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Assessment of Safety Culture and Maturity in Mining Environments: Case of Njuli Quarry

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Abstract

Due to an ever increasing concern for safety at most mines in Malawi, this paper aimed at assessing the safety culture and maturity in mining environments by applying the Safety Culture Maturity Model (SCMM). The SCMM is a practical and reliable diagnostic tool to use in the context of Malawian mining environments because it emphasizes the importance of employee involvement in assessing and improving safety culture. Njuli quarry is used as a case study due to its adoption of modern mining technologies and long existence in the mining industry. The methods used to assess the level of maturity of safety culture comprised questionnaires, interviews and behavioral observations. To test the reliability of the questionnaire, the respondents were interviewed using the same questions and comparing the results. There was good reliability of the measures used since the correlation coefficients between questionnaire and interview ranged from r = 0.9 to 1. The results demonstrate that Njuli quarry has more characteristics of the Managing Level 2 or Developing Stage with percentages ranging 55% - 60% followed by the Emerging Level 1 ranging 33% - 36%. The Involving Level 3 ranged 4% -10% showing improvement in some items of the dimensions of the safety framework. The company had the lowest percentages of 0% - 2% in Cooperating Level 4, and 0% - 1% in Continually Improving Level 5. This was expected because most mining companies in Malawi focus on maximizing production regardless of the safety implications, and also employees do not take safety issues seriously despite minor accidents and near misses. Therefore, the company should carry out safety trainings, set up a safety department, provide PPE to employees, and introduce rewards for best safety performance. Present study has added new knowledge on levels of maturity of safety culture in Malawi's mining environments which will influence the Department of Mines in policy development, site safety inspections and safety audits.

Keywords: Malawi, Maturity Model, Safety Management

1. Introduction

Despite Malawi experiencing an increase in the number of open pit quarries, there is a research gap on the state of safety culture maturity in mining environments. Therefore, the question that arises is how safe are these mining environments. Present study seeks to address the research question by assessing the level of safety

culture and maturity in Malawi's mining environments with Terrastone Njuli quarry used as a case study. The mining site is chosen due to its adoption of modern mining technologies and long existence in the mining industry. Research by Chiocha et al. (2011) found that optimum health and safety leadership, management commitment to and management involvement in health and safety, increasing awareness, and appropriate enforcement of legislation can lead to a decline in the number of construction-related fatalities and injuries in Malawi. In recent years, there has been an increasing recognition of the importance of organisational, cultural and behavioural aspects of safety management in high reliability industries (Lardner, 2002). Management has realized that the general likelihood of an accident occurring in their plant depends not only on the actions of individual employees, but also on the "safety culture" of their organisation, defined by the Confederation of British Industry as "the way we do things around here" (Lardner, 2002). Research by Lardner (2002) also suggests that the Safety Culture Maturity Model (see Figure 1) aims at assisting organizations in establishing their current level of safety culture maturity and identifying the actions required to improve their safety culture.

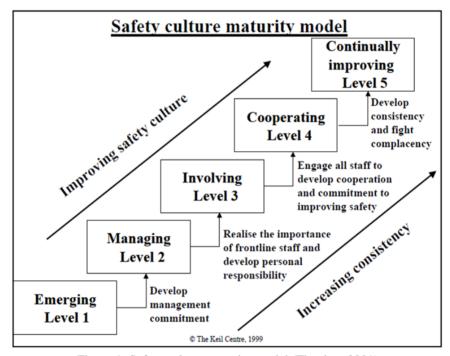


Figure 1: Safety culture maturity model (Fleming, 2001)

Figure 2 is based on Figure 1 and it shows how an improvement in safety culture lowers the rate of incidents occurring at a company. The key elements that constitute a good foundation for safety in an organization comprise strategic plans and action plans that integrate safety into all aspects of an organization's activities, presence and quality of the organization's risk control systems & safety management information system, the extent to which an organisation' safety management systems are reviewed and the extent to which every employee receives high quality integrated job and safety training (IAEA 2002a, Goncalves et al., 2010).

