	56%

used for this purpose. Student attendance was optional. The practical sessions were run on a weekly basis from Monday to Friday. The students who accepted the invitation to be part of the programme were received on a 'first-come first-served' basis in a group of 5 to 6 per session.

The first week of the practical sessions was devoted to traversing. The following week, students were exposed to levelling and grading techniques. This sequence was repeated alternately to accommodate all the students booked for training.

Performance of students

A study conducted at the University of the Witwatersrand

developed methodologies for assessing the effectiveness of supplemental instruction (SI). The method involves various kinds of comparison between students who have attended a given number (or more) of SI sessions and those who have attended fewer than this number, or no sessions at all ((Martin *et al.*, 1992; Bidgood, 1992; Congos and Schoeps, 1993), cited by McCarthy, *et al.*, 1997). Practicals on campus can be assimilated to supplemental instruction. Therefore the same methodology is used in this paper for comparing the performances of two groups of students.

The key metric used to quantify students' performance is the pass rate calculated after each examination period (January/February, May/June, and October/November). For

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simplicity, these periods are labelled as January, June, and October respectively. The official examination results are kept in the database of the academic department for each subject. These are filed as historical data for auditing purpose and statistical analysis. They can also be obtained on request from the Examination Administration Division. These two sources of information were used and consulted to compile the pass rates over five years (2011 to 2015) for six mine surveying modules forming part of the National Diploma in Mining Engineering and National Diploma in Mine Surveying offered at UNISA during the period under consideration: Mine Survey II and III, Mine Valuation II and III, and Mine Survey and Valuation II and III.

Mine Survey II and Mine Valuation II were offered during the period under investigation as semester modules with two sitting examinations June and October. Mine Survey and Valuation II and III were offered as full-year modules until 2013, with one examination in October followed by a supplementary in January. Therefore, the results for the January session are combined with those of the October session from the previous year to obtain the overall results for each year. However, these modules were 'semesterized' from 2014 and now have two examination sittings – one in June and one in October. For semester modules, the June and October results are combined to reflect the results for each year. Students who fail in June and qualify for supplementary examination re-write in October of the same year, or in general during the next semester session of examination.

The principle of combining October and January results applies also to Mine Survey III and Mine Valuation III, which were full-year modules during the entire period of investigation.

The pass rate is calculated as the number of students who passed as a percentage of the number of students who wrote the examination in each period. However, it should be noted that all students admitted for examination do not necessarily write, due to the drop-out rate.

The full names of modules are presented in Tables I and II. However, for the analysis of the results, each subject is further described by its code as listed in Table IV.

Student attendance at mine survey practicals

A roster was designed for mine surveying practicals for implementation over a year, split in the two semesters. Students had the choice to opt into two of the six sessions scheduled per semester on the roster, shown in Table V. Three groups were formed; labelled A, B, and C.

Students' attendance at practicals was recorded and is summarized in Table VI.

It appears that the attendance was very low, at 6%, for the first semester. This can be explained in part by the fact that the practicals were optional. The attendees were monitored for the duration of this research. It will be shown later, when discussing the results, that not all students registered were admitted to sitting for the May/June examination period. Some of students cancelled their registration for financial reasons, which is one of the causes of drop-out. Some did not meet the minimum requirement of submitting at least one assignment in order to gain access to examination.

Results and findings

As stated prior to the analysis, the average pass rate for all the subjects over the last five years is very low (28%), and varies significantly from one year to another as well between

Table IV

Mine surveying modules offered in the two qualifications NDMIN and NDMSR

Subjects	Module codes
Mine Survey II	MSG211Q
Mine Valuation II	MVA231Q
Mine Survey and Valuation II	SAV2601
Mine Survey III	MSG3601
Mine Valuation III	MVA3601
Mine Survey and Valuation III	SAV3601

Table V

Roster of survey practicals

Semester 1			
	Group A	Group B	Group C
Traversing	22/02–26/02	07/03–11/03	04/04–08/04
Levelling /grading	29/02–04/03	14/03–18/03	11/04–15/04
Semester 2			
Traversing	18/07–22/07	15/08–19/08	29/08–02/09
Levelling /grading	25/07–29/07	22/08–26/08	05/09–09/09

Table VI

Number of students who attended practicals vs number of students enrolled in 2016

	Number of students enrolled in 2016 (Semester 1 and year)	Number of students attended practicals	Attendance (%)
Mine Survey II	61	7	11%
Mine Valuation II	40	2	5%
Mine Survey III	29	2	7%
Mine Valuation III	27	1	4%
Mine Survey and Valuation II	170	13	8%
Mine Survey and Valuation III	163	6	4%
Total	490	31	6%

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the different modules. The low pass rate can be attributed to the lack of practical experience among students enrolling directly from high school.

