

Engineering and Technology Quarterly Reviews

Matsimbe, Jabulani, Ghambi, Steven, and Samson, Abdul. (2020), Assessment of Safety Culture and Maturity in Mining Environments: Case of Njuli Quarry. In: *Engineering and Technology Quarterly Reviews*, Vol.3, No.2, 137-146.

ISSN 2622-9374

The online version of this article can be found at:
<https://www.asianinstituteofresearch.org/>

Published by:
The Asian Institute of Research

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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.

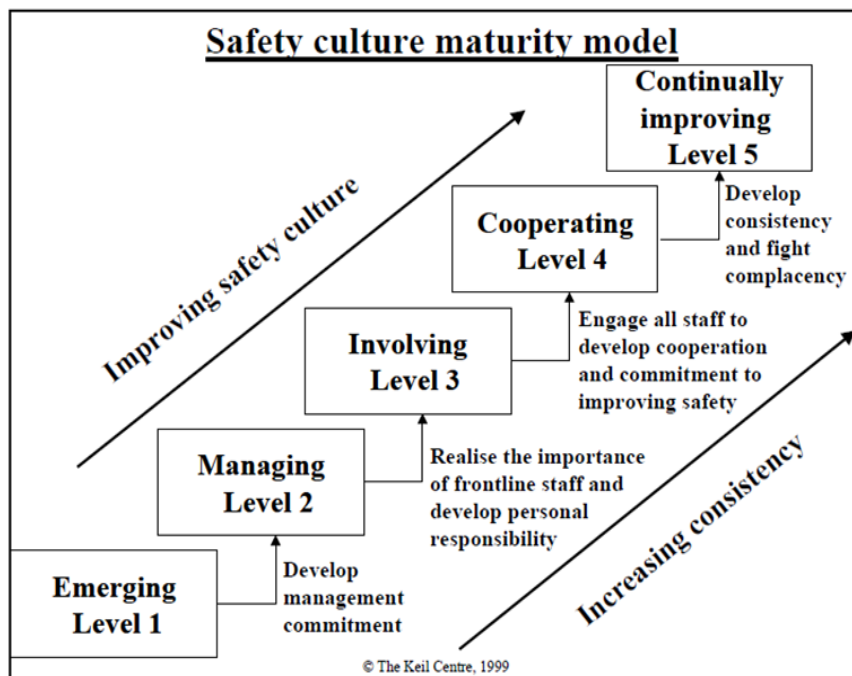


Figure 1: Safety culture maturity model (Fleming, 2001)

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's 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).

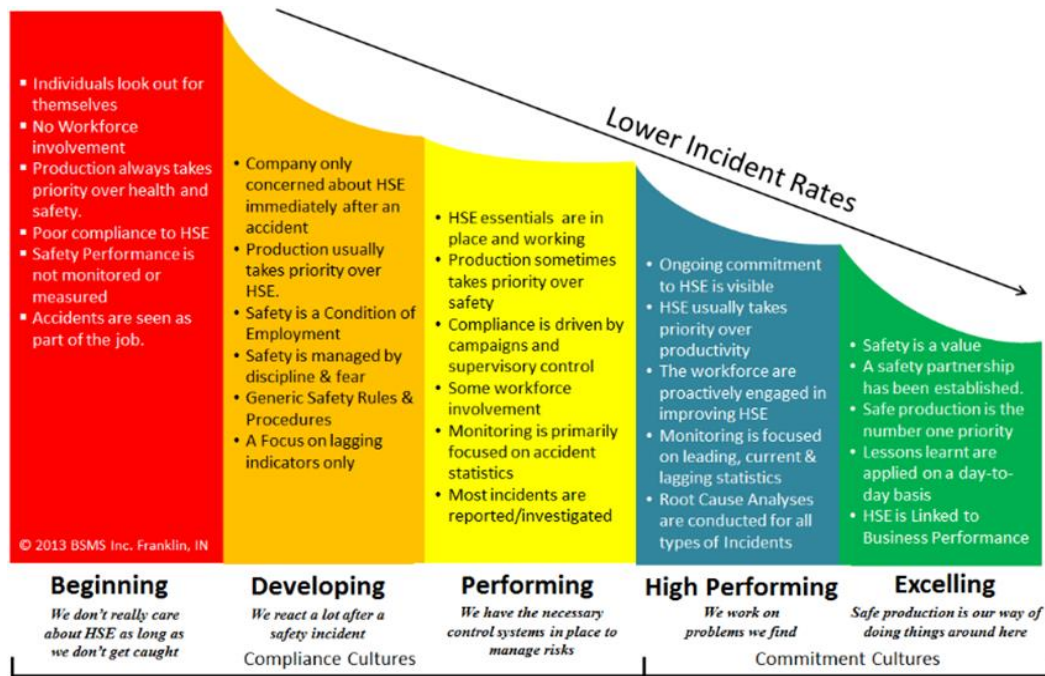


Figure 2. Maturity Model of Safety Culture (British HSE, 2007)