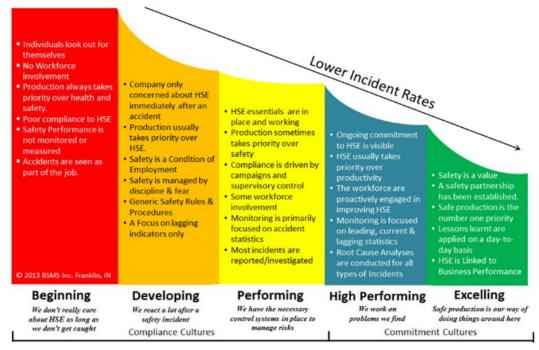


Figure 2. Maturity Model of Safety Culture (British HSE, 2007)

Njuli quarry is involved in high risk mining operations such as drilling, blasting, loading, hauling and processing of rock aggregates hence there is a need to assess the state of safety culture at the mining site. It is hoped that the output of this research will provide insights on how to assess and improve safety culture maturity in Malawi's mining environments.

2. Materials and Methodology

2.1. Study Area

Njuli Quarry is an aggregate mine located at Latitude -15.706495° and Longitude 35.118275° (see Figure 3). The quarry supplies construction materials to the surrounding areas. There are drilling, blasting, hauling and processing activities at the mine site which might affect mine workers as well as residents of Chakachaza, Chikuse, Luwanga and Namakhuwa villages.



Figure 3: Arial view of Njuli quarry (Google Earth 2020)

2.2. Procedure

The Safety Culture Maturity Model (SCMM) used in this research is based on Fleming (2001) because the model emphasizes the importance of employee involvement in assessing and improving safety culture. In order to establish the level of maturity of Njuli quarry's safety culture, a framework of five dimensions (Fleming, 2001; IAEA 2002a; & Goncalves et al., 2010) was applied:

- i. Information: involves the way the organisation allows its employees to inform about any near misses and accidents as well as the confidence the employees have in the organisation.
- ii. Organisational Learning: describes how the organisation deals with the information, how the organisation analyses the accidents and near misses at the workplace, and if the organization keeps the employees informed about these events.
- iii. Involvement: explains the way the organisation leads the employees to a growing participation in safety issues, in accident analysis and in reviewing procedures and rules. It also includes if the employees participate in safety committees and safety meetings.
- iv. Communication: describes how, when and what to communicate regarding safety issues to employees. Also, if there is an open communication channel between employees and managers. It also describes if the communication reaches the employees and is understood by them.
- v. Commitment: describes the support given by the organisation as far as Health and Safety is concerned: planning, priorities, training, auditing, contractor, rewards, investment, procedures and teaming. It also describes there is a Health, Safety and Environment Management System. Truthful commitment means more than writing political statements to say that Health and Safety are important, it needs to have coherence between words and reality.

2.2.1. Questionnaire (Based on Fleming, 2001; & Goncalves, 2010)

The five dimensional frameworks had items which were used as statements to develop a safety maturity questionnaire for Njuli Quarry. Tables 1–5 show the framework and how each one of the five dimensions is treated in each one of the five stages of maturity of safety culture. Each item represented one level: 1 – Emerging, 2 – Managing, 3 – Involving, 4 – Cooperating and 5 – Continually Improving. The questionnaire had 22 questions: 14 questions with five items and 8 questions with four items, hence totalling 102 items. For each question, the respondents were required to select the item that best represented the position of the company.

