

Safety in Mines Research Advisory Committee

Final Project Report

**Learning outcomes and effective
communication techniques for hazard
recognition learning programmes in the
transportation thrust area.**

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Executive Summary

The brief of this research was to identify the hazards associated with underground track bound transportation on Gold and Platinum mines, describe the learning that is necessary to recognise these hazards and then to determine the most suitable techniques for transferring this learning to individuals.

Prior to the commencement of the research the project team had expected that the final outcomes might resemble a checklist of learning techniques and learning outcomes. This was not to be. Instead a complex interaction of organisational and individual factors emerged. The research found that measuring and understanding this interaction is key to designing learning programmes that will significantly impact on safety performance.

The early stages of the research utilised the data from the SAMRASS database and findings from previous SIMRAC research reports. The previous reports were particularly helpful in identifying the major hazards associated with underground transportation accidents. These are summarised in table 4 in the report. From the SAMRASS data the project team was able to isolate the most vulnerable occupation categories, with regard to transportation accidents. The team then investigated the causes of accidents for these occupations. By far the most significant reason was 'a lack of adherence to standards'. One possible reason for this was that workers did not have sufficient knowledge and skills with regard to the hazards. The project team therefore spent considerable time observing training in practice at three different mining groups. Their conclusion was that workers are well trained and are competent to work safely underground.

The liberal use of 'a lack of adherence to standards', given as a cause of accidents in the SAMRASS data, was a concern to the project team. It seemed a catch-all reason that could minimise detailed accident investigations. However, it was what the data reported. It also pointed to behavioural and organisational issues, rather than technical failures and this was consistent with other findings of the research. The project team therefore felt confident in accepting this data, although they acknowledge that further research and better accident recording might be required to fully understand the true causes hidden behind this reason.

At this stage the research was redirected towards other factors that impact on performance and adherence to safety standards. From a variety of sources, a highly complex set of organisational, environmental and individual factors was identified. These interact in a variety of ways to ultimately determine the way people perform. The corner stones were found to be individual self-confidence and the operational wherewithal to perform assigned tasks. This insight enabled the project team to compile table 14 that is a list of the most appropriate learning areas for each of the occupational categories identified earlier.

The project team explored several techniques currently in use by the mines that are aimed at addressing these issues. Although many of the programmes were found to have value, most were used in an ad hoc manner without a concrete understanding of what they were addressing. Although table 15, which lists learning techniques and approaches, was constructed, the team concluded that individual mining operations need to measure and understand their own particular circumstances before they are in a position to embrace any of these techniques.

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Note on the GAP857 Database associated with this report

During the compilation of this report extensive use was made of data extracted from the Department of Mineral and Energy's South African Mines Reportable Accident Statistical System (SAMRASS) database.

The reader can interrogate the SAMRASS data used for this research directly by accessing the database designed by the researchers. Most of the charts and tables in the report can be reproduced directly from the data. Many other views and details are available. You will need to have Microsoft Access loaded on your PC to use the database. If you are reading the report from the CD the following hyperlink should open the database

[GAP857 Database](#)

The bulk of the SAMRASS data is unaltered in the GAP857 database. However, some changes were made in order to provide a clearer picture. These are listed below:

1. The SAMRASS data contained several codes that all referred to the same activity. Where this was detected the codes were combined into a single code. In particular the codes 'standing/sitting/waiting', 'sitting/standing/waiting' and 'waiting/standing/sitting' were all treated as a single code.
2. For the purposes of this research several occupation codes were combined because accident occurrences followed very similar patterns for them and the analysis was simplified through treating them as a group.
 - 'Loco Drivers' and 'Loco Guards' were put into one group called 'Loco Drivers and Guards'
 - 'Drillers', 'General Miners' and 'Stope Workers' were grouped together as 'Miners'
3. The time of accidents was consolidated into four time zones as follows:
 - '1. Night' – Midnight to 06:00 am
 - '2. Morning' - 06:00 am to 12:00 pm
 - '3. Afternoon' - 12:00 pm to 06:00 pm
 - '4. Evening' - 06:00 pm to midnight

At times throughout the report reference is made to the GAP857 database. The relevant chart or table can be accessed using the menu numbers given as reference and then typing in the relevant variables.

It is hoped that the database will provide relatively easy access to the SAMRASS data and as such be valuable for further research in this field.

1 Introduction

The purpose of this research is to make a contribution towards improving safety standards in the underground transportation area. The scope of the research is limited to horizontal track bound transportation on Gold and Platinum mines. The emphasis of the research is on learning and behavioural causes and remedies for accidents rather than on technical and engineering related causes.

The research has three primary outputs:

1. A summarised list of the most significant risks to health and safety associated with track-bound underground transportation.
2. Descriptions of the learning outcomes that would need to be achieved to address these risks.
3. Recommendations for the most appropriate and effective communication techniques for hazards and hazard identification in the area of horizontal underground track-bound transportation.

Several previous research projects have shed light on the first of these outputs, i.e. the risks associated with underground transportation. This body of literature was reviewed to construct an initial list of these hazards. Thereafter the Department of Minerals and Energy's SAMRASS accident data from 1994 until May 2001 was reviewed to confirm that no major shifts had occurred in recent times.

The second output required considerable more primary research. A detailed analysis of the SAMRASS data was undertaken from a behavioural perspective and from this several groupings of employees that are at high risk in terms of transportation accidents were identified. The accidents associated with these groups were further analysed in terms of the activities of the people involved and the causes of the accidents. This analysis provided a framework for the construction of matrix of learning outcomes. The matrix was enhanced by the findings of earlier research in the fields of both organisational learning and organisational performance and by the preliminary work that has been completed by the Mining Qualifications Authority (MQA) in this field. Once the framework had been devised it was tested in discussions with mining personnel and this input was used to revise and refine the matrix.

The final output was constructed from a combination of previous research into training and communication techniques, an analysis of current practices on mines and input from a range of mining personnel who were interviewed on this topic.

The findings of the research should be of particular interest to:

- The relevant Standards Generating Bodies of the MQA.
- Mine management in terms of improving safety standards and the productivity of staff.
- Engineering management in terms of improved transportation efficiencies and safety.
- Safety and training departments in terms of the design and implementation of effective learning programmes.

The structure of the report approximates the methodology outlined above. Firstly, previous literature and accident data are reviewed to identify the list of hazards associated with underground transportation. Thereafter, the data is analysed from a behavioural perspective and combined with input from the MQA and mines to build the framework of learning outcomes. Finally the specific learning and communication techniques have been added.

2. Hazards Associated with Underground Transportation

2.1 Trends in underground transportation accidents revealed by previous literature

Transportation accident statistics have been analysed in several earlier research papers. Most of these papers have concentrated on the technical causes and remedies for accidents. This section of the report reviews some of these earlier papers and identifies important trends over the last two decades.

2.1.1 Shift from technical and logistic causes to human error and a lack of adherence to standards.

An investigation done by Banks in the 1980's identified a significant number of technical shortcomings in engineering and logistical aspects of underground transportation. Collisions were high on the list as a major cause of fatal accidents. His figures put these at 41% of all fatal transportation accidents. Research conducted during the 1990's showed a significant decline in engineering and logistical causes. Page, et al (GAP520, 1999) indicated that between 1988 and 1997 collisions accounted for only 13.5% of fatal accidents. The chief causes had shifted to issues related to human error and a lack of adherence to standards. For example work carried out by the Mines Regulations Advisory Committee (MRAC) Work Group using 1993 and 1994 data revealed the following:

Table 1
Causes of transportation accidents

Cause of accident	%
Failure to comply to standards	39
Lack of caution/alertness	17
Failure to use safety devices	17
Lack of clearance or obstruction	9
Failure to comply to instructions	6
Inadequate inspection / test / examination	3

A similar conclusion was reached by Willis who compiled GAP055 in March 1994. He found that other than rock bursts and falls of ground, human error was the major cause of accidents. In April 1996 GEN213 (Talbot et al) was specifically commissioned to explore why safety and work standards were not complied with on mines. Its conclusions are summarised below:

- Managers and supervisors need to ensure compliance with codes and practices and to provide the necessary resources to enable effective compliance
- Training methods of workers in the codes and practices need to be improved.
- There is a need for mine specific action based on circumstances at the individual mine to improve compliance with codes and standards.

Research in related areas revealed a similar pattern. For example Simpson, et al (OTH202, 1996) identified a comprehensive list of latent failures as the underlying cause of transportation accidents. These included aspects such as attitudes to safety, training, organisation and working methods,

rules and procedures, attitudes to rules and procedures, safety commitment of management, supervision style, organising for safety, equipment design and maintenance. Only the last two are engineering issues.

The trend is clear. Improvements in engineering design have significantly reduced the number of accidents that result from technical failure. Good progress has been made in terms of transportation logistics that has lowered the risk of accidents resulting from poor planning. The key issue, as identified by these previous research reports, is that human error resulting from a lack of adherence to standards is the major cause of transportation accidents. This has significant implications for designing learning outcomes that will reduce accidents. It shifts the emphasis from technical training to behavioural issues.

2.1.2 The location of the majority of transportation accidents.

Page, et al (GAP520, 1999) identified that haulages with 47%, cross cuts with 30% and stations and tips with 13 percent were the most significant accident sites. A large number of the coupling accidents occurred in the haulages or cross cuts. Being struck by material on a car or next to the track occurred frequently while tipping was the most frequent cause at the tips or stations.

The Page research indicated a similar pattern for fatal accidents:

- Haulages 68%
- Cross cuts 15%
- Reef and collection drives 6%

Although this is an expected result, it has important ramifications with regard to the brief for this research. Its implication is that the vast majority of accidents occur in areas that are relatively isolated and away from direct supervision. This places a large responsibility on those who operate the transportation equipment to monitor their own compliance to safety standards and also to monitor the compliance of those who move through the haulages.

2.1.3 The occupation of those involved in the accidents.

Earlier literature on transportation accidents placed little emphasis on the occupation of those involved with the exception of Page where it was found that almost 50% of all those injured in transportation accidents were transportation workers. Other than this, the focus was usually on the causes of accidents. However, one of the recommendations of the MRAC Work Group was that safety training relating to transportation should include awareness training for persons other than drivers and operators. In other words, there was recognition of the broad range of people who are injured in transportation accidents. For the purposes of this research, occupation has been identified as an important variable. It is a major determinant of the type of learning that should be given to workers. This is explored in detailed in section on the analysis of accident statistics.

2.1.4 Recommended remedies to reduce the number of accidents.

It is interesting that training and learning have not often been identified as key areas that should be addressed in order to reduce the occurrence of transportation accidents. In fact Willis (1994) specifically highlighted that a lack of training was not amongst one of the common causes for accidents.

Many of the previous recommendations do however have significant training implications. The MRAC Work Group recommended that clearer and simpler language be used in regulations, the code of conduct be revised and that broad based awareness training be implemented. Rushworth et al (1999) highlighted ergonomic issues and supervisory competence.

2.2 Major transportation hazards identified in previous literature

Previous research into transportation accidents took one of two approaches. The first was to identify the hazards themselves. Research done by the MRAC Work Group and by MJ Parker is examples of this approach. Their findings are summarised in the following table.

Table 2
Hazards that caused fatal accidents

Hazards that Caused Fatal Accidents.	MRAC Work Group	MJ Parker
Derailments (caused by fouling, collision or inadequate trackwork)	42.2%	41.9%
Insufficient track clearances from the sidewall, parked cars or stacked material	15.7%	16.7%
Collision with ventilation doors	11.8%	11.1%
Run over while walking ahead of train	9.8%	
Illegal riding on locomotives and hoppers	5.9%	4.2%
Struck by hopper while operating switch	4.0%	10.3%
Others (coupling, crushed in battery bays, leaning out of cab etc.)	11.6%	
Shunting		11.9%
Operating		3.9%

These two research reports show similar patterns of transportation hazards but they are limited because they place little emphasis on the activity of the injured person at the time he/she was injured.

Page provided the most comprehensive survey of transportation accidents compiled to date. Its value over earlier research is that it attempted to combine several factors in determining the hazards. It investigated the actual cause of the injury, the circumstances that led to the injury (what the person was doing) and the severity of the injury. The research methodology went beyond an analysis of SAMRASS and involved a detailed investigation of several thousand accident reports. This approach enabled the researchers to identify the hazards with more precision than is possible from the SAMRASS database. They were also able to factor in the severity of accidents and their ranked list of hazards therefore reflects the most significant hazards rather than merely the most numerous. The final Page rankings are given in the following table.

Table 3
Ranking of hazards

Ranking	Hazard	Rank Number
1	Walking	100
2	Derailment	84
3	Collision	80
4	Travelling on	80
5	Coupling	76
6	Obstruction	60
7	Re-railing	44
8	Trackwork	44
9	Falling	36
10	Tipping	24
11	Lying	16
12	Machine parts	12
13	Material off	8
14	Material on	4

Page defined each of these hazards in more detail and these are given in Table 4.

2.3 Analysis of the most recent SAMRASS data on accident statistics

A detailed analysis of the most recent SAMRASS data from August 1994 to May 2001 is given in section 3.1 of this report.

For the purposes of this section of the report, i.e. the identification of transportation hazards, the latest data correlates very well with the findings of Page in terms of broad categories. Figure 1 (in section 3.1) shows the percentage occurrence of accidents by activity from 1994 to 2001. This data again ranks the relatively passive activities of walking, waiting, standing and sitting as the most hazardous situation. These are followed by coupling situations, derailing / re-railing situations and then mobile situations. The differences between Page and the most recent data can largely be attributed to the severity factors that Page built into his rankings.

It is also significant that the pattern of accidents appears to have stabilised. A variety of longitudinal analyses over this period showed no significant emerging trends. The patterns for 'activities' ([SAMRASS database 2.1. \[Graphic view\]](#)) and 'occupation' ([SAMRASS database 2.2. \[Graphic view\]](#)) in particular remain constant until 2001. The 'accident cause' graph ([SAMRASS database 2.3. \[Graphic view\]](#)) shows an initial decline in 'lack of adherence to standards' but from 1996 this too levels out. All the trend graphs appear to be showing new patterns for 2001. There are two reasons for this. The first is that the data is incomplete in that it reflects only five months of the year. The second and more important explanation is that a significant number of new reason codes have been added to the database. The purpose of this is to enable researchers to identify causes more precisely but it does cause discontinuities with previous data. For the purposes of this research it is reasonable to treat the SAMRASS data as a single entity rather than analyse it on an annual basis. Statistically this has considerable advantages because it means that sample sizes remain large even when the data is dissected by several variables.

The scope of this research does not allow for another detailed investigation into the hazards associated with underground transportation. In view of the similarities between Page, the most recent data and the lack of any new trends, this report has accepted the findings of Page in terms of hazard identification.

All previous research regarding transportation accidents is interesting silent on occupational health risks. It is probable that these risks result in injury over the longer term and so are more difficult to attribute directly to the transportation environment. It is beyond the scope of this report to embark on new long-term research to isolate the extent of health risks in the transportation arena. However, some possible hazards are listed in appendix 8.