Figure 2 shows the pass rates for all the modules from 2011 to 2015.

In order to assess the trend in pass rates over the period under investigation, separate charts with trend-lines are provided for each module in Figures 3 and 4. Similar trends can be observed for the other mine surveying modules as shown in Figure 2.

It can be noted that the pass rate is decreasing for all the modules except for MVA3601. This is alarming and indicates the need to find solutions that can help to improve the situation.

The pass rates for all the modules over five years from 2011 to 2015 are summarized in Table VII.

The number of students enrolled in 2016 was reported in Table VI. As stated previously, not all students who registered wrote in the June examination period, which will be used to assess the impact of practicals on the results of semester's mine survey modules MSG211Q, MVA231Q, SAV2601, and SAV3601. Table VIII shows the number of students who wrote in the June examination period and therefore indicates the number of students who dropped out for any of the reasons mentioned.

The ratio of students writing the examination to those enrolled is 82%, indicating a significant rate of absence (18%) at the examination. Dropping out remains a serious concern for engineering studies. A study conducted at the Faculty of Engineering of the University of KwaZulu-Natal reports a similar academic drop-out rate of 14% (Pocock,

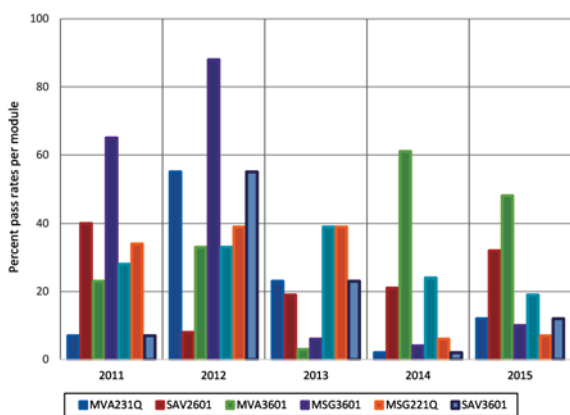


Figure 2—Historical records of pass rates per mine surveying module over the period 2011–2015 at UNISA

2012). An analysis of, and interviews with, a sample of the students who left showed that financial reasons played a significant role, with 49% of non-academically excluded students having financial difficulties, and that a significant proportion of students continue their studies at universities of technology.

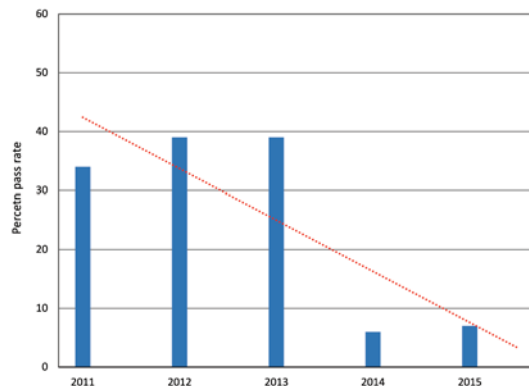


Figure 3—Percentage pass rates for Mine Survey II (MSG211Q)

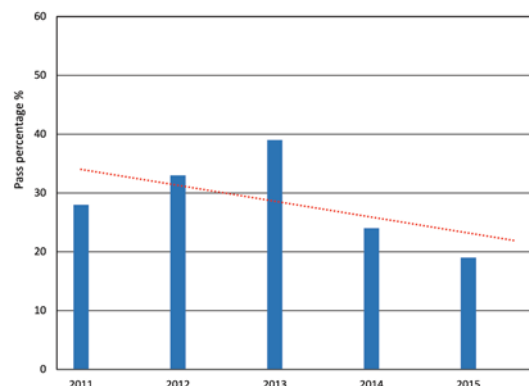


Figure 4—Percentage pass rates for Mine Valuation II (MVA231Q)

Table VII

Pass rates per module per year (%)

	2011	2012	2013	2014	2015
Mine Survey II	34	39	39	6	7
Mine Valuation II	28	33	39	24	19
Mine Survey III	65	73	6	4	10
Mine Valuation III	23	33	3	61	48
Mine Survey and Valuation II	40	8	19	21	32
Mine Survey and Valuation III	7	55	23	2	12

Table VIII

Number of students writing examinations vs number enrolled and drop-outs

	Number of students enrolled in 2016 (S1)	Number of students written in 2016 (S1)	Number of students absent (not admitted and drop-outs)	Students writing examination (%)
Mine Survey II	61	50	11	82%
Mine Valuation II	40	31	9	78%
Mine Survey and Valuation II	170	145	25	85%
Mine Survey and Valuation III	163	128	35	79%
Total	434	354	80	82%

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After the inception of the practicals, it was noted that a low proportion of students attended compared to the total number of students enrolled for the year and the first semester. From Table VI, a total of 31 students, representing 6% of the total enrolled, attended. A further investigation shows that out the 31 students, only 19 students wrote the June examination, which represents 5% of the cohort examined, as illustrated in Table IX.