Table 1: Framework to identify maturity of safety culture in information

Tube 1. Fame work to identify inaturity of surery curtain in information						
	I. Information					
Emerging	Managing	Involving	Cooperating	Continually		
Level 1	Level 2	Level 3	Level 4	Improving		
				Level 5		
1. The unusual	1. Only the serious	1. Most of the	1. Most of the	1. All the unusual		
events which occur	accidents are	unusual events	unusual events	events which occur		
in the	reported by the	which	which occur	in the organisation		
organisation are not	employees	occur in the	in the organisation	are reported by the		
reported by the	2. There is a formal	organisation are not	are reported by the	employees		
employees	system which	reported by the	employees	2. There is a formal		
2. There is not a	allows the	employees	2. There is a formal	system that allows		
formal system that	employees to inform	2. There is a formal	system that allows	the employees to		
allows	only the serious	system that allows	the	inform all the		
the employees to	accidents occurred	the employees to	employees to	unusual events,		
inform any unusual	in the organisation	inform	inform all the	including accidents		
events, including	3. The employees	only the accidents,	unusual events,	and serious		
accidents and	do not inform any	including the	including accidents	accidents, occurred		
serious ones,	unusual events	serious ones,	and serious	in the organisation		
occurred in the	occurred because	occurred in the	accidents, occurred	3. All the employees		
organisation	they do not feel	organisation	in the organisation	feel comfortable		
3. The employees	comfortable enough	3. The minority of	3. The majority of	enough to inform the		
do not inform any	in relation to the	the employees feel	the employees feel	unusual events		
unusual	organisation	comfortable enough	comfortable enough	occurred in the		

events occurred because they do not feel comfortable enough in relation to the organisation 4. There are no performance indicators of safety at work	4. The only performance indicators of safety at work are the serious accidents occurred in the workplace	to inform the unusual events occurred in the organisation 4. The only performance indicators of safety at work are the accidents and work-related illnesses rates	to inform the unusual events occurred in the organisation 4. The organisation has other performance indicators of safety at work as well as the accidents and work-related illnesses rates	organisation 4. Besides having performance indicators of safety at work, the company has indicators of performance in the environmental area
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Table 2: Framework to identify maturity of safety culture in organisational learning

Table 2: Framework to identify maturity of safety culture in organisational learning				
I. Organisation		T	T	Γ
Emerging	Managing	Involving	Cooperating	Continually
Level 1	Level 2	Level 3	Level 4	Improving
				Level 5
1. The organisation	1. Only the serious	1. Most of the	1. Most of the	1. All the unusual
does	accidents are	unusual events	unusual events	events which occur
not analyse any	reported by the	which occur in the	which occur in	in the organisation
unusual	employees	organisation are not	the organisation are	are reported by the
events	2. There is a formal	reported by the	reported by the	employees
2. The analysis of	system which	employees	employees	2. There is a formal
unusual	allows the	2. There is a formal	2. There is a formal	system that allows
events aims to	employees to inform	system that allows	system that allows	the employees to
identify	only the serious	the employees to	the employees to	inform all the
the guilty ones only	accidents occurred	inform only the	inform all the	unusual events,
3. The organisation	in the organisation	accidents,	unusual events,	including accidents
does	3. The employees	including the	including accidents	and serious
not propose any	do not inform any	serious ones,	and serious	accidents,
improving actions	unusual	occurred in the	accidents,	occurred in the
for	events occurred	organisation	occurred in the	organisation
safety at work	because they do not	3. The minority of	organisation	3. All the employees
4. The organisation	feel comfortable	the employees feel	3. The majority of	feel comfortable
does	enough in relation	comfortable enough	the employees feel	enough to inform the
not inform the	to the organisation	to inform the	comfortable	unusual events
analyses	4. The only	unusual events	enough to inform	occurred in the
results of unusual	performance	occurred in the	the unusual events	organisation
events to its	indicators of safety	organisation	occurred in the	4. Besides having
employees	at work are the	4. The only	organisation	performance
	serious accidents	performance	4. The organisation	indicators of safety
	occurred in the	indicators of safety	has other	at work, the
	workplace	at work are the	performance	company has
		accidents and	indicators of safety	indicators of
		work-related	at work as well as	performance in the
		illnesses rates	the accidents	environmental area
			and work-related	
			illnesses rates	