2.4 Conclusions

The main conclusions for this section of the report are summarised as follows:

- Human error, rather than technical failure, remains the major cause of underground transportation accidents.
- The majority of accidents occur away from areas of close supervision.
- Although transport workers form the largest group of people injured in transportation accidents they comprise less than 50% of the total. Other occupational categories must therefore also be considered.
- The transportation hazards identified by Page remain the chief causes of accidents and were used as the foundation for further research in this report. These are summarised in Table 4.

Table 4

Outcome 1 - Hazards Associated with Underground Transportation.

Ranking	Hazard	Description
1	Walking	Walking injuries to persons who were either walking or standing next to or on the track (Note — it would have been desirable to distinguish these two activities, namely, walking or standing, but insufficient information on the report form precluding this.)
2	Derailment	Injuries to persons who might have been on the train or next to the track caused by a derailment.
3	Collision	A collision between a moving vehicle and another vehicle.
4	Travelling on	Injuries received while travelling on a vehicle.
5	Coupling	Injuries received while coupling vehicles.
6	Obstruction	Injuries to persons as a result if a collision some part of the transport system, such as a partially open ventilation door or a loading chute or with some permanent structure, the sidewall or hanging.
7	Re-railing	Injuries to persons while re –railing derailed equipment.
8	Trackwork	Injuries to persons working on the track. This did not include Injuries caused by the trackwork, but only injuries that were caused by being struck by a vehicle.
9	Falling	Injuries resulting from people falling into a excavation forming a part of the transport system.
10	Tipping	Injuries that occurred at the tip excluding injuries listed as “Working on hopper “.
11	Lying	Sufficient information was supplied to determine that in some cases the injured party had been lying on or next to the track. In some cases the report stated that the person was asleep at the time of the accident.
12	Machine parts	Injuries caused by parts of the vehicle. This category excluded injuries caused by part of the vehicle during another event such as a collision or a derailment.
13	Material off	Injuries to members of the train operating team or a passenger on the train being struck by material at the track side.
14	Material on	Injuries to persons being struck by material being transported on a train.
Not ranked	Working on hopper	Injuries resulting from work on a hopper, such as clearing large rocks or mud from a hopper.
Not ranked	Moving vehicle	Injuries resulting from a person boarding, or alighting from, a moving vehicle.
Not ranked	Battery changing	Injury resulting from changing batteries

3 The Learning Outcomes Associated with the Hazards of Underground Transport

3.1 Introduction

It is clear from the conclusions in section 2.4 that the major focus of analysis in this research should be on behavioural aspects of learning rather than technical skills and competence. It is necessary to investigate people related causes of accidents in more detail. In order to do this several sources of data are explored.

In the first instance the data from the Department of Minerals and Energy was interrogated from a behavioural perspective. This identified certain patterns with regard to groups of workers who were involved in the accidents and their activities at the time of the accident.

The findings from the data analysis provided a framework for the research conducted at various training centres at mines. The objective of this primary research was to ascertain what training is currently given to these groups of workers and to identify any gaps in their learning programmes. International practice was also investigated, largely via the Internet, but also through discussions conducted with mining consultants in the UK.

The third source of learning data was the work that has been done to date by the Mining Qualifications Authority.

The findings from all these sources are discussed in the following sections.

3.2 A Behavioural Analysis of SAMRASS Data

Data from the Department of Minerals and Energy accident statistics database, SAMRASS, from August 1994 to May 2001 was used for the analysis. The Department provided an extract from the SAMRASS database that related to underground transportation accidents in Gold and Platinum mines. In total over 8000 accident records were included in the analysis. The data collected in SAMRASS is not ideally suited to behavioural research¹ but was nevertheless useful for identifying some patterns that gave direction to the research.

The approach taken in the analysis was people centred. The data was initially analysed in terms of the activities of those who were injured at the time that they were injured. This was done to confirm the validity of accepting the results of Page. In total the data identified about 150 different activities. This indicates the wide range of situations in which people are injured. However, despite this range 10 activities account for about 75% of the accidents as shown in the following chart.

¹ Appendix 4 contains some of the problems associated with the SAMRASS data that were identified during the research. Although this was not part of the original brief of this project, it has been included as an additional outcome.

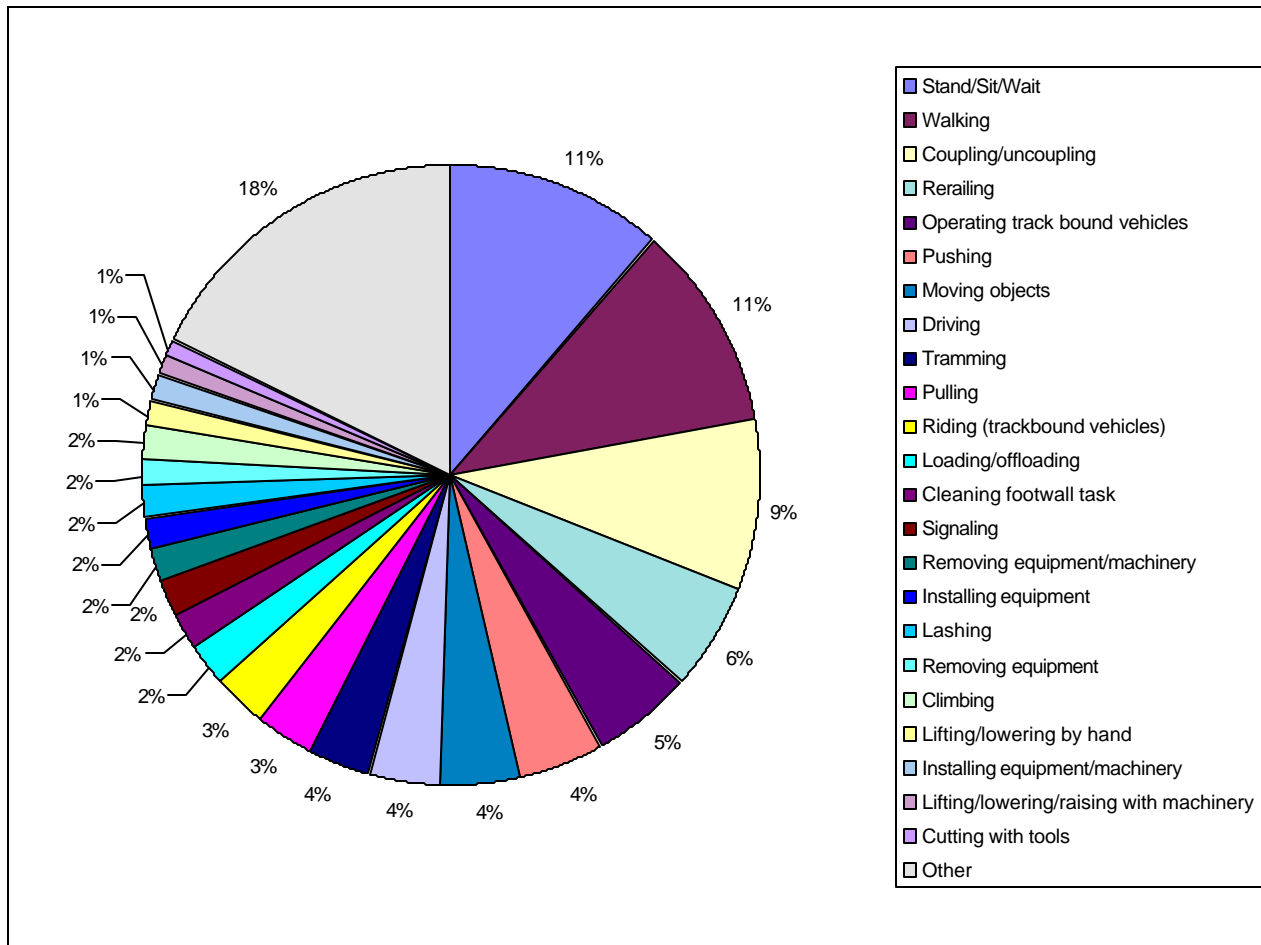


Figure 3. 1 Categorisation of Transportation Accidents by Activity at Time of Accident.

This pie chart confirms the large variety of activities during which persons were injured. It is of interest that the two largest segments (standing/waiting/sitting -11% and walking -11%) are both relatively passive activities and have little to do with the actual operation of transportation machinery. The inference of these statistics is that for these two segments (22% of the total) most of the responsibility for the accident probably did not lie with the injured person. This has several implications in terms of learning and hazard recognition that is required for these for these people. Some of the issues that will be explored later in the research include:

- Knowledge of specific hazards associated with transportation.
- The identification of potentially hazardous situations.
- Appropriate behaviour in the vicinity of transportation vehicles.
- Interpretation of transportation signage.

The second set of activities that are prone to transportation accidents are closely related to direct involvement with tasks associated with vehicles and their loads.

The breakdown by activity given above was useful in confirming the findings of earlier research regarding the identification of hazardous situations. It is, however, not very informative with regard to designing learning programme. What is required is an understanding of the occupational role of

the injured person. Through understanding the combination of what the person had been trained to do and what he was actually doing at the time he was injured will provide insight into what additional learning and knowledge he requires. The following table shows the breakdown by occupation of those involved in transportation accidents.

Table 5
Occupation and activity of Personnel involved in accidents

Occupation	Percentage of Total
Loco driver (underground)	25
Monorail winch operator	14
General miner	11
Shaft foreman	8.9
Stope team worker	6.2
Driller: hand percussion/jackhammer	6.2
Loader driver (trackless)	3.7
Loco guard (underground)	2.8
Lasher/loader	1.5
Pipes and tracks worker	1.3
Miner's assistant	1.3
Supervisor's assistant (underground)	1.2
General engineering worker	1.2
Unclassified occupation (unknown/unspecified)	1
Banksmen/onsetter	1

This analysis by occupation indicates that only eight occupations are involved in more than 77% of the accidents. Thereafter, from Lasher and below, there is a significant decline in the number of accidents for each occupation. The occupation 'Loader driver (trackless)' is beyond the scope of this research that is limited to track bound transportation. 'Loco Guard' was included with 'Loco Driver' because these occupations receive very similar training. It was decided that the research would concentrate on these six occupations.

Having identified the occupations of those most frequently involved in accidents the next step was to explore the activities in which they were involved at the time of the accident. The purpose of this was to identify behavioural patterns for individual occupations or groups of occupations. The following chart shows the activities for the six most common classes of occupation that are involved in transportation accidents.

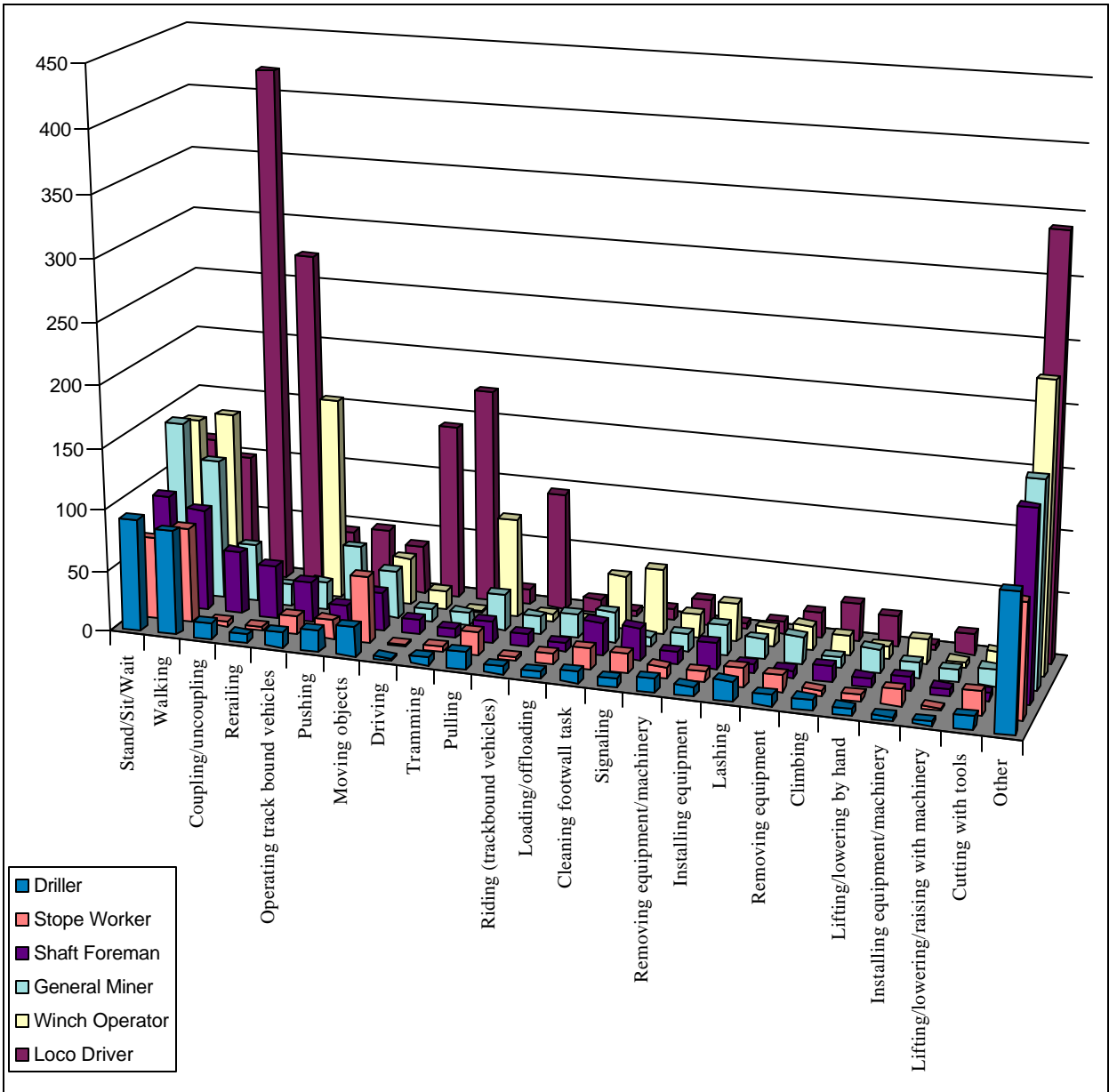


Figure 3.2 1: Occupations of Personnel Involved in accidents

If this diagram is analysed in terms of the frequency of occurrence of accidents four distinct patterns emerge in the data:

- The first pattern consists of Loco Drivers and Guards. Activities that led to their injuries are associated directly with the performance of their normal duties. They include coupling / uncoupling, re-railing, driving, tramming and riding on vehicles.
- The second group is Drillers, Stope Workers, General Miners. It is an interesting group since the activities that led to their injuries tend to be more passive activities such as sitting / standing / waiting and walking. They are also a group that represents occupations that are not specifically trained for tasks relating to transportation. In general they are on route to their workplace or returning to the shaft when injured.