To assess the impact of practicals, the pass rates of students who attended are compared to those who did not attend. The average pass rate of students who attended is 46%, while it is 39% for the other group. A single factor analysis of variance (ANOVA) was performed using Microsoft Excel to test the hypothesis that the means of the two groups are equal. The result of the test is summarized in Table X.

The terms from Table X have the following meanings in the test as performed using the data analysis tool in Excel: SS = Sum of Squares, df = Degree of freedom, MS = Mean square, F = Test statistic, and F crit = the critical value of the test. In concluding the test, $F < F_{crit}$ means that we fail to reject the hypothesis that the two means are equal. In other words, the sample evidence is not strong enough to warrant rejection of the null hypothesis.

The individual pass rates for the modules written in the June examination are shown in Table XI. A noticeable improvement is evident compared to the previous examination period.

Discussion

The improved pass rate among students who attended the

practical sessions can be regarded as an incentive to make the mine surveying practicals compulsory in future while integrating them to the current learning and assessment.

Is the overall and partial pass rate increase compared to five previous years attributable to practicals? Considering the amount of information available at this stage, it would be premature to give a definite answer. Therefore it is recommended that the scope of the investigation be extended beyond one year and to cover various cohorts of students.

Conclusions

The results of this study constitute an incentive to make the mine surveying practicals compulsory in future while integrating them with the current learning and assessment. One consequence of this would be the training of well-rounded technicians with sought-after skills for the South African mining industry.

Table XI

Comparison of pass rates in June examination to the previous sessions

	Pass rates	
	2011-2015	2016 (S1)
Mine Survey II	24	26
Mine Valuation II	29	68
Mine Survey and Valuation II	25	50
Mine Survey and Valuation III	20	22
Average	25	36

Table IX

Summary of the results per module

	Number of students examined 2016 (S1)	Number of students attended practicals	Attendance (%)	Examination pass rate	Relative pass rate increase
Mine Survey II	50	4	8%	26%	8%
Mine Valuation II	31	0	0%	68%	134%
Mine Survey and Valuation II	145	10	7%	50%	100%
Mine Survey and Valuation III	128	5	4%	22%	10%
Total	354	19	5%	36%	44%

Table X

Analysis of variance

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Students who attended	19	864.08	45.478	428.06
Students who did not attend	335	13211	39.437	326.3

ANOVA

Source of variation	SS	df	MS	F	P-value	F crit
Between groups	656.24	1	656.24	1.9796	0.1603	3.86801
Within groups	116689	352	331.5			
Total	117345	353				

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The findings in this paper are limited to UNISA. However, it would be interesting to investigate and compare the performance of students in surveying disciplines at other institutions in South Africa and internationally. In this regard, attempts were made to collect statistical information from neighbouring institutions (in South Africa), but data could not be obtained before this paper was submitted for publication. The same challenge may arise when dealing with institutions abroad.

In the opinion of the author, a more detailed paper can be presented in the future that can shed light on what is happening elsewhere with teaching and learning of geomatics.

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advanced metals initiative



AMI Precious Metals 2017

THE PRECIOUS METALS DEVELOPMENT NETWORK (PMDN)

In Association with **Platinum 2017**

17–20 October 2017

Protea Hotel Ranch Resort, Polokwane, South Africa

BACKGROUND

The Precious metals Development Network (PMDN) of the DST's advanced metals initiative (AMI) programme will host the AMI's annual conference in 2017.

The AMI Precious Metals 2017 Conference will be held in association with the Platinum 2017 Conference. The Platinum conference series has covered a range of themes since inception in 2004, and traditionally addresses the opportunities and challenges facing the platinum industry.

This AMI Precious Metals 2017 Conference will present a forum where scientists and technologists can come together

to learn and discuss the latest advances in precious metals (platinum group metals and gold) science and technology, under the broad themes of:

- < Catalysis
- < Materials
- < Chemistry



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