Table 3: Framework to identify maturity of safety culture in involvement

I. Involvement				
Emerging	Managing	Involving	Cooperating	Continually
Level 1	Level 2	Level 3	Level 4	Improving
				Level 5
1. The employees do not engage in safety issues 2. The employees have no interest in participating in safety-related issues	1. The employees are invited to participate in safety-related issues only when serious accidents occur 2. The employees are interested in participating in safety-related issues only when serious accidents occur	1. The minority of the employees is engaged in safety- related issues 2. The minority of employees is interested in participating in safety related issues	1. The majority of the employees are engaged in safety- related issues 2. The majority of employees are interested in participating in safety related issues	1. All employees are engaged in both safety-related and environmental issues 2. All the employees are interested in participating in safety-related issues

Table 4: Framework to identify maturity of safety culture in communication

I. Communica	I. Communication				
Emerging	Managing	Involving	Cooperating	Continually	
Level 1	Level 2	Level 3	Level 4	Improving	
				Level 5	
1. The organisation	1. The organisation	1. The organisation	1. The organisation	1. The organisation	
does not	communicates	communicates its	communicates its	communicates its	
communicate its	its employees the	employees the least	employees the most	employees all the	
employees any	safety-related issues	part of the safety-	part of the safety	safety-related issues	
safety-related	only when serious	related issue	related issue	2. There is an open	
issues	accidents occur	2. There is an open	2. There is an open	channel of	
2. There is not an	2. There is an open	channel of	channel of	communication	
open channel of	channel of	communication	communication	between the	
communication	communication	between the	between the	organisation and its	
between the	between the	organisation and its	organisation and its	employees because	
organisation and its	organisation and its	employees;	employees because	the former considers	
employees about	employees only	however, it is still	the former	safety-related issues	
safety-related	when serious	incipient and	considers safety-	relevant	
issues	accidents occur	bureaucratic	related issues	3. The organisation	
3. The organisation	3. The organisation	and it is based on	relevant	checks if all the	
does not check if	checks if the	norms and	3. The organisation	communication	
the communication	communication	procedure	checks if most part	about safety-related	
about safety-related	about safety related	3. The organisation	of	issues is effective	
issues is effective	issues is effective	checks if the	the communication		
	only when serious	communication	about safety related		
	accidents occur	about safety-related	issues is effective		
		issues is effective			
		only in			
		areas where there			
		are risks of accident			
		and			
		work-related			
		illnesses			