- The third group is Winch Operators. The activities of this group when injured differ from the second group in a few significant ways. Whilst passive activities of sitting / standing / waiting and walking rank high so do active roles such as operating track bound equipment, pulling and signalling. These activities are of particular importance because they do not form part of the normal training for Winch Operators yet Winch Operators appear to be required to perform them fairly regularly. This seems to indicate a certain degree of informal multi-skilling.
- The fourth group is Shaft Foremen. It is surprising that a supervisory occupation ranks so high amongst those injured particularly since the major activities when injured are the more passive ones. This is significant because it implies that this first level of supervision, and the one most closely associated with transportation activities, is not itself adhering to standards and setting the example that it should.

A further level of investigation was explored for each of these groups to gain some understanding as to the cause of accidents. These tables provided the basis for the initial identification of the key learning issues and areas for each occupation.

Table 6
Loco Drivers and Guards

Occupation Group: Loco Drivers and Guards (2175 of 7797 – 28%)				
Activities when injured	Reasons for accident			
Coupling / uncoupling 21%	Inadequate adherence to standards - 49%	Available not used – 21%	Lack of knowledge – 14%	Poor co-ordination – 4%
Rerailing 13%	Inadequate adherence to standards – 47%	Inadequate systems – 21%	Lack of knowledge – 13%	Available not used – 6%
Tramming 9%	Inadequate adherence to standards – 50%	Poor co-ordination – 10%	Lack of knowledge – 8%	Not registered at planned maintenance – 7%
Driving 7%	Inadequate adherence to standards – 49%	Lack of knowledge – 11%	Available not used – 11%	Poor co-ordination – 8%
Sitting/standing/waiting 6%	Inadequate adherence to standards – 55%	Lack of knowledge – 11%	Poor co-ordination – 11%	Available not used – 8%
Riding 5%	Inadequate adherence to standards – 57%	Inadequate systems – 8%	Lack practice under supervision – 7%	Lack of knowledge – 7%
Walking 5%	Inadequate adherence to standards – 58%	Poor co-ordination – 12%	Lack of knowledge – 10%	Wrong equipment – 4%

Key areas that require attention, in order of significance, are:

- Adherence to standards – 50%
- A lack of knowledge – 12%
- Available equipment not used – 11%

- Inadequate systems - 6%
- Poor co-ordination – 5%
- A lack of practice under supervision – 4%

Table 7

Miners

Occupation Group: Miners (Stope Team Workers, Drill Operators, General Miners) 1858 of 7797 – 24%)				
Activities when injured	Reasons for accident			
Sitting/standing/ waiting 16%	Inadequate adherence to standards - 48%	Poor co-ordination - 12%	Lack of knowledge – 11%	Lack of practice under supervision – 10%
Walking 15%	Inadequate adherence to standards – 51%	Lack of practice under supervision – 11%	Lack of knowledge – 9%	Available not used – 7%
Moving objects 6%	Inadequate adherence to standards – 41%	Lack of practice under supervision – 13%	Lack of knowledge – 10%	Available not used – 10%
Pushing 5%	Inadequate adherence to standards – 51%	Lack of practice under supervision – 17%	Available not used – 9%	Poor co-ordination – 8%
Coupling / uncoupling 4%	Inadequate adherence to standards – 47%	Available not used – 27%	Lack of knowledge – 8%	Lack of practice under supervision – 6%
Pulling 3%	Inadequate adherence to standards – 47%	Lack of knowledge – 10%	Available not used – 10%	Lack of practice under supervision – 6%

Key areas that require attention, in order of significance, are:

- Adherence to standards – 48%
- A lack of practice under supervision – 10%
- A lack of knowledge – 11%
- Available equipment not used – 8%
- Poor co-ordination – 6%
- Inadequate systems - 2%

Table 8
Winch Operators

Occupation Group: Winch Operators (1101 of 7797 – 14%)				
Activities when injured	Reasons for accident			
Operating track bound vehicles – 15%	Inadequate adherence to standards - 51%	Lack of knowledge – 8%	Wrong equipment – 7%	Poor training – 6%
Walking 13%	Inadequate adherence to standards – 63%	Lack of practice under supervision – 9%	Poor co-ordination – 6%	Lack of knowledge – 6%
Standing/Sitting /Waiting 13%	Inadequate adherence to standards – 59%	Lack of knowledge – 14%	Poor co-ordination – 5%	Lack of practice under supervision – 4%
Pulling 7%	Inadequate adherence to standards – 62%	Lack of knowledge – 10%	Lack of practice under supervision – 5%	Available not used – 5%
Signalling 5%	Inadequate adherence to standards – 49%	Lack of knowledge – 16%	Poor co-ordination – 9%	Lack of practice under supervision – 8%
Clearing footwall 4%	Inadequate adherence to standards – 64%	Lack of practice under supervision – 7%	Lack of knowledge – 5%	Available not used – 5%
Moving Objects 4%	Inadequate adherence to standards – 41%	Available not used – 15%	Wrong equipment – 8%	Lack of practice under supervision – 8%

Key areas that require attention, in order of significance, are:

- Adherence to standards – 54%
- A lack of knowledge – 10%
- A lack of practice under supervision – 8%
- Available equipment not used – 7%
- Poor co-ordination – 4%
- Inadequate systems - 3%

Table 9
Shaft Foremen

Occupation Group: Shaft Foremen (697 of 7797 – 9%)				
Activities when injured	Reasons for accident			
Standing/Sitting/ Waiting 13%	Inadequate adherence to standards - 54%	Lack of knowledge – 12%	Poor co-ordination – 9%	Poor training – 7%
Walking 12%	Inadequate adherence to standards – 59%	Lack of practice under supervision – 8%	Wrong equipment – 8%	Poor co-ordination – 6%
Coupling / uncoupling 7%	Inadequate adherence to standards – 49%	Lack of knowledge – 20%	Available not used – 18%	Damaged material – 4%
Supervising 7%	Inadequate adherence to standards – 50%	Poor co-ordination – 11%	Available not used – 8%	Poor training – 6%
Rerailing 6%	Inadequate adherence to standards – 60%	Available not used – 12%	Lack of knowledge – 9%	Inadequate systems – 7%

Key areas that require attention, in order of significance, are:

- Adherence to standards – 55%
- A lack of knowledge – 9%
- A lack of practice under supervision – 6%
- Available equipment not used – 6%
- Poor co-ordination – 5%
- Inadequate systems - 4%

The above data shows that ‘a lack of adherence to standards’ is, according to the SAMRASS data, the most significant cause of accidents. The liberal use of this reason is a concern to the project team. It seemed a catch-all reason that could be used to minimise detailed accident investigations and shift all blame onto an individual. However, it was what the data reported. It also pointed to behavioural and organisational issues, rather than technical failures, as discussed later in this report, and this is consistent with other findings of the research. The project team therefore felt confident in accepting this data, although they acknowledge that further research and better accident recording might be required to fully understand the true causes hidden behind this reason.

It is important that the above causes are related to the activity. For example Loco Drivers need to adhere to standards concerning the operation of transportation equipment whereas in the case of Miners it is more general safety awareness within the transportation environment that requires attention. Similarly for ‘lack of knowledge’. In the case of Loco Drivers it is knowledge about their job whereas with Miners it is knowledge about the safety requirements in an environment different from where they actually work. Based on this a table can be constructed that identifies the fields in which learning is required in the three most significant areas.

Table 10
Fields of Learning

	Loco Drivers and Guards	Miners	Winch Operators	Shaft Foremen
Adherence to standards	Ways of improving adherence to standards relating to the job.	Ways of improving adherence to standards in workplaces other than their own.	Ways of improving adherence to standards relating to jobs that they do but for which they are not specifically trained.	Ways of improving adherence to standards for which they should be responsible.
Knowledge	Improve knowledge of their own job.	Improve knowledge of the work environment of others.	Improve knowledge of work for which they are specifically trained.	Improve knowledge of work for which they are responsible.
Practice under supervision	Create more opportunities to gain confidence under supervision.	Create more opportunities to gain confidence under supervision.	Create more opportunities to gain confidence under supervision.	Create more opportunities to gain confidence under supervision.

Of these the first, 'adherence to standards', is the most significant by a large margin. Much of the remaining research is focused on this aspect as it has the most potential for affecting a change to accident statistics. It is important to explore why standards are not followed. There are two distinct possibilities. The one is that standards are not adequately learned in the first place. To explore this the research team investigated the progress made by the MQA in this regard and the actual practices in place on mines. The MQA work would identify the extent to which standards are formally defined and the mine visits would give an indication as to the thoroughness of the training and assessment given to workers in the relevant occupations.

3.3 Learning Outcomes and Standards Identified by the MQAs' Standard Generating Body.

At the time of compiling this report the Mining Qualifications Authority (MQA) had completed very little work on unit standards and qualifications relating to lateral underground transportation. Their initial thrust had been on the production areas of stoping and development. They will deal with logistics, of which transportation is a component, at a later stage.

It is nevertheless evident from the qualifications and unit standards that have been completed that the MQA outputs will become an essential reference for determining the specific technical and safety learning required for any aspect of mining. An example of an MQA qualification specification is given in appendix 6. The table below contains an small extract.

Table 11
Example of MQA unit standards

<i>Specialisation area 2: Horizontal Transport</i>			
The following unit standards are elective to Engineering Maintenance and Repairing Underground Hardrock - Horizontal Transport.			
Number	Unit Standard Title	Level	Credit
EnE-G005	Inspect and clean a 3-phase transformer	1	1
ENE-G006	Connect an industrial plug (Exceeding/higher/larger than 16amps)	2	2
ENE-G007	Install an industrial socket outlet (Exceeding/higher/larger than 16amps)	2	2
ENE-G027	Install a gully box	2	2
EnE-G055	Carry out a detailed inspection on an electrical motor	2	3
EnE-G050	Carry out a detailed inspection on an overhead trolley line	2	4
EnE-G051	Install an overhead trolley line in a underground haulage	2	6
EnE-G053	Carry out a detailed inspection on a cam operated motor controller	2	5
EnE-G075	Repair a water level control system	3	3
EnM-G002	Replace a taper sleeve bearing	2	2
EnM-G008	Replace an inline ventilation fan in an underground environment	2	2
EnM-G010	Replace a vertical spindle pump	2	2
EnM-G120	Replace a pin and bush type drive coupling	2	2
Total			36+

It is evident from this extract that the MQA qualifications define specific learning areas in considerable detail. However, the learning definitions are still, of necessity, generic. It would not be realistic to specify particular makes pumps, locos or winches. This level of detail will always remain the responsibility of each mine. As a result this research does not address this level of detailed learning. Also, as discussed in the following section, the research found that mines have done an excellent job of specifying technical and safety training at this level of detail.

As mentioned, the MQA units standards indicates that a distinct bias towards developing technical and safety competencies. While these are critical, it is hoped that the recommendations of this research will broaden the scope of the competencies deemed necessary to create a safer working environment.

3.4 Current Practice on South African Mines

The purpose of the practical research conducted at a few selected mines was to identify particular practices that are in place at present. Initially a cross section of three mines was selected; two gold mines and one platinum mine. The one gold mine had an underground training centre, the other gold mine had a surface training centre and the platinum mine had both surface and underground training centres. The research team planned to visit more mines if the trends that emerged from the first three were inconsistent. This proved not to be the case. In fact remarkably similar patterns were evident at all three sites and hence the research was not extended to other mines.

As mentioned earlier in the report, poor training was not often identified as a cause of accidents in the SAMRASS data. The research team was particularly interested in exploring this during the site visits. Three fundamental questions regarding current training practices required answers:

- Did insufficient knowledge and skills regarding the technical operation of equipment, as a result of poorly designed training courses, lead to 'a lack of adherence to standards'?
- Was there sufficient emphasis on the potential hazards associated with the machinery the workers were being trained to use? Did a lack of training on safety procedures and accident prevention contribute to 'a lack of adherence to standards'?
- Were the training methods that were employed effective in ensuring that trainees acquired the knowledge and skills with regard to both the technical and safety aspects of the machines and working environments for which they were being trained?

To answer these questions interviews and discussions were held with training managers, instructors and trainees. In addition many hours were spent actually observing training in both underground and surface situations. All discussions were open-ended in the sense that a formal questionnaire was not used. The research team used the findings of the data analysis and a specifically designed list of questions to obtain answers to the three main questions above.

The details of the findings from the mine visits are summarised in appendix 5. In general all three centres were well organised and thorough in their approach to training. Systematic procedures were in place to monitor the quality and effectiveness of training. Safety aspects were high on the agenda. In fact in most of the cases, observed by the research team, safety was the main issue as the workers were returning from leave and their technical ability to operate the equipment was not in question. The training centres did vary in their professionalism with regard to training methodology. Two of the three were very traditional in their approach and relied almost exclusively on tried and tested behaviourist methods to teaching. The third centre also employed traditional methods but was experimenting with more participative methods. Trainees from all three centres were confident that they could perform their jobs at the completion of the training and that they understood all the hazards and safety precautions associated with the equipment they operated.

Several conclusions were drawn from the findings of these visits.

- A lack of competence in the specific job for which workers are trained is not a significant cause for the lack of adherence to standards. The research came to this conclusion for the following reasons:
 - The technical content of training courses was comprehensive. It was designed in consultation with operational staff and was reviewed frequently to ensure that it remained current.
 - Instructors were all ex operators of the equipment they were training others to use. They understood the technical and safety intricacies of their tools and the environment in which they were used.

- Training content was professionally presented in training manuals and was implemented via checklists that ensured that all technical and safety aspects were covered each time the course was run.
- The use of underground training environments greatly improved the trainees appreciation of the risks and hazards associated with the production environment.
- Workers were finally declared competent by the production staff. In other words the final test of their ability was in the workplace.
- There were gaps in training in situations where informal multitasking was occurring. Other than the general induction, all training was very specific to the actual job for which the worker was being trained. The accidents statistics, however, indicated that many workers are injured in other situations. Training programmes did not take cognisance of this fact.
- Training methods are effective in developing the appropriate skills and knowledge in workers. This conclusion was reached largely as a result of the discussions held with trainees. Much of the training on mines was very behaviourist in its approach. This is evident for the fact that signs were designed to produce a specific response. Training techniques were very repetitive to ensure that knowledge and the appropriate response to a situation became automatic. The main language used was fanakalo. Workers felt comfortable with this approach. In general they were confident that they understood what was being taught and that the methodology was appropriate.
- Training designed to influence attitudes is emerging but is not directed and still in its infancy. Some examples of this were the following:
 - Pockets of training that were beginning to use discussion as a method of instruction rather than repetition. The research team was impressed by the multilingual capabilities of the instructors in these situations.
 - Team based training was being piloted in some cases. Unfortunately, from the research team's perspective, this was always an entirely separate exercise to the standard technical and safety training.
 - Some thought was being given to broadening the educational base of workers by providing business-related training.

The overall conclusion of the research team was that whereas there are some gaps in the training of workers, training as a whole is thorough and well integrated into the production environment. The visits confirmed the findings of the data analysis that a lack of competence is not a significant reason why workers do not adhere to standards relating to their own job. The reason for this need to be sought elsewhere.