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: Aerial 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

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

Table 2: Framework to identify maturity of safety culture in organisational learning

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

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

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

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

| I. Commitment | | | | |
|---|---|--|--|--|
| Emerging Level 1 | Managing Level 2 | Involving Level 3 | Cooperating Level 4 | Continually Improving Level 5 |
| <p>1. Planning for safety at work is not done by the organisation</p> <p>2. The organisation does not audit in safety at work</p> <p>3. The organisation does not invest in safety at work</p> <p>4. The organisation does not provide any safety at work training</p> <p>5. The organisation does not have a team to give support in safety at work</p> <p>6. The organisation considers safety at work only an expense</p> <p>7. The procedures in safety at work are seen as limiting as far as activities are concerned</p> <p>8. The organisation does not adopt a rewarding system to stimulate safety at work</p> <p>9. The organisation hires outsourced companies for a lower price and shows no concern with safety</p> | <p>1. Planning for safety at work is focused only on what went wrong in the past</p> <p>2. The organisation audits in safety at work only after serious accidents and work-related illnesses occur</p> <p>3. The organisation invests in safety at work only after serious accidents and work-related illnesses occur</p> <p>4. The organisation provides resources so that specific training program in safety at work can take place only after serious accidents occur</p> <p>5. The organisation has a small team to give support in safety at work</p> <p>6. The organisation considers safety at work important only when serious accidents or work-related illnesses occur</p> <p>7. The procedures in safety at work are written only in face of serious accidents that occur</p> <p>8. The organisation adopts a rewarding system to stimulate safety at work only in specific situations, that is, after serious accidents and work-related illnesses occur</p> <p>9. The organisation worries about safety at work in relation to outsourced</p> | <p>1. Planning for safety at work is focused only on the identification and analysis of existing risks in the workplace</p> <p>2. The organisation has an auditing program in safety at work only in areas where risk of accident and work-related illness exist</p> <p>3. The organisation invests only to avoid risks of accident and work-related illnesses on the job</p> <p>4. The organisation has standard safety at work training only for the employees who work in places where risks of accident and work-related illnesses exist</p> <p>5. The organisation has a team that is big enough to give support in safety at work</p> <p>6. The organisation considers safety at work important, but it emphasises production</p> <p>7. The procedures in safety at work focus only the sectors where risks of accident and work-related illnesses exist</p> <p>8. The organisation adopts a rewarding system for good</p> | <p>1. Planning for safety at work is well structured with problem prevention and work procedures improvement, but It is not integrated with the other areas of the organisation</p> <p>2. The organisation has an auditing program in all its sectors for safety at work</p> <p>3. The organisation invests systematically in safety at work in all its sectors</p> <p>4. The organisation has a continuous training process in safety at work for all its employees</p> <p>5. The organisation has a team that is big enough to give support in safety at work</p> <p>6. The organisation seeks to prioritise safety at work, but it is not a reality yet</p> <p>7. The procedures in safety at work are done the best way possible, but they are not periodically reviewed</p> <p>8. The organisation adopts a rewarding system for all its sectors due to the employees' performance in safety at work</p> <p>9. The organisation</p> | <p>1. Planning for safety at work is well structured with problem prevention and work procedures improvement and It is integrated with the other areas of the organisation</p> <p>2. The organisation has an auditing program in all its sectors for both safety at work and environment</p> <p>3. The organisation continuously evaluates the need for new investment in both safety at work and the environment</p> <p>4. The organisation has a continuous training process in safety at work for all its employees</p> <p>5. The organisation does not have a team to give support in safety at work specifically because the responsibility for it is shared by all the organisation members</p> <p>6. The organisation, in fact, prioritises safety at work and production equally</p> <p>7. The procedures in safety at work are done the best way possible and are constantly reviewed for better effectiveness</p> <p>8. The organisation considers its</p> |

| | | | | |
|--|---|--|---|---|
| | employees only when serious accidents or work-related illnesses occur | performance in safety at work only for those sectors where risks of accident and work-related illnesses exist 9. The organisation has a pre-qualification process in safety at work before contracting outsourced companies. Nevertheless, there is no follow-up afterwards | has a pre-qualification process in safety at work before contracting outsourced companies. Nevertheless, there is no follow-up afterwards | employees are highly motivated by both safety at work and the environment; therefore, it does not see the need for a rewarding system 9. The organisation considers the outsourced companies as part of its safety and environmental management system |
|--|---|--|---|---|

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, τ |
|-------------------------|----------------------|
| 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 each one of the dimensions

| 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 non-compliance. 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.

Acknowledgements

The authors would like to thank University of Malawi, The Polytechnic for supporting the research.

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