Table 5: Framework to identify maturity of safety culture in commitment

Emerging Level 2 Level 3 1. Planning for safety at work is not done by the organisation does not on what went wrong in safety at work a 4. The organisation does not nevet in safety at work 4. The organisation does not never in safety at work a 4. The organisation does not have a team to give support in safety at work of training are seen as limiting as far as activities are concerned 8. The organisation bas a maltin only in specific training proyagam in safety at work can take place only after serious accidents work considers safety at work and that specific training proyagam in safety at work can take place only after serious accidents work can take place only after serious accidents or work are concerned as far as activities are seen as limiting as far as activities are s	I. Commitmen	able 5: Framework to 16	dentity maturity of safe	ty culture in committine	ont .
Level 1 Level 2 Level 3 Level 4 Improving Level 5 I. Planning for safety at work is focused only on what went wrong in the past of extending system to stimulate safety at work are seen as limiting as far as activities are concerned in Safety at work are seen as limiting as far as activities are concerned below to stimulate safety at work are seen as lower price and shows no tadopt a rewarding system to stimulate safety at work and safety at work are seen as limiting as far as activities are concerned below to stimulate safety at work are seen as lower price and shows no consourced companies for a safety at work are serious accidents and work related linesses occur as the safety at work are serious accidents and work related in safety at work are seen as limiting as far as activities are concerned below to stimulate safety at work are serious accidents occur as ferious accidents and work related illnesses occur as the safety at work are serious accidents or a concerned with safety at work are serious accidents and work related illnesses occur as limiting as far as activities and the serious accidents and work related illnesses occur as the safety at work are very strict of the safety at work are related illnesses occur as limiting as far as activities and the safety at work are related illnesses occur as the safety at work are related illnesses occur as the safety at work are related illnesses occur as the safety at work are related illnesses occur as the safety at work are related illnesses occur as the safety at work are all s			Involving	Cooperating	Continually
I. Planning for safety at work is not done by the organisation does not adult it in safety at work aram to give support in safety at work training on some seen as limiting active are seen as limiting as far as activities are concerned in S. The organisation does not adopt a rewarding system to stimulate safety at work and work-related illnesses occur shows no radopt a rewarding system to stimulate safety at work affect work are with safety at work and work-related illnesses occur shows no radopt a rewarding system to stimulate safety at work only in safety at work on shows no concern with safety at work and work-related illnesses occur shows no radopt a rewarding system to stimulate safety at work only and the specific situations, that is, after serious accidents and work-related illnesses occur shows no related i					
1. Planning for safety at work is not done by the organisation does not audit in safety at work a. The organisation does not not audit in safety at work a. The organisation does not provide any safety at work only after store team to give support in safety at work only and expense 7. The procedures make after at work only an expense 7. The procedures make after at work only an expense 7. The procedures make after at work only an expense 7. The procedures make after at work only an expense 7. The procedures make after a work only an expense 7. The procedures of that specific training after as after as activities are concerned by 1. The organisation does not adopt a rewarding system to stimulate safety at work shows no concern with safety with safety at work and surface of scrious accidents occur a lower price and shows no concern with safety at work and expense occur 9. The procedures in safety at work are serious accidents occur at lower price and shows no concern with safety at work are serious accidents or a lower price and shows no concern with safety at work and expense occur 9. The procedures in safety at work and work-related illnesses occur 4. The organisation indoes not adopt a rewarding system to stimulate safety at work are written only in face of scrious accidents or a lower price and shows no concern with safety at work are written only in face of scrious accidents or work-related illnesses occur 9. The procedures in safety at work are written only in face of scrious accidents or work-related illnesses occur 9. The procedures in safety at work are written only in face of scrious accidents or work-related illnesses occur 9. The organisation work accidents or work-related illnesses occur 9. The procedures in safety at work are written only in face of scrious accidents or work-related illnesses occur 9. The procedures in safety at work are written only in face of scrious accidents or work-related illnesses occur 9. The procedures in safety at work are writtened with problem work work and analysis of	Level 1	Level 2	Level 5	Level 4	
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2.2.2. Respondents

The sample of respondents was randomly selected from the production, maintenance and management teams. A total of 10, 10 and 4 respondents from the production, maintenance and management teams were selected respectively. Respondents from the management team comprised of the Managing Director, Quarry Manager, Safety Manager and Safety Officer. The respondents were advised to maintain anonymity when filling out the questionnaire.

2.2.3. Interviews

In order to correlate the respondents' answered questionnaires, all 24 respondents were interviewed by the researcher a week later after questionnaire submission and the interview lasted 30 minutes. Due to the non-parametric nature of the data, the verification of the questionnaire and interview scores were done by Kendall' tau, τ (Field 2005). During the time of this research, three students from The Polytechnic were on industrial attachment at the mining company thereby making it convenient for the researcher to observe the behaviour of management and employees towards safety. In addition, the researcher was given one month unlimited access to the site so as to observe employee' behavior, and carry out situational audits on safety culture. This on-site experience assisted in getting reliable responses from the interviewees.

3. Results and Discussion

All 24 respondents answered their questionnaire and returned it a week later. Interviews done on the respondents showed a correlation of between 0.9 and 1 indicating a good reliability of responses to questionnaire.