3.5 Lessons from International Experience

At this point in the research the emerging picture was that a lack of 'adherence to standards' was the most significant cause of accidents and that insufficient training or inappropriate training methods were not the chief cause.

The research team believed it was necessary to investigate other international experiences to confirm whether this was a situation particular to South Africa or whether it was an international phenomenon. The bulk of this research was conducted via the Internet. The most significant report found was from the Ontario Ministry of Labour.

The Ontario Internal Responsibility System (Plummer, 2000) is a system that places direct responsibility for health and safety on each person in the organisation. The final report on the system was completed in October 2000 after a survey involving six mines and 267 employees at all levels. The report correlated various IRS indicators with actually Occupational Health and Safety (OHS) performance. The results are summarised in the following table.

Table 12

Ontario OHS performance ratings

IRS Indicator	Correlation with OHS performance.
Planning	Good
Information regarding OHS	Reasonable
Beliefs – attitudes to the IRS	Reasonable
Handling OHS concerns and complaints.	Fair
OHS initiatives and responses	None
Accountability	None
Demonstrating leadership	None
IRS issues and responses	None
Corporate level	None
Mine management	Some
Middle management	None
Front-line supervisors	Good
Workers	Good
OHS co-ordinator	None
MOL Inspectors	None

The report confirmed some of the trends identified in this research and highlighted some additional areas. It confirmed that attitudes are important to health and safety and also indicated that it is the attitudes of front-line supervisors and workers that are most significant. The report also highlighted planning and information regarding OHS as important factors but again implies that these must be at the level of the supervisors and workers. It is interesting that ‘demonstrating leadership’ or management commitment had little impact on OHS performance.

In addition to the Internet research, a brief report was requested from HSEC (Health, Safety and Engineering Consultants Ltd) in the UK. This report highlighted that to achieve improvements in safety it was necessary to look beyond basic training techniques.

“There has been, over recent years, an increasing realisation that in the UK mining industry any approaches in improving health and safety awareness among the workforce must be based on a sound analysis of the human factors which lie behind a successful safety culture.”

3.6 Models of Organisational Learning and Performance

The preceding sections of this report have identified several vital factors with regard to where the emphasis on learning should be placed if underground transportation accidents are to be reduced.

- Section 3.2 identified ‘lack of adherence to standards’ as the overwhelming cause of all accidents.
- In section 3.3 it was demonstrated that MQA unit standard development concentrates on content and safety rules. They are few outcomes that relate to attitudes.
- Section 3.4 showed that the technical and safety content of training on mines has reached a high level of professionalism and that training methodologies and techniques are effective in transferring learning.

- Some international experiences were investigated in section 3.5 that showed that safety performance is directly related to supervisor and worker motivation and attitude.

The question these conclusions raise is how to improve adherence to standards in a situation where training content is not the issue.

Research relating to individual and organisational performance provides some insight into this question. Based on research conducted largely within the mining industry Dr S Kossuth has developed and validated a useful model of performance. The premise of the model is that organisational performance can only be achieved through individual performance. One therefore needs to identify and understand the factors that influence individual performance. This is what the performance model does.

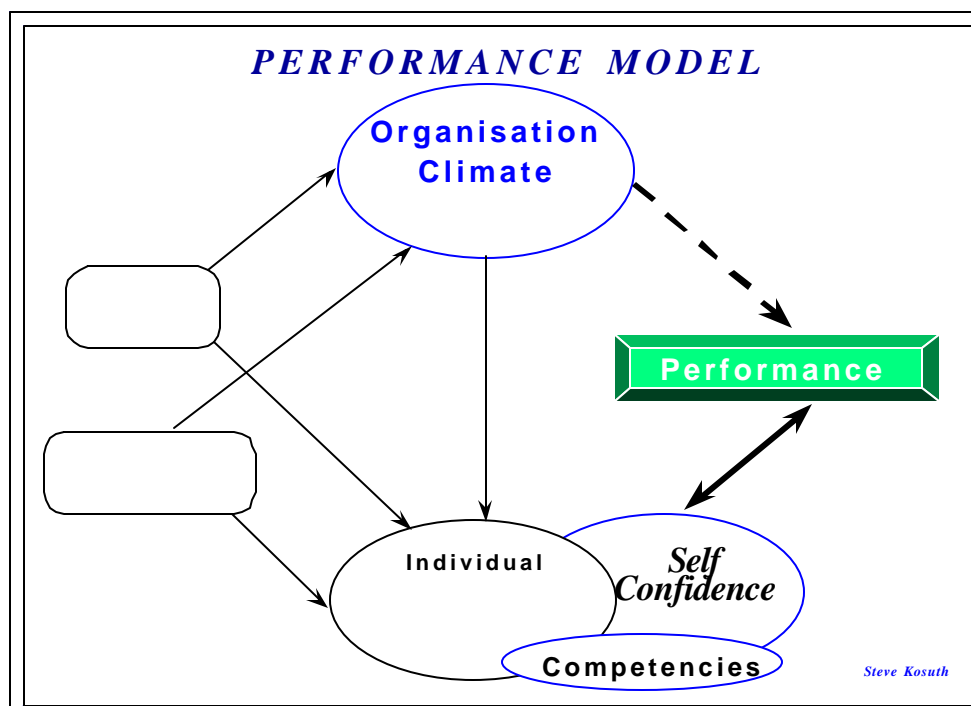


Figure 3.6 1 Kossuth's Performance Model

In essence the model identifies organisational climate and individual self confidence as the two drivers of performance. What is critical are the factors that determine self confidence. Competence is just one. The others relate to how an individual perceives himself/herself within the context of the organisation. They include issues such as:

- Individual worth, which is a measure of extent to which a person sees meaning in his/her job and can understand how what they do, contributes to the organisation.
- Whether the person is internally or externally motivated. Internally motivated people are confident and therefore perform better than those who rely on external instructions before they will act.
- An individual's hardiness or toughness. This is a measure of an individual's ability to remain positive despite a working in a negative environment. Tough or resilient people have a higher degree of self-confidence.

What is interesting in the performance model is how an individual's self confidence is influenced by organisational factors. Factors such as organisational climate, the style of supervision and management and team dynamics all impact directly on 'sense of meaning' and the resilience of staff.

Within the context of this project the performance issue that has been identified is a lack of adherence to standards. To change this performance it is necessary that both competence and confidence be addressed. Competence is relatively straightforward and has been addressed by professional training staff on the mines and formally by the MQA. Confidence is a much more complicated issue. The specifics of how confidence increases an individual's performance can only be determined after a thorough study of the complexities of dynamics within a particular organisation.

Other research that has a direct bearing on understanding performance is work done by Booyens (1999). Booyens maintains that because of cultural differences within the South African workforce diverse management structure, diverse styles and behaviours are emerging. Her research, for her DBL, shows that there are differences in the way that South African leaders of different races and genders perceive the importance of leadership practices and beliefs. These beliefs and practices are based on Hofstede's eight cultural dimensions, and have a significant impact the functioning of racial and gender sub-groups.

Table 13

Preferred Sub-Cultural Dimensions Of Managers
(importance ranking)

SUBCULTURE/ DIMENSION	WHITE MALE	WHITE FEMALE	BLACK MALE	BLACK FEMALE
Uncertainty Avoidance (need for structure and rules)	2	2	4	3
Assertiveness	4	7	6	6
Gender Egalitarianism (seeing genders as equal)	8	8	8	8
Future Orientation (planning vs spontaneity)	3	4	6	7
Power Distance (hierarchical, status-conscious)	5	3	5	5
Collectivism (teamwork, co-operation, interdependence)	6	6	1	2
Humane Orientation (fairness, respect, concern for people)	7	5	2	1
Performance Orientation (challenging assignments, recognition for high achievement)	1	1	3	4

This table indicates the following patterns:

- Most important
 - White males and white female managers: performance orientation
 - Black males: collectivism

- Black females: humane orientation.
- Second most important
 - White males and white females: uncertainty avoidance
 - Black males: humane orientation
 - Black females: collect visa
- Third most important
 - White males: future orientation
 - White females: power-distance
 - Black males: performance
 - Black females: uncertainty avoidance
- Other rankings
 - White males rate assertiveness as moderately important. The other groups rate it as unimportant.
 - It is interesting that only white males are future orientated. White females view the future as moderately important. The black male and female managers rate future orientation as unimportant.
 - The white male and female managers rate collectivism as unimportant. White females rate humane orientation as moderately important. This is a significant finding that points to the strong Eurocentric style of the Whites that is characterised by individualism and rationalism with little feeling for subordinates. The Blacks on the other hand exhibit the Afrocentric style preferring the group approach and taking into account the feelings of others.

The above suggests fundamental differences between black and white cultural values that are likely to influence behaviour.

From the above findings of her research, Booyens points out that the dominant management practices in South Africa are still white male dominated (Eurocentric). Characteristics of this style stress the importance of the individual, hierarchy, power/position status, efficiency and top down management. This is in contrast with the values of the black (Afrocentric) culture that is characterised by humanism, collectivism, teamwork and reciprocal moral obligations. Furthermore, the cultural constellation of female South Africans emphasises collaboration, participation, empathy, commitment and relationships.

Booyens indicates further that the international trends in organisational structure and strategy are shifting the paradigm from traditional hierarchical management models towards a more people-centred or inter-action approach and that the leadership style of the 21st century will focus on inclusiveness, participation, team management and transformational interaction and relationship-building leadership. In essence a new model of leadership should reflect the best from the values of the various sub-cultural groups (the best of Eurocentric and Afrocentric).

The Kossuth and Booyens research add several factors to the learning necessary for hazard identification. The Kossuth model places a significant responsibility on the immediate supervisor for building the self-confidence that leads to performance. It in effect shifts a significant portion of the learning from the individual who did not adhere to standards to the supervisor. The insight provided by Booyens takes this further. She suggests that 'cultural comfort', which leads to self confidence and hence performance, is highly dependant on the fit between the business culture of an organisation and its workers. This adds three additional occupational groups into the equation. These are the learning required by instructors, supervisors and the organisation as a whole.

3.7 Framework for Learning Outcomes

The arguments developed thus far in this report are summarised in the following diagram. It shows that performance, both safety and production, is a product of competence and confidence and that confidence is influenced by the complex interaction of organisational and cultural issues.

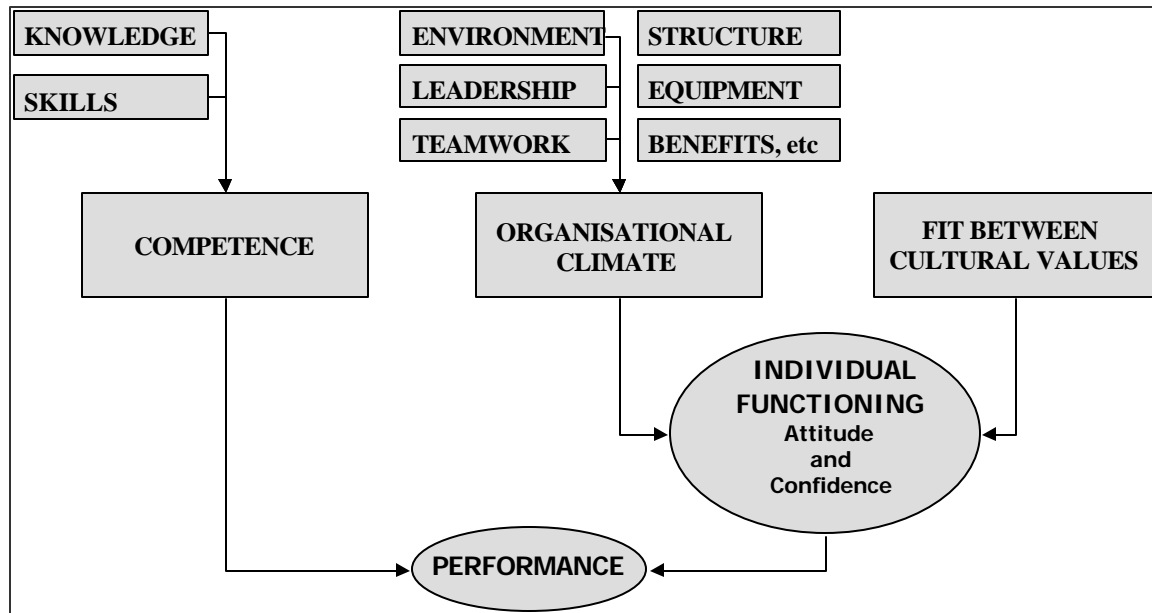


Figure 3.7 1: Interaction of factors that influence performance

The accident data indicated that a 'lack of adherence to standards' was the overwhelming cause of injury. The research into training systems confirmed that competence per se was not a significant contributing factor. The cause of accidents must therefore be sought in organisational and cultural issues.

Research conducted recently by the Sociology of Work Unit at the University of the Witwatersrand for the Deepmine project (Webster et al, Aug 2001) arrived at similar conclusions. Their research found that despite impressive programmes and skilled trainers, work place practices had not changed significantly. They identified several organisational issues such as shortages of materials, breakdown of machinery, and staffing levels as reasons why teams and individual workers were not performing optimally. The Kossuth model suggests that while these operational issues have a direct impact on the ability of workers to perform, they also undermine self-confidence and impact on the attitude that workers have towards their work. It is important that, at the supervisory and organisational levels, these operation issues are identified and addressed.

As a result the learning outcomes that are deemed to be significant are those associated with attitude and confidence. These are the ones that are identified in Table 14. It is important to note that the research took this route only because it found that specific technical and safety knowledge was already in place. Competence remains crucial and the learning associated with particular working environments and items of machinery is a prerequisite to the learning outcomes identified by this research.

The research results and discussions in the preceding sections enabled the research team to construct Table 14, which summarises the learning outcomes required for each occupational category identified in the research.

The three columns in the table relate to the most common reasons given for transportation accidents. As shown earlier in this report, by far the most significant issue is 'lack of adherence to standards'. It is given as the reason for the accident in more than 50% of the cases. Hence most of the learning is directed towards addressing it.

The table rows are divided into two groups of occupational categories. The first group is the four occupational categories that are prone to injury in transportation accidents. This is the primary group. Their learning is specific to their work environment and as such has a direct impact the reduction of accidents. The second group are those who have a significant influence on the first group. The learning they need to acquire is associated with ways in which they can influence the behaviour of the primary group. For example, the learning required by instructors on adherence to standards is not to do with how they can better adhere to standards but how they can influence the primary group to adhere to standards. This is an important distinction. The learning in table 14 is therefore all directly linked to hazard recognition and accident prevention. It is not directly associated with producing better instructors, supervisors or organisations.

Table 14

Outcome 2 - Learning Outcomes Associated with Underground Transport Hazards

	Adherence to standards	Knowledge	Practice under supervision
Loco Drivers and Guards	Improve adherence to standards relating to their own job.	Improve knowledge of their own job.	Create more opportunities to gain confidence under supervision.
Miners	Improving adherence to standards in workplaces other than their own.	Improve knowledge of the work environment of others.	Create more opportunities to gain confidence under supervision.
Winch Operators	Ways of improving adherence to standards relating to jobs that they do but for which they are not specifically trained.	Improve knowledge of work for which they are specifically trained.	Create more opportunities to gain confidence under supervision.
Shaft Foremen	Ways of improving adherence to standards for which they should be responsible.	Improve knowledge of work for which they are responsible.	Create more opportunities to gain confidence under supervision.
Instructors	Develop training methods that build confidence and produce a constructive attitude.	Improve their knowledge about training techniques.	
First line supervisors	Develop leadership styles that address worker attitude.	Understand the operational issue that impact on workers ability to perform. Understand issues of cultural diversity within the context of a work environment.	
Organisational learning	Develop organisational values that encourage commitment and participation and hence influence worker attitudes.	Identify organisational factors that impact on safety and performance. Build a 'business culture' that encompasses the diverse values of individuals.	

4. Learning and Communication Techniques

4.1 Review of previous literature on training techniques on South African mines

Earlier literature, on how to train miners, concentrated on hazard signs. The studies included sign identification and general safety training. They all indicate a need for perceptive skills. Weiten (1989), defined perception as "the selection, organisation and interpretation of sensory input". As indicated by this definition, most of this literature placed the responsibility for learning, and the consequent behaviour, solely on the learner. Specific attributes of workers were explored in detail and studies included investigations into the interpretation and identification of safety signs, the workers' perception of hazardous conditions and the role of psychology in safety. More detail is given on these topics in appendix 7. The consequence of this earlier research was an approach to safety training that relied heavily on behaviour modelling. This was manifest in safety training techniques that relied on repetition and the extensive use checklists. More recent research, as illustrated by the findings of Venter (GAP609b, 2000), emphasises a more comprehensive approach to the factors that influence learning.

All of this research has had a considerable impact on the approach to training and safety on mines. Behaviour modelling techniques are thoroughly embedded in much of the training on mines. Signage has been standardised in line with national and international conventions. And the content of training courses has been refined through the development of extensive checklists and the identification of comprehensive cues in all areas of underground production. In terms of the Kossuth model, these techniques address the knowledge and competence of workers. The Venter (2000) findings support the Kossuth model and Booyesen's research in suggesting that broader organisational issues are as important in determining the actual performance of workers.

4.2 Practice on South African mines

In section 3 of this report it was concluded that training systems on South African mines produce knowledgeable and competent workers. The purpose of this section is to briefly review that actual training techniques used by instructors. These are then compared to the findings from the literature survey and this comparison forms the basis of the final recommendations regarding learning and communication techniques.

Training sessions, observed by the research team, used a range of techniques to transfer learning. Some of these are discussed below.

4.2.1 Classroom theory

The purpose of these sessions was to transfer or refresh knowledge, particularly regarding mine and safety standards. Some sessions involved repetitive chanting where trainees were expected to repeat checklists and safety procedures. These concentrated on ensuring that trainees knew 'what' had to be done. The emerging trend, however, was theory sessions that involved more discussion and question and answer interchanges. There was more emphasis in these sessions on developing understanding through 'why' and 'how' questions as well as modelling behaviour through the 'what' questions. The shift from chanting to inclusive training seemed to be dependent on the prevailing methodology of the training centre and on the ability of the instructor. Knowledge levels were assessed by using questionnaires. These were administered verbally by instructors for non-literate workers.

In some situations classroom sessions were supported by videos but these were deemed to have only a limited use. They were useful in situations where specialist knowledge was required from experts or where specific visual pictures of a work environment could enhance a trainee's

understanding. They were best used in conjunction with an instructor who could provide the interaction with the trainees. Stand-alone videos have not proved to be effective in training mine workers.

4.2.2 Observation and practice

In all situations observation and then practice always followed theory. Trainees were given the opportunity to observe safe operating procedures and then to work through operational checklists themselves. Once these and all safety precautions had been completed they were given the opportunity to operate the equipment. Considerable peer learning occurred during these sessions. The assessment was practical and trainees had to demonstrate that they could perform all the safety checks and operate the machinery effectively and safely.

4.2.3 Workplace competency assessment

The final technique used was workplace assessment where production staff made the final judgement regarding the competence of all workers. A vital ingredient of this technique was the professionalism and thoroughness of those performing the assessment. A precursory 'observe and tick' approach to ensure that the trainee returns to production as soon as possible added no value to the process.

The above three techniques, i.e. classroom theory, observation and practice and workplace assessment, all address the development of competency. They have proved to be effective techniques.

Mines have also introduced techniques and programmes to address issues of commitment, business understanding, attitude and confidence. Some of these include:

4.2.4 Workplace team development and coaching

This is a technique used by some mines to help teams establish themselves in the workplace. A team of trainers / coaches work with the team until a high level of expertise has been developed and all aspects of the work environment are of a high standard. The coaching team then withdraws but knows that it has left behind a competent team. Future assessment of performance is made against these high standards. This technique is used mainly for stope teams. It has potential to be extended to other areas and even used on a one-on-one basis with occupations such as loco drivers.

4.2.5 Team building

The team building programmes encountered by the research team were all run as total separate interventions from the normal training given to workers. In many cases consultants ran them. Their methodology was to use adventure type games to create a sense of teamwork and co-operation between the team members.

4.2.6 Business awareness programmes

The purpose of business awareness programmes was to build commitment to the mine through creating an understanding of business principles. Most programmes were designed to show how attention to cost saving and better production would prolong the life of the mine and therefore ensure greater job security.

4.2.7 Classroom techniques – 'why' and 'how' as well as 'what'

It was clear from many observations sessions that the extent to which instructors were able to create understanding in the trainees was dependent on their classroom technique. There was

some evidence that this had been recognised and that instructor development was being viewed as an important component of effective training.

4.2.8 Industrial theatre

Most mines have used this technique. It appears to be an effective communication technique but has limited value as a training tool. It does not enhance the longer-term acquisition of knowledge and plays no role in the development of skills. On the other hand it has been effectively used for conveying changes in company policy, changes to condition of service and for awareness programmes regarding safety and aids. The downside of industrial theatre appears to be that it is viewed as entertainment and therefore does not produce a lasting impact.

Although several of these techniques have produced positive results, they were usually implemented in an ad hoc way and were always separated from technical training. As a result the impact on the actual workplace performance of workers has not been significant (Webster, 2001).

The conclusion of this research was that South African mines have developed successful techniques for behaviour modelling. These have resulted in knowledgeable and competent workers. However, questions of confidence and motivation, as reflected by issues such as contribution, a sense of meaning and cultural fit, were not usually catered for in the training techniques used by mines. It is techniques that address these aspects that will require attention in the future.

4.3 People development and training techniques associated with confidence, attitudes and leadership

There is a vast body of literature that addresses the question of leadership and how to build successful organisations. Most recent authors and academics have shifted the emphasis of successful leadership in organisations away from a 'management' style of planning, organising and control to a 'leadership' style that seeks to build confident and productive people. This trend is evident in the works of popular writers such as Tom Peters, John Kotter, Bernard Bass, Peter Senge, Stephen Covey and many others. Guy Charlton, a South African author, has expressed this trend as follows:

“The new competitive agenda has become clear. The old strategies and attitudes of changing the hard organisational ‘levers’ (structure, strategy, updated information technology) and emphasis on cost cutting have at best delivered short-term results.”

He goes on to say:

“One of the hardest tasks confronting an organisation is the conscious development of the human habits in a team, let alone an entire organisation.”

Within the terms of reference of this research there are two questions. Firstly, what tools and techniques are there that can influence a worker's confidence and hence his / her attitude to safety standards. And secondly, what role must the organisation play to create the environment where the learning associated with these techniques can be effectively implemented in the workplace.

There are no 'quick fix' answers to these questions but the authors mentioned above provide some insight into kind of organisational culture that is conducive to developing confident workers. Some of the key principles are summarised below:

4.3.1 Transformational leadership

Kotter (1996) draw clear distinctions between transactional leadership and transformational leadership. He equates transformational leadership to qualities such as developing vision, effective communication and empowering individuals. Webster's finding that transformational type training did not transfer into the workplace implies that leadership on mines is still rooted in the transactional model. Kotter acknowledged that transactional leadership is required but should be exercised alongside transformational leadership. A deliberate shift, at all levels, to a transformational leadership style is one technique / programme that will improve self-confidence levels.

4.3.2 Mentoring and coaching

A second technique is the introduction of mentoring and coaching at all levels. Jack Welch, CEO of General Electric, believed this was his primary role as a CEO. If it is viewed as an intervention aimed at developing staff and not as a mechanistic exercise, then it has the potential to become a powerful tool in the long-term sustainability of an organisation.

4.3.3 Continual learning

Senge emphasised the need for individuals and organisations to be continually learning. He stressed learning directed towards self-mastery and organisational 'interconnectedness' as well as technical and product knowledge. He saw the development of 'learning organisations' as the only sustainable competitive advantage that an organisation could have.

4.3.4 Individual habits of success

Covey stressed the need for individuals to develop habits of success. He identified his well known seven habits that lead to confident and successful people. These are:

- Be proactive
- Begin with the end in mind
- Put first things first
- Think win / win
- Seek first to understand, then be understood
- Synergise
- Sharpen the saw, i.e. revitalise and reinvent oneself

A key component of his argument was that production must be balanced with production capacity. Developing the seven habits in a workforce builds production capacity and thus builds sustainability.

4.3.5 Human habits of organisations

Charlton's thesis is centred more on organisational human habits than on the individual. He provides insight into the learning that organisations require to develop a productive workforce and thereby ensure their sustainability. His key components are:

- Leadership
- The diversity habit
- The habit of sustained change
- Sustained performance
- A strategic human resources perspective that unifies the human habits

This brief review of some of the approaches to building successful organisation through developing confident people indicates that there are no magic solutions. In fact none of these ideas are new. They have all been around in one form or another for years. It is valuable to revisit them in terms of this research because they address issues that influence attitudes to safety.

4.4 Recommended learning techniques associated with hazard recognition

It became clear to the research team at an early stage in the project that it was unlikely that the final deliverable, i.e. the identification of learning and communication techniques, would provide a simple checklist of how best to reduce accidents through improved learning. Past literature, data analysis and the observation of training all pointed to issues of attitude rather than knowledge and skills. The work of Kossuth, Booyens and Webster indicated that to address this issue involves understanding a complex interaction of organisational and individual factors. It is imperative that the interaction between these factors be measured. This will ensure that the correct factors impacting on attitude and thus safety and production performance will be identified by well-researched measurement techniques. An ad hoc or generic approach is unlikely to produce a sustainable change in attitudes and behaviour.

The table below is thus not the 'final solution' but rather an indication of how some of complexities could be approached. It must also be remembered that these learning techniques are directly solely at hazard recognition and accident reduction with regard to lateral rail bound transportation. For example, winch drivers must also learn to operate winches and the safety aspects associated there with but these considerations are not specifically mentioned in the table.

Table 15

Outcome 3 - Recommended Learning and Communication Techniques

Occupation Group	Key learning areas	Learning and Communication Techniques
Loco Drivers and Guards	Adherence to standards	<ul style="list-style-type: none"> • Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. • Design integrated programmes to address these specific issues. These programmes could include: <ul style="list-style-type: none"> - Activity based team building - Business understanding. - Ongoing life skills learning (individual habits)
	Knowledge of their own work environment.	<ul style="list-style-type: none"> • Interactive classroom sessions with an emphasis on 'why' and 'how'. • Repetitive practice and observation. • Professional workplace assessment.
	Practice under supervision.	<ul style="list-style-type: none"> • Workplace training and coaching.
Drillers, Miners and Stope Workers	Adherence to standards	<ul style="list-style-type: none"> • Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. • Design integrated programmes to address these specific issues. These programmes could include: <ul style="list-style-type: none"> - Activity based team building - Business understanding - Ongoing life skills learning (individual habits) - Create an understanding of workplaces other than their own.
	Knowledge of workplaces other than their own.	<ul style="list-style-type: none"> • Broad based awareness classroom sessions with an emphasis on 'why'. Use of case studies that encourage interaction and discussion. • Extensive observation of transportation procedures and safety practices. • Professional workplace assessment, relating to transportation procedures and safety standards.
	Practice under supervision.	<ul style="list-style-type: none"> • Observation of workplace behaviour in all environments with which the worker interacts. (Role of Safety Officers and Shift Leaders.)
Winch Operators	Adherence to standards	<ul style="list-style-type: none"> • Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. • Design integrated programmes to address these specific issues. These programmes could include: <ul style="list-style-type: none"> - Activity based team building - Business understanding - Ongoing life skills learning (individual habits) - Create an understanding of workplaces other than their own.

Occupation Group	Key learning areas	Learning and Communication Techniques
	Knowledge	<ul style="list-style-type: none"> • Specific classroom sessions on high priority transportation activities such as rerailing and coupling, i.e. selective multi skilling. (Winch operators seem to perform these activities even though they are not supposed to. Perhaps it is better to accept this reality and train for it than to try and enforce standards that forbid it.) • Practice of these selected activities. • Workplace assessment of these activities. • Broad based awareness classroom sessions with an emphasis on 'why'. Use of case studies that encourage interaction and discussion. • Extensive observation of transportation procedures and safety practices. • Professional workplace assessment, relating to transportation procedures and safety standards.
	Practice under supervision.	<ul style="list-style-type: none"> • Workplace training and coaching on the selected activities. • Observation of workplace behaviour in all environments with which the worker interacts. (Role of Safety Officers and Shift Leaders.)
Shaft Formen	Adherence to standards	<ul style="list-style-type: none"> • Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. • Design integrated programmes to address these specific issues. These programmes could include: <ul style="list-style-type: none"> - Activity based team building. - Business understanding. - On going life skills learning (individual habits) - Cultural diversity and an appropriate 'business culture' - Principles of supervision, including styles of leadership and types of role models.
	Knowledge	<ul style="list-style-type: none"> • Broad based awareness classroom sessions with an emphasis on 'why'. Use of case studies that encourage interaction and discussion. • Extensive observation of transportation procedures and safety practices. • Professional workplace assessment, relating to transportation procedures and safety standards. (Supervisory levels should not be exempt from this.)
	Practice under supervision.	<ul style="list-style-type: none"> • Formal mentoring and coaching with regard to the role of supervisory.