Table 6: Correlation between questionnaire and interview scores

Dimensions	Kendall' tau, T
Information	0.915
Organizational Learning	1
Involvement	0.9
Communication	1
Commitment	0.908

Collected data was analyzed using Microsoft Excel statistical package. Table 7 shows the percentage of responses from 22 questions for each one of the five dimensions from all the 24 respondents. The use of the questionnaire, on-site behavioral observation, and interviews provided a satisfactory correlation on the maturity

of safety culture at Njuli Quarry. The researcher was taken through all sections at the quarry mine and this provided a better perspective on the company's adherence to the five dimensions and frameworks of safety.

Table 7: Maturity of safety	culture scores for eac	h one of the dimensions
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Dimensions	Emerging (%)	Managing (%)	Involving (%)	Cooperating (%)	Continually Improving (%)
Information	36	60	4	0	0
Organizational Learning	34	56	7	2	1
Involvement	33	55	10	1	1
Communication	33	59	8	0	0
Commitment	34	58	8	0	0

Njuli quarry's maturity of safety culture varies across the five different maturity levels. The different levels of maturity found in this Njuli Quarry sample are consistent with the safety culture maturity concept in that safety culture does not develop at the same pace in all dimensions (IAEA, 2002a; Goncalves et al., 2010; Fleming, 2001). From the results, it is clear that Njuli quarry has more characteristics of the Managing Level 2 or Developing Stage with percentages ranging 55% - 60% followed by the Emerging Level 1 ranging 33% - 36%. The Involving Level 3 ranged 4% - 10% showing improvement in some items of the dimensions of the safety framework. The company had the lowest percentages of 0% - 2% in Cooperating Level 4, and 0% - 1% in Continually Improving Level 5. The results were anticipated by the researcher due to the fact that there is little to no literature available on safety culture in Malawi's mining environments, and through observation, most mining companies mainly focus on maximizing production regardless of the safety culture. Njuli quarry has no designated safety department thereby making it difficult for employees to report on near misses and noncompliance. The employees blame the company for not providing them with enough personal protective equipment and safety training thereby fostering complacency. However, the company indulges in safety talks and equipment inspection at 6:45am every morning before any work starts thereby showing the companies' commitment to improving safety culture. In addition, before blasting is carried out the company notifies the surrounding community of a date when blasting will be done. Blasting is normally carried out at 12pm noon and warning sirens are done 15 minutes prior to ignition of blast.

4. Conclusion and Recommendation

Fleming's (2001) safety culture maturity model was successfully applied to Njuli quarry mining environment and it has proven to be a reliable diagnostic tool for assessing safety culture maturity. The Emerging and Managing Levels of safety culture represent a true reflection of the maturity of safety culture in Malawi's mining environments because mining is still at the developing phase in Malawi and mining companies are mostly focused on maximizing production regardless of the safety culture. Present study findings will assist the Department of Mines when carrying out safety inspections in mining environments. In addition, mining companies will apply this new knowledge when carrying out safety audits on their operations thereby complying with the Malawi government's safety regulations. According to the Mining Safety Regulations (1982), all mining companies are encouraged to adhere to safety rules but most of these companies take shortcuts and reduce safety budgets so as to maximize production. Therefore, to continually improve safety culture in Malawi's mining environments, it is recommended to:

- > Provide PPE to all employees at all working times
- Encourage housekeeping
- > Carry out safety trainings, audits, and provide scenarios of near misses
- > Set up an on-site safety department and develop a risk management system
- > Introduce rewards for best safety performance to increase motivation amongst employees.

Future research work can look into the application of the safety culture maturity model to a heterogeneous environment like the construction sector so as to test its dimensional validity. In addition, a comparative analysis can be done on safety culture maturity between the construction and mining sectors in Malawi.

Conflict of Interest

The authors have not declared any conflict of interest.

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