Occupation Group	Key learning areas	Learning and Communication Techniques
Instructors	Adherence to standards – how to develop attitudes that will achieve this.	<ul style="list-style-type: none"> • Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. • Design integrated training approaches to address these specific issues. These programmes could include: <ul style="list-style-type: none"> - Classroom techniques. - Use of case studies. - Ways of increasing participation. - Assessment techniques. - Integration of technical and development training.
	Knowledge of training techniques	<ul style="list-style-type: none"> • Formal ‘train the trainer’ sessions including approaches to theoretical teaching and practical instruction. • Peer observation and team teaching. • Professional workplace assessment, including trainee assessment of performance as instructors.
	Practice under supervision.	<ul style="list-style-type: none"> • Formal mentoring and coaching.
Front-line supervisors	Adherence to standards	<ul style="list-style-type: none"> • Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. • Design integrated programmes to address these specific issues. These programmes could include: <ul style="list-style-type: none"> - Activity based team building. - Business understanding. - Cultural diversity and an appropriate ‘business culture’
	Knowledge	<p>Knowledge of the transportation environment</p> <ul style="list-style-type: none"> • Broad based awareness classroom sessions with an emphasis on ‘why’. Use of case studies that encourage interaction and discussion. • Extensive observation of transportation procedures and safety practices. • Professional workplace assessment, relating to transportation procedures and safety standards. (Supervisory levels should not be exempt from this.) <p>Knowledge of supervision</p> <ul style="list-style-type: none"> • Principles of supervision, including styles of leadership and types of role models. • Transformational leadership.
	Practice under supervision.	<ul style="list-style-type: none"> • Formal mentoring and coaching.

Occupation Group	Key learning areas	Learning and Communication Techniques
Organisational learning	Adherence to standards	<ul style="list-style-type: none"> • Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. • Design integrated programmes to these specific issues. These programmes could include: <ul style="list-style-type: none"> - Developing a business culture (organisational habits) - Addressing environmental issues - Addressing workplace frustrations (materials and equipment) - Review organisational structures (levels of authority, team vs individual responsibilities and rewards, staffing levels, etc.) - Review of HR policies - Benefits and rewards structure - Employee assistance programmes - Training and education programmes - Community development - Housing and social activities <p>Where the purpose of all of these programmes is to improve the worker's attitude and thereby impact on safety and production performance. It is not in terms of social responsibility or shareholder perceptions.</p>
	Knowledge	<ul style="list-style-type: none"> • The organisation can only improve its knowledge of human dynamics and interaction through measurement. Tools and methodologies need to be developed for this.

5. Final Conclusions

This research report set out to establish the learning associated with hazard recognition in the transportation arena in Gold and Platinum mines. This has been attained and the findings are set out in tables 4, 14 and 15. However, tabulating the findings runs the risks of over simplifying what the researchers found to be very complex issues. Hazard recognition and safety awareness will not be adequately addressed by following a tabulated list of recommendations. The reasons for this arose from the following sequential findings of this report.

1. SAMRASS accident showed that the chief cause of accidents was 'a lack of adherence to standards'.
2. An analysis of actual training practice showed that a lack of competency, i.e. knowledge and skills, was not a major contributing factor.
3. Organisational factors have made multi-skilling an informal reality underground and workers need to be trained accordingly. Current job specific training has led to gaps in their safety knowledge.
4. Various research models, i.e. Kossuth and Booyens, indicated that organisational issues and a lack of confidence were major contributors to individual performance.
5. These models point to the need to measure and understand the complex interaction of organisational and individual issues prior to designing learning programmes that will successfully address these non technical aspects of adherence to safety standards.

These findings indicate the need for further research that will identify and develop comprehensive tools and techniques for measuring organisational and individual factors that impact on performance. Statistical methods need to be introduced that will correlate these factors with safety, environmental, staffing, production and performance measures. A well packaged set of tools of this nature will enable South African mines to identify and then address the underlying issues in each operational area that are hindering safety and production. Intervention programmes will then be targeted at the correct issues and not implemented in an ad hoc fashion. Research of this nature would be a relatively long-term project. It would require input from organisational development experts and industrial psychologists, from sociologists, from statisticians and IT experts, from trainers, and from mining and engineering staff. Its end product should be a highly practical tool that could be used by current human resources staff on the mines, without the need for extensive assistance from external consultants. A final recommendation of this report is that SIMRAC seriously consider embarking on a project of this nature.

Appendices

Appendix 1: List of relevant literature

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Appendix 2: List of Organisations who were Interviewed

1. The Mining Qualifications Authority (MAQ): represented by Mr Mzandile Nombewu at the Braamfontein offices.
2. The National Union of Mining Workers (NUM): represented by Mr Frans Baleni at the Yeoville training centre.
3. The Department of Mineral and Energy.
4. Harmony: Cooke 3 training centre.
5. Goldfields: Kloof training centre.
6. Anglo Platinum: Rustenburg training centre.
7. The University of the Witwatersrand Sociology of Work Unit (SWOP): represented by Mr Paul Steward.

Appendix 3: Research Questionnaire

This appendix contains a sample of the data and questionnaire that was used to guide mine visits. This sample is for the occupational group 'Loco Drivers and Guards. Similar data sheets were constructed for 'Miners', 'Winch Operators' and 'Shaft Foremen'.

Occupation Group: Loco Drivers and Guards (2175 of 7797 – 28%)				
Activities when injured	Reasons for accident			
Coupling / uncoupling 21%	Inadequate adherence to standards - 49%	Available not used – 21%	Lack of knowledge – 14%	Poor co-ordination – 4%
Rerailing 13%	Inadequate adherence to standards – 47%	Inadequate systems – 21%	Lack of knowledge – 13%	Available not used – 6%
Tramming 9%	Inadequate adherence to standards – 50%	Poor co-ordination – 10%	Lack of knowledge – 8%	Not registered at planned maintenance – 7%
Driving 7%	Inadequate adherence to standards – 49%	Lack of knowledge – 11%	Available not used – 11%	Poor co-ordination – 8%
Sitting/standing/waiting 6%	Inadequate adherence to standards – 55%	Lack of knowledge – 11%	Poor co-ordination – 11%	Available not used – 8%
Riding 5%	Inadequate adherence to standards – 57%	Inadequate systems – 8%	Lack practice under supervision – 7%	Lack of knowledge – 7%
Walking 5%	Inadequate adherence to standards – 58%	Poor co-ordination – 12%	Lack of knowledge – 10%	Wrong equipment – 4%
Shunting 2%				

Education level of trainees		Location of training	
Language used for training		Numbers trained per annum	
Duration of initial training		Duration of refresher training	

Focus on the specific activities and caused when obtaining answers to the following questions. In the case of Loco drivers and guards the main focus needs to be on learning associated with the application of standards to the technical operation of the equipment they utilise. A secondary focus is their awareness of hazards in the broader context of their working environment.

Entry level criteria – (physical, medical, educational, psychological)	
Technical training: Key competencies related to the activities above.	
Safety training: Key competencies	
Training methods used	
Incentives (positive / negative)	
Safety training related to transportation	
Incentives (positive / negative)	
Monitoring of adherence to transportation standards	

Appendix 4: SAMRASS data shortcomings for behavioural research and recommendations

The initial findings of this research report were directly influenced and guided by an analysis of the data extracted from the SAMRASS database. The research felt that whilst the format of this data might be suitable for technical analysis it has some distinct shortcomings in terms of behavioural research. This special appendix identifies some of these short-comings of the SAMRASS database.

- **Duplicate codes especially in the 'activities' codes**
- There are several duplicate codes used for 'activities'. For example, 'sitting/standing/waiting' appears in various permutations. These had to be eliminated before any analysis could be done. There were other examples where the data had to be cleaned to reduce the occurrence of odd results. It appears as if most data entry in the SAMRASS system is driven by codes so that capture errors are kept to a minimum but it might be necessary to enforce this approach with all fields except those of a descriptive nature.
- **There is no indication of who was responsible**
This is especially a problem where the cause was 'non adherence to standards' and the activity was 'Standing/sitting/waiting'. The implication is that a third party might well have been responsible since the activity of the injured party was a passive one. The data needs to provide an indication as to who did not adhere to standards.
- **Research into behavioural causes of accidents is not possible**
The existing data provides no insight into the circumstances of the accident from a behavioural perspective. A researcher can only infer what the situation might have been.

Appendix 5: Details of the visit to mine training centres

A specific set of questions was designed to guide the mine visits. They provided much of the background information on how training was conducted. The more important conclusions were drawn from the actual observation of training and a review of training material at each site. These observations and reviews were directed by the findings from the SAMRASS data analysis as indicated in appendix 3. Lengthy informal discussions with training managers also proved to a valuable source of information.

The more formal responses from each training centre are contained in this appendix.

Typical Questions asked

- Location of training?
- What is the general program?
- Is your safety teaching program specific to the type of work?
- What is the education level of the trainees? Is there a screening process?
- Number trained?
- What language is used?
- What is the duration of training (daily, and till course is complete)?
- Is it mainly practical or theory?
- Do you provide refresher training? What is the program?
- Are the trainees taught the standards?
- With regard to feedback on the training, how is that accessed i.t.o. improving future training methods?
- With regard to safety training what are the areas of concern?

Visit to the training centre at Rustenburg Platinum Mine training Centre (Anglo platinum) ... *Surface*

1. Location of training?

Currently the training centre is part on the surface and part underground (only one meter under). This depended on the type of training. There are surface lecture rooms where theory is taught. The practical side of the training centre was structured such that the rocks used by the winch drivers to practice driving the winch is brought to the surface, then loaded by the loader drivers into the loco and are circulated back to the haulage area.

There are developments aimed at structuring an underground training centre with all the facilities that the surface centre has.

2. What is the general program?

Trainees are given an induction course that would cover general aspects of mining for example the importance of safety, signs, rules and regulations. The trainees are then separated into job specific groups. They are then given job specific lectures that are supplemented by practical training. Vocal repetition of rules and regulations are also used but it was shown that during practical training these rules are revised with an emphasis on practical implementation of the rules.

3. Is your safety teaching program specific to the type of work?

The induction course only covers general signs. The trainees are taught job specific safety issues. They are not made aware of warning signals outside of their job for example whistles which are used by winch drivers to indicate that the passageway must be cleared because the winch motor is about to be turned on.

4. What is the education level of the trainees? Is there a screening process?

The trainees are screened according to the type of job that they are employed for. The trend of late is to employ literate people. All trainees are tested for their hand, foot and eye coordination as well as their trainability. All the people interviewed for a loco-driver job would have to first pass this test before being accepted.

5. Number trained?

It was estimated that between 21 000 and 24 000 people were trained at the training centre this year.

6. What language is used?

The instructors are currently being sent on courses to become multilingual (fanakalo and English). The aim apparently is to move towards English. At present instruction is given in fanakalo or English or Afrikaans or a mixture of Sotho and Zulu, depending on the trainees.

7. What is the duration of training (daily, and till course is complete)?

None of the trainees are permitted to leave the training centre until the senior supervisors has approved the competency of the trainee. Following approval from the senior supervisors, the trainees have to undergo a test on site before being placed in the workflow.

8. Is it mainly practical or theory?

Both practical and theoretical training is provided. It has been shown that theoretical training is supplemented with a practical demonstration of the application of the theory.

9. Do you provide refresher training? What is the program?

Refresher training is provided to staff that go on leave.

10. Are the trainees taught the standards?

Yes they are, in a verbal repetitive way.

11. With regard to feedback on the training, how is that accessed i.t.o. improving future training methods?

At the end of the training program, trainees are given assessment forms to complete that allow them to comment on the program. These forms are assessed and the problems are considered and changes are made. Another trigger for the reviewing of the training methods is when an accident occurs at the mine. An investigation is initiated which looks at the training history of the mineworker.

12. Other

The co-ordinator of the human resource division, who is responsible for the risk management has a vision to improve the current system, which entails instructing trainees (in all facets of mining) in other fields such as finance to encourage learning and to develop individuals.

There are apparently incentive schemes in place to encourage safe mining practices.

Comments

The interaction between trainee and instructor seems less inclined toward the "show and tell" approach but concentrates more on the "show, do and explain why" which is said to be the better technique according to the literature survey.

The move toward English based instruction is slowly becoming a reality but the instructors at this training centre were more positive about the change than at Harmony.

From this it would seem that the difficulty in changing the type of training method is dependent on the trainer rather than the actual task of change.

12/09/2001 – Visit to the training centre at Harmony Gold (Randfontein) ...*underground* centre

Two visits were conducted at Harmony's Cooke 3 shaft. The first involved a visit to the underground training centre to observe training taking place. Unfortunately the linguist on the research was unable to go underground for health reasons and so a second visit was arranged in order that he could meet trainees on surface.

Report back on underground visit under the guidance of the training manager and trainers

1. Location of training?

Induction courses are conducted on surface while practical as well as job-specific training is given to the students underground.

2. What is the general program?

Surface training - Induction:

The teaching aids for the courses include watching video as well as instructor training where the trainees are required to recite rules. The program includes general safety-sign board recognition training. It was claimed that the trainees were given reasons explaining why the signs were necessary.

Underground training:

All the rules are taught to the trainees by getting them to recite the rules and then are expected to repeat them with vigour back to the instructor when the instructor requests that rule. It was observed that during the more practical training of locomotive drivers, the trainees together conduct the locomotive inspection procedure after which they are required to recite a rule and then are required to answer specific questions related to safety procedures. Apparently, in the event the incorrect answer is given, the trainee would be corrected immediately.

3. Is your safety teaching program specific to the type of work?

The induction training on safety signs is general. Underground training however is more specific to the job type. All the trainees that are learning about winch driving would be separated from those learning loco driving to learn more job specific work.

4. What is the education level of the trainees? Is there a screening process?

The trainees are selected generally according to previous work performance. Rarely are new recruits externally employed. There is a type of hierarchy system where all the employees of a mine would have to start off as a miner and then move up the ranks to a locomotive driver. However, before being sent to do a new type of job, a person is sent on training.

New recruits are usually given jobs if they are recommended by current mine workers.

5. What language is used?

The language used is fanakalo. The reason for use given was the employees are from all over Africa, with no common language and it is felt that English would take too long to teach.

6. What is the duration of training (daily, and till course is complete)?

The duration of a daily lesson is usually from 8h30 to 13h30 with an hour lunch underground. Lunch is not provided but will have to be brought by trainees. The duration of the course is about three days, however, no person is allowed to stop training until the instructor feels that the person is ready.

7. Is it mainly practical or theory?

There is both practical and theoretical training. Practical training consists of “show and tell” lessons, as well as driving on the locomotive. With practical driving training, the trainees would have to ensure that the locomotive is stopped before a marker, they would be made aware of signs and that they should look out for signs. Theoretical training consists of a mixture of vocal repetition of rules and regulations as well as lecturing.

8. Do you provide refresher training? What is the program?

Refresher training is provided. Whenever an employee is away from his job for a few weeks, he/she has to complete a multiple-choice test. Based on that test, the trainers can identify which aspects require refresher training. The trainee would then have to attend those courses.

9. Are the trainees taught the standards?

The trainees are apparently taught the standards for symbols, and if they have questions on ‘why things are the way they are’ these questions are answered as well.

10. With regard to feedback on the training, how is that accessed i.t.o. improving future training methods?

There are two ways in which the training centre obtains feedback. The first way is via random mine inspections, where the trainers visit the mines to ensure that the training that was taught is being implemented. The second way is when there are complaints about trainees that have not been performing well. If any irregularities are found, then there is an investigation to find out the reason for the lack of performance. Every so often (a time frame is not allocated), the training techniques are reviewed to ensure that training is effective.

11. Other

- *To encourage the staff to adhere to rules* (for both supervisors and miners) if rules are not being applied, the trainee will have this put on their record. At the moment the mine is using a soccer system where the employees get yellow cards for bad work. After two yellow cards, the next warning is a red card. A blue card represents awards for good work done. Thus, training is enforced by providing consequences to incorrect actions.
- *The symbols they are taught to recognise* are varied. They are taught to identify the SABS-standard warning signs, as well as observation techniques. Along the walls of their underground training centre are posters that use words to convey messages rather than pictures. The instructor ensures that those are just used to make the drivers aware of posters that may be on the walls. However, it was noticed that such posters were also stuck

on the walls in the classrooms even though an instructor mentioned that such posters were not affective since many trainees were illiterate.

- *The learning environment* is appropriate for practical training because it is located underground which is the environment in which the trainees will eventually work in. However, it was noticed that the classrooms were located in an environment where the ventilation is poor.

Comments

The trainers have a mind set that the only way to teach the trainees the rules is to make them repeat the rules out loud, and then get them to apply the rules via “show and tell” sessions. Whether the trainees truly understand what it is they are being taught or whether they are understanding what they are taught has to be further investigated.

The classroom learning environment was found to have bad ventilation. There is a possibility that this could hinder learning. This should also be investigated.

The actual method of training the trainees to read SABS signs/symbols has not been observed. Whether the training is a “repeat after me” training or a training for understanding of why signs are different colours or a mixture of both, as was the case for “on the job” training, needs to be investigated.

19/10/2001 – Visit to the training centre at Harmony Gold (Randfontein) ... Surface

The video on “Safety”

On the previous visit to Harmony’s training centre, the supervisors mentioned that during the induction courses a safety video is shown to the trainees. On request, this video was shown to us. It entailed a play, which was performed by the “Blue Moon” company, which was filmed with an audience.

The play centres around three characters who are mineworkers within a team. The play progresses from discussions between the three from when they are in the change room, down the shaft, in the man-carriage and at the stope. To emphasise the importance of safety one of the characters is portrayed as seeing safety as secondary to his bonus so production was primary. Eventually this character recognises the importance of safety and is rewarded for his safety awareness.

In terms of its relevance, it appeared to be pitched at a level that the trainees would understand and could relate to especially since the events in the play were realistic. At the end of the video, the important messages that the play was trying to put forward were re-looked at and would be discussed in workshops. This appears to be well structured. A concern maybe that the safety topic was general. The example used in the play was concerned with securing the hanging wall. The dangers with regard to locomotives (e.g. coupling, getting run over) were not addressed. The play touched on the fears of passengers when there is reckless locomotive driving.

The video was viewed before the interview with the miners that gave some starting point in terms of questions that were asked.

Questions Asked

- Tell me about the relevance of the training to your job
- What were some of the most important things you learnt?

- Explain to me why these are important
- Do you have problems applying what you learn in training when you are back at work?
- Tell me about the way in which you were trained:
- How do you feel about the way in which you are trained?
- Are you given the opportunity to ask questions?
- Can you contribute towards the training content?
- What changes do you think could be made to the way in which you are trained?
- What changes should be made to the content of what you are taught?

Responses to the questions

1. Tell me about the relevance of the training to your job
 - ® Yes.
2. What were some of the most important things you learnt?
 - Identifying hazards, think safety, take action i.e. reporting hazards to safety representatives, everyone is made aware of hazards, team work was important in the working environment.
3. Explain the importance of identifying hazards.
 - Cost effective, family implications (how it would affect the family, loss of “bread winner”), effect on work place e.g. loss of production.
4. Importance of team work.
 - maximises achievement (only in the team can you get the maximum reward).
 - Support structure for personal problems
 - Helps develop the sense of responsibility
 - Formulates discipline (e.g. if one doesn't perform the team will ensure discipline)
5. How do you deal with introverts
 - The team encourages the person to talk (either as a team as a whole or individuals).
6. Tell me about the way in which you were trained:
 - lectures, videos, industrial theatre
 - (see comments)
7. How do you feel about the way in which you are trained?
 - Acceptable
9. How do you deal with people from different levels
 - The novices are usually placed with instructors that can speak their language, this was said by trainees that have been at the mine for a number of years already.
 - The group interviewed were already well educated and therefore didn't require a special type of trainer. They could comfortably learn from a white trainer.
10. Are you given the opportunity to ask questions?
 - The impression was that they did not feel the need to ask questions or felt that what was taught was fact that had to be accepted. (This impression was obtained through talking to the trainees for a long period of time)

11. Can you contribute towards the training content?
- The trainees felt that they don't contribute all
 - They didn't want to verbalise anything because of fear of victimisation
 - They would not speak of their feelings in front of trainers they would prefer questionnaires (it should be remembered however that these people were literate).
12. Do you have problems applying what you learn in training when you are back at work? Why are there still accidents if the training is sufficient?
- Negligence. They know it should be done but it is ignored.
 - Low retention level. They feel that should remind each other in the team rather than waiting for retraining after they come back from leave.
 - The attitude of the team leaders and members. If the leaders didn't have the right attitude, the members tended to behave the same.
13. What changes do you think could be made to the way in which you are trained?
- No, the content of the training was sufficient.
14. What changes should be made to the content of what you are taught?
- None
15. Other
- Team leaders should be willing to accommodate other's advice or ideas
 - i. Team leaders did not always listen to team members. This may be attributed to race, e.g. if the person was black, some members of the team tended to take advantage of the leader.

Comments

In general, the trainees interviewed were literate, they had already gone through a few levels of training and it was difficult to determine whether they would retain any information that was taught to them via repetition. A measure of whether repetitive teaching works would be to speak to novices and/or intermediate trainees because they cannot read and have to rely on oral teaching. Another problem was that the environment in which the interview took place may have influenced the responses obtained. The ideal situation would be to sit through a lecture and observe the true interaction between the trainees and trainers and perhaps have lunch with them to create the environment that would encourage the trainees to speak more freely.

14/11/2001 – Visit to Kloof Goldmine, surface training centre ...*Surface*

Description of the centre

The training centre consists of a number of classrooms on surface as well as mock-ups for simulation of underground activities like loading, loco driving, winch driving. Similarly to Rustenburg platinum training centre, the processes are circular with winch operators scrapping material down the ore pass, which is loaded into hoppers and transported out by the loco drivers. The training centre also has a climate-tolerance testing facility, where miners are placed in humid conditions and are expected to climb up and down a step for half an hour. If the person's temperature is found to be over 36.6°C then they are considered in tolerant and tested after 3 days.

Types of training offered

The training centre offers training of recruits, refresher training as well as awareness training, teambuilding training, safety officer training.

The new recruits, particularly for locomotive driving have to comply to certain criteria, for example, they have to pass an induction pre-test, a coordination test and a medical examination. The difference between the refresher training and the recruits training is not only the fact that new recruits will cover more, but the length of time of the training.

The awareness testing is for all types of miners to make them aware of the safety methods of the other mine-job types so that if they see unsafe practice taking place, they will be able to identify this and make the appropriate mine personal aware of the problem. This seems to be done with a lecture-type system first in a classroom where the appropriate safety equipment and signals are shown to the audience, followed by a practical show and tell session at the training centre's locomotive. However, a demonstration is not given for rerailing of the trains because of time restraints. We were informed that during this awareness session, the students are instructed that they are not to participate in such dangerous acts but should rather advise the appropriate persons.

Teams from the mines are sent to the training centre to accomplish tasks that are designed to make the team realise aspects of production and the benefits of team work. However, team leaders are not trained on how to get team participation or how to lead the team.

Safety officer training is conducted externally if required. However it was mentioned that training of these officers is very rare since the officers are usually chosen by the team and is usually someone who knows their work.

Training methods

The training method used at the centre is more of a lecture-type of training where it is up to the trainer to get participation from the trainees. In the case of the awareness training, the instructor at the time lectured the audience without getting much audience participation. However, when sitting through a lecture regarding loco driving, the instructor encouraged audience participation and kept the audience interested in the topic of his lecture.

According to the training coordinators none of their training is conducted using the repeatative teaching method. This style was said to have stopped in the 1990s as this style was considered demoralising.

There are two groups being trained, they are split into the English group and the Inguni group. The Inguni group seems to speak fanakalo. The reason for this division is unclear however it appears that the English group is in fact the literate group while the Inguni group are the illiterate ones.

When asked about their opinion on industrial theatre the coordinators considered it a tool used to convey messages that are would be stored in ones short term memory. This mode of teaching was considered inappropriate for long term memory.

Generally the content of the training programs appear thorough in the coverage of all the safety procedures and rules. In terms of practical training, this process was not observed. There is no underground training centres, there is however underground simulation models built on surface. The only aspect of the model that is similar to underground situations are the tracks and the process of transporting loads. When asked for a comment on use of an underground training centre, the response was that underground conditions were not conducive to lecturing, especially in terms of the environment and was not favoured.

Evaluation system

After the training, the trainees are given tests either written for the literate group or orally for the illiterate group. All have to achieve 100% before being allowed to leave the training centre. On leaving the centre, the trainee's supervisors have to evaluate the performance of the trainee. The time period for a response from the supervisor is 1 month. If the training centre does not get an evaluation form back from the supervisor after 1 month then the trainee is immediately pulled out of production and sent back to the training centre.

In some worker groups, the workers are allowed to give their opinions on the content of the training. These groups have well established forums for this kind of communication.

Outside the training centre, the workers are evaluated on a point system where a certain number of points symbolises a reward.

At the training centre, the instructor is evaluated by their supervisors and by the trainees.

General Comments

The coordinators are presently passionate about having the "buy in" of all concerned (trainers, trainees and unions) when it comes to implementing new training methods in order to ensure the success of the training.

The coordinators had a strong sense that the fault of accidents is due to human error possibly caused by bad habits. However, the truth may be determined by interviewing miners in the production environment.

It was noticed that throughout the mine training centre visits that there was an aspect of training that would not be considered by coordinators because they felt "it wouldn't work". However, evidence of that concept is working at training centres at other mines. It seems very much the state of mind of the co-ordinators that determines whether a concept will work or not.

It should be kept in mind that the co-ordinators that were interviewed were not in the high management team. This may influence any ideas or hopes they have on any improvements to the centre.

Appendix 6: Extract of MQA Qualification



SGB for the Mining and Minerals Sector

NATIONAL CERTIFICATE

ENGINEERING MAINTAINING AND REPAIRING

**UNDERGROUND HARD ROCK
(METALLIFEROUS)**

LEVEL

2

TOTAL CREDITS

Specialisation Area 1: Stopping and Developing

160

Specialisation Area 2: Horizontal Transport

149

Specialisation Area 3: Horizontal Transport Services

179

PRACTICING PERSON FOOTPRINT

Practicing person with qualification registered on the NQF

Yes

Mandatory licensing

No

Discretionary licensing

No

Currency of competency

No

Date **6 November 2001**

Version **0**

Qualification Description

1. National Certificate in Engineering Maintenance and Repairing for Underground Hard Rock (Metalliferous) ~ Level 2

There are 3 specialisation areas for this qualification:

- Engineering Maintenance and Repairing Underground Hardrock – Stoping and Developing
- Engineering Maintenance and Repairing Underground Hardrock – Horizontal Transport
- Engineering Maintenance and Repairing Underground Hardrock – Horizontal Transport Services



2.

3. **Registration Number:**

4. **Total Credit Value:**

Specialisation area 1 – Stoping and Developing : 160 credits

Specialisation area 2 – Horizontal Transport : 149 credits

Specialisation area 3 – Horizontal Transport Services : 179 credits

5. **Field:** Manufacturing Engineering and Technology

Sub Field: Fabrication and Extraction

6. **Issue Date:**

7. **Review Date:**

Summary of credit composition

Specialisation area 2:

Engineering Maintenance and Repairing for Underground Hard Rock - Horizontal Transport

(These figures do not include those for “generic to the workplace or society in general”).

LEVEL	FUNDAMENTAL	CORE	ELECTIVE	TOTAL
1	0	5	1	6
2	36	48	38	122
3	0	18	3	21
4	0	0	0	0
TOTAL	36	71+	42	149+

ANNEXURE B

CORE UNIT STANDARDS

The following unit standards are generic to the workplace or society in general.

All candidates must achieve the following generic unit standards.

This list will be as per the recommendations of SAQA/MQA

Number	Unit Standard Title	Level	Credit
	Demonstrate basic understanding of AIDS		
OcM-G002	Carry out basic first aid treatment in the workplace.	3	3
	Protect health and safety in the workplace		
	Extinguish a fire by means of a fire extinguisher		
	Understand emergency preparedness and response		
	Understand the identification of hazards and risks and relevant response		
	Understanding of legislation and compliance in terms of the Mining and Minerals Sector		
	Understand Quality Management principles and processes		
Total			

The following unit standards are core to Engineering Maintenance and Repairing for Underground Hard Rock (all specialisation areas).

All candidates must achieve the following unit standards.

Number	Unit Standard Title	Level	Credit
EnE-G001	Install an electrical cable	2	3
EnE-G002	Restore power by joining a cable	2	4
EnE-G009	Terminate and connect low voltage cable ends	2	3
EnE-G010	Isolate and restore power to an electrical system	2	2
EnE-G014	Install a lighting system	2	4
EnE-G015	Repair a lighting system	2	2
EnE-G016	Install earthing and bonding on electrical installations	2	2
EnE-G018	Install a cable support system	2	2
EnE-G019	Use and care for hand held electrical test instruments	2	3
EnE-G020	Install or replace an earth leakage unit in a low voltage circuit	2	3
EnE-G021	Install a low voltage supply in underground workings	3	5
EnE-G030	Replace an electrical cable	1	3
EnE-G048	Connect and commission a 3 phase direct on line starter to a motor	3	6
EnE-G060	Carry out a detailed inspection on an electrical enclosure.	2	3
EnE-G064	Disconnect and reconnect an electrical motor	2	3
EnE-G069	Test a three phase low voltage induction motor	2	2
EnM-G007	Lift and move a load	3	7
EnM-G023	Replace an electric motor	2	5
EnM-G054	Replace a flange mounted valve	1	2
EnM-G055	Replace a flanged pipe section	2	2
EnM-G119	Replace a tyre type drive coupling	2	2
EnM-G126	Replace a direct mount bearing	2	3
Total			71

ANNEXURE C

ELECTIVE UNIT STANDARDS

Candidates are required to achieve all the credits for any one of the following specialisation areas.

Specialisation area 2: Horizontal Transport

The following unit standards are elective to Engineering Maintenance and Repairing Underground Hardrock - Horizontal Transport.

Number	Unit Standard Title	Level	Credit
EnE-G005	Inspect and clean a 3-phase transformer	1	1
ENE-G006	Connect an industrial plug (Exceeding/higher/larger than 16amps)	2	2
ENE-G007	Install an industrial socket outlet (Exceeding/higher/larger than 16amps)	2	2
ENE-G027	Install a gully box	2	2
EnE-G055	Carry out a detailed inspection on an electrical motor	2	3
EnE-G050	Carry out a detailed inspection on an overhead trolley line	2	4
EnE-G051	Install an overhead trolley line in a underground haulage	2	6
EnE-G053	Carry out a detailed inspection on a cam operated motor controller	2	5
EnE-G075	Repair a water level control system	3	3
EnM-G002	Replace a taper sleeve bearing	2	2
EnM-G008	Replace an inline ventilation fan in an underground environment	2	2
EnM-G010	Replace a vertical spindle pump	2	2
EnM-G120	Replace a pin and bush type drive coupling	2	2
Total			36+

Specialisation area 3: Horizontal Transport Services

The following unit standards are elective to Engineering Maintenance and Repairing for Underground Hardrock - Horizontal Transport Services.

Number	Unit Standard Title	Level	Credit
EnE-G032	Carry out a detailed inspection on a DC motor	2	3
EnE-G055	Carry out a detailed inspection on an electrical motor	2	3
EnE-G052	Repair an electronic controller for a battery operated machine	2	5
EnE-G076	Repair a battery charger	3	3
EnE-G077	Repair a lead acid battery comprising of independent cells	2	3
EnE-G078	Install an Intercom system	2	2
EnM-G002	Replace a taper sleeve bearing	2	2
EnM-G004	Replace a single stage centrifugal pump	2	2
EnM-G013	Repair a single stage centrifugal pump	3	7
EnM-G021	Repair the mechanical brake system of an underground locomotive	2	5
EnM-G114	Repair the upper gearbox on an air driven track bound mechanical loader	2	4
EnM-G115	Repair the lower gearbox on an air driven track bound mechanical loader	2	4
EnM-G117	Replace the axle assembly on an air driven track bound mechanical loader	2	3
EnM-G142	Repair a vertical spindle pump	2	4
EnM-G143	Replace a final drive (gearbox) assembly of an underground locomotive	2	5
EnM-G144	Replace an axle assembly of an underground locomotive	2	4
EnM-G147	Trace and correct faults on a diesel engine of an underground locomotive	3	7
Total			66+

The following unit standards are elective to individuals.

The candidate must choose a total of at least six credits.

Number	Unit Standard Title	Level	Credit
	Demonstrate knowledge of problem solving and apply a problem solving technique to a problem		
	Produce a plan for own future directions		
MnH-G 001	Follow basic health and safety practices underground	2	2
MnH-G 038	Make safe a workplace by means of barring	2	2
OcS-G008	Deal with hazardous substances in a workplace	3	5
OcH-G006	Test for harmful gases by means of an approved hand held electronic instrument and take appropriate action.	4	5
RoC-G032	Acquire an appreciation for the role of rock engineering in the mining process.	1	3

Appendix 7: A review of previous research and literature on learning techniques

Studies on Interpreting and Identifying Safety Signs

A study, by Rodenwoldt, Mauer and Griffiths in 1975 investigated the underground use of safety signs and symbols and their perception by black mineworkers. Signs were shown to 224 workers from seven different mines, differing in education and work experience. The responses showed that many signs were frequently misunderstood and misperceived, indicating that the signs (in terms of design) were perhaps ineffective. Tests also showed that too much detail distracted from comprehension while too little detail is ineffective and therefore presentation of the sign was important. An investigation on the types of hazard signs used underground was conducted.

Many of the specific findings of this investigation, such as a lack of standardisation, written rather than pictorial messages, and a lack of use of signs, have subsequently been addressed by South African mines.

However, the study also identified perceptual difficulties in the recognition of signs. Subjects were able to identify the contents of a sign but were unable to identify the important attributes in a sign. Some of the factors that influenced this were the level of experience of workers and the extent of their literacy. One of Rodenwoldt's main recommendations in 1975 was that education was key to better sign recognition and hence better safety performance on the mines.

Melamed and Phetha (1976), did a follow up to the report by Rodenwoldt, Mauer and Griffiths (1975), that was to devise a system of safety signs that could be taught easily to illiterate mineworkers. Melamed and Phetha devised a simple systematic sign system so that each sign contained only relevant cues. Furthermore, signs were constructed such that the shape and colour depicted the sign type (i.e. prescriptive sign, prohibitive sign, informative or warning). Their subjects consisted of 50 black mineworkers returning to the industry (they had worked at least one contract). Half the subjects were taught to "read" the signs (i.e. they were taught the meanings of the four types of signs, as well as the meanings of two specific examples that would help them interpret other signs. They were then shown how to combine cues into an appropriate message) and the other half was taught to simply "recognise" the signs (i.e. this sign means...). In each case, training continued until all eight training signs were interpreted correctly. The outcome was that it took longer to train workers to "read" signs as opposed to training them to "recognise" signs. However, when presented signs that had not previously been seen, those who were taught to read the signs fared better. Lawrence, A.C., (1977), in his reference to Melamed and Phetha. Identifies several important principles, some of which are:

- Men should be taught to "read" signs rather than "recognise" signs so that they perform better when confronted with new signs.
- If men are taught the full range of signs, performance would be better.

The use of signs is still a critical aspect of safety and the findings of this research from the 1970's are still relevant today.

Studies conducted on the perception of hazardous conditions

Melamed and Beadle (1976) conducted an examination of decisions about the degree of danger present in various underground situations. Their experiments were conducted on 36 learner officials and 13 men of considerable mining experience. From their study, they found that pictorial material produces similar results to the more frequently used numerical representation.

They suspect this occurs because the recognition of a cue (something one is trying to recognise) is dependent on whether the cue is made explicit or implicit and not whether it is a picture or number. They also noted that similarly trained people behaved quite differently from each other. This result was found to be independent on whether the persons worked on the same mine or not. Explanations for the differences include:

- that people may not be specifically trained in the importance of accessing a situation by effectively combining aspects of the situation,
- experience may teach some people while others may never learn,
- there are no specific rules to follow.

A follow-up study conducted by Melamed, Lederman and Phetha (1976) on "Learning to recognise hazardous conditions underground", involved training subjects to use three cues. The subjects consisted of 56 learner miners from two different mining training colleges, 30 team leaders and 30 trainee team leaders from two mines. Two different training methods were used to determine the better training method. Half of the subjects (30 team leaders and 30 learner miners) were told what the cues were (e.g. look at the man, the stick, and the hanging wall) and were expected to judge the safety situation. From this, it was found that there was no improvement in accuracy or consistency as a result of this training. The other remaining subjects (30 trainee team leaders and 26 learner miners) were told what the cues were, were made aware of the importance of the three cues, and were told how to combine the information drawn from the cues to come to some conclusion. This training showed significant improvement in accuracy or consistency as the result of this training. However, it was found that feedback on what the correct interpretation was vital in the training process, to produce successful results. Thus, the results of the study show that it is insufficient to simply tell workers what are the relevant cues. They should be taught the appropriate policy in using cues and be provided with feedback.

In their conclusion, Lawrence and Blignaut, list a number of aspects that should be assessed to reduce perceptual failures. They are as follows:

- Identify the cues that the worker should look for to determine whether the conditions are hazardous and also the policy he should apply to come to some conclusion about the cues he finds.
- Current safety training on each mine should be reviewed critically to assess how well "cues" and "policy" are dealt with and how training can be improved.
- Attention should be given to improve the sensitivity of workers in detecting individual cues visually. Verbal instructions should be supplemented by exercises in visual detection should be a prominent feature in training programs.

Research conducted by Blignaut (1977), aimed at determining whether underground experience improved performance in detecting loose rock, and secondly to determine whether performance in detecting loose rock could be improved through training. Blignaut's subjects consisted of novices and experienced mineworkers. Their responses were analysed in terms of the Theory of Signal detection. The results of the investigation indicated that novices that were trained by practising on a set of stereoscopic slides (slides that gave a three-dimensional view of rock conditions) and experienced men performed significantly better than novices that had no training. However, novices that were trained through instruction only on what to look for performed the same as novices with no training. Thus, the investigation suggested that underground experience develops detection skills and that training and practice can develop the same kind of skill. Training should involve providing the knowledge, the opportunity to practise and prompt feedback. The training method that was proven to be most successful, by Blignaut, was based specifically on the detection of loose rock. Generally the method used was as follows:

- A list of the objectives of the training program. That is, what is the information, which the trainee must know, when the training is completed?
- An introduction about what is the hazard that the trainer is teaching the trainee to detect, why it is important to detect the hazard, and what the role of the trainer is.
- The cause of the hazardous condition (e.g. why does loose rock develop?)
- The reason for the importance of seeing the relevant cues.
- A detailed description of what the cues are to detect the onset of the hazard.
- Provide an action that the trainee can take once the cues are detected.

Blignaut (1979) conducted other studies on the perception of hazards. Firstly, Blignaut investigated the contribution of visual search to hazard perception. Four sets of subjects were involved. The one set was taught only how to react to loose rock and how to fill the pegboards used for testing, these were termed "novices with no training". The second set received the same instructions as the first set, except they were told why it was important to look for loose rock, they were called "warned" novices. The third set were told the same things as the second set were told where and when loose rock occurred and the group was given exercises, this group was termed "skills trained" novices. The fourth group consisted of the experienced mineworkers. The results of the investigation showed similar results to the study conducted in 1977. That is that novices that with skills training together with experienced training performed the best, while the warned and the no training novices performed very much the same. The difference in performance between the skilled novices and the no training novices was great. This gave an indication that visual search skills are important in the performance of workers to detect hazards. Furthermore, the results imply that novices can be trained to detect hazards with the same or even better performance as experienced mineworkers.

The follow up to this investigation, Blignaut (1979), was concerned with the ability of mineworkers to visually detect warning signals associated with dangerous rock conditions. Again, Blignaut compared experienced mine workers to novices that were trained in different ways. The "no training" novices were given no instructions but were required to respond to a set of test slides. The "knowledge trained" novices were instructed on the nature and appearance of the visual cues associated with dangerous rock, while the "skills trained" novices were given the same instruction as the "knowledge trained" novices, however, they were given opportunities to put their training into practise. As before, the results indicated that the skills trained novices were the best, followed by the experienced mineworkers performed, and in general, these two sets of subjects performed much better than the novices with trained knowledge or no training. However, it should be noted that the novices that were provided with some knowledge performed better than the novices with no training. The outcome suggested that the effectiveness of the skills training program was due to the knowledge, the opportunity to practise and the prompt feedback provided by the program. To explain the differences in performance, Blignaut distinguishes between two kinds of search behaviour:

- Casual search – adopted spontaneously by an individual
- Formal search – a behaviour taught to and applied by an individual

Both novice groups are thought to use casual search initially, however, the skill-trained novice uses formal search method to supplement the casual search.

The role of Psychology in Safety

A simple behaviourist approach to safety psychology has identified only three causes of accidents; physical environment, personality (the individual's attitudes and traits) and behaviour. According to this view the only one that can be managed to a certain extent is the behaviour of an individual. Minter (1990) argued for a better understanding of the role of behavioural psychology in the work place and how it could benefit the employer, in terms of preventing

hazards and promoting safety. He presented a simple "ABC" model for describing the basic tenets of behavioural psychology:

- "A" = Antecedent or Anything that stimulates or triggers action
- "B" = Behaviour or any action that is taken.
- "C" = Consequence or any action that follows a behaviour

Minter encouraged the use of positive consequences to encourage required behaviour as opposed to negative behaviour. This approach encourages employee participation rather than employee control. Employee control is said to be inefficient because it gains only compliance instead of acceptance. Minter suggested that the best way to promote safe behaviour is to involve workers in the development and administration of the safety program. Minter's thesis suggested that an important step in setting up a behavioural safety program was to conceptualise safety in positive terms.

Recent studies in learning outcomes GAP 609b

A recent study on learning outcomes, Venter (GAP 609b, 2000), confirmed the value of behavioural modelling but also identified organisational issues that have a significant influence on safety performance.

"Concerning underground safety the most important learning outcome is to have workers with appropriate safety habits or strategies ingrained in their daily expert behaviour. To approach this ideal it is necessary to institutionalise many of the principles and characteristics related to human learning and performance."

The report summarised its findings in terms of factors that influence individual learning and those that influence organisational learning. In terms of the individual it referred to the 'Creative Learning Experiences' and identified the following key aspects:

- People learn naturally through a process called modelling. Formal modelling can enhance this.
- Learning is a constant body wide process.
- Learning is best done in the context of work.
- Cognitive apprenticeship seems a valid model.
- Combining the above mentioned with African Collective Learning Systems suggests the best practice for learning in the mining industry.

As mentioned these findings placed considerable value on modelling but also emphasised that learning occurs in a broad environment. The ultimate behaviour of a worker is as dependent on his / her work environment, work roles models and cultural values as it is on the formal behavioural modelling that occurs during training. This shifts the emphasis for safety performance away from the individual. It becomes the dual responsibility of individual learning and organisational learning.

Venter identified several key aspects of organisational learning:

- Teams should work and learn together.
- The workplace is in most cases the best place to learn.
- The "bottom up" approach for change is compatible with the organisation of people working and learning together.
- Organisational structures to support learning need to be in place. These include:
 - Performance and competency definitions and models
 - Learning paths
 - Learning support systems

- Assessment and evaluation systems

Appendix 8: Occupational Health risks for tramming / haulage workers in gold mines

The principal occupational health risks that people who travel or work in haulages in mines are:

- **Pneumoconiosis (occupational lung disease).**
This is caused by the inhalation of airborne dust (in particular silica dusts) and has as its source the loading, transfer and tipping of broken rock, leaking backfill pipes, spillages drying out and dust becoming airborne.
- **Hearing impairment**
This is caused by exposure to elevated noise levels for long periods of time. Levels above 85 dBA for an 8 hour shift will result in permanent hearing impairment to a greater or lesser degree. Drivers, operators and attendants, and guards involved in tramming are often exposed to noise above 85 dBA. Where noise is greater than 82 dBA, a hearing conservation programme should be in place. The primary sources of noise include engine noise, loading and discharging of rock, impact of car and hopper buffers, haulage fans and pumps.
- **Exposure to exhaust gases and diesel particulate matter.**
This exposure arises from diesel exhaust emissions from mobile machinery and locomotives. The driver or operator of such equipment is the person at greatest risk in this case.
- **Occupational skin disease (Dermatitis and other skin ailments)**
Skin diseases may be caused by coming into contact with substances such as cement powder (whilst loading or transporting), diesel fuel and lubricants.
- **Occupational musculoskeletal disorders**
These disorders are caused by actions or posture (usually repetitive) carried out or adopted in the course of work.
- **Heat / cold disorders**
These are caused by the exposure of tramming workers to excessively hot (or cold) temperatures.

None of the work reviewed for the current project indicated significant injury arising from the risks mentioned above, and so they were not included in the analysis. It is probable that these risks will lead to injury over the longer terms, unless adequately managed.