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The Impact of Employee Training and Development on the Adoption of New Mining Technologies in Zambia. A Case Study of FQM - TRIDENT.

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Abstract

This study investigated the impact of employee training and development on the adoption of new mining technologies at First Quantum Minerals (FQM) Trident in Zambia. Utilising a mixed-methods approach, the researchers combined quantitative surveys with qualitative interviews to collect data from 40 employees across various roles within the organization. A purposive sampling technique was employed to select participants directly involved in training and technology implementation, ensuring a diverse range of perspectives. Data collection tools included structured questionnaires for surveys and semi-structured interview guides for qualitative insights. Quantitative data were analysed using statistical software (e.g., SPSS) and correlational analysis techniques to assess relationships between training participation and technology adoption. Qualitative data were transcribed and analysed thematically to identify key themes related to training effectiveness and challenges to technology adoption. The findings revealed that effective training programmes significantly enhanced the adoption of new technologies, with 75% of participants indicating participation in training related to technological advancements. Key challenges identified included resource limitations, insufficient training content, and resistance to change among employees, which hindered the full realisation of technological adoption. The study emphasised that tailored training initiatives not only fostered employee confidence in using new technologies but also contributed to overall operational efficiency and safety improvements. The implications of this research are substantial, suggesting that a well-structured training framework is critical for sustaining competitive advantage in the mining sector. By addressing the identified gaps and enhancing training initiatives, FQM Trident can better prepare its workforce for the evolving technological landscape, ultimately promoting sustainable practices in mining operations.

Keywords: *Employee training, technology adoption, mining sector, First Quantum Minerals, Zambia.*

1.1 Introduction

The mining sector in Zambia had historically been characterised by traditional methods and practices, often relying on manual processes and outdated machinery. This reliance on conventional techniques limited operational efficiency and productivity, leading to challenges in meeting both local and global demand (Mwanza, 2019). For instance, the country faced difficulties in achieving its production targets, with a reported shortfall of 10% in copper output in recent years (Zambia Chamber of Mines, 2021). However, the increasing global demand for minerals, particularly copper and cobalt, prompted a significant shift toward more advanced and automated mining technologies.

Advanced technologies, including automation, data analytics, and artificial intelligence (AI), were integrated into mining operations to improve efficiency, reduce costs, and enhance safety standards (World Bank, 2020). According to a report by the International Council on Mining and Metals (ICMM, 2021), companies that adopted these technologies noted an average increase of 15% in operational efficiency. These technologies streamlined operational processes and provided valuable insights that led to informed decision-making. For instance, data analytics optimised resource allocation and maintenance schedules, thereby reducing downtime and operational costs. Deloitte (2020) found that data analytics-enabled predictive maintenance could reduce equipment downtime by up to 30%.

As the industry evolved, employee training and development emerged as critical components in this transition. A skilled workforce was essential for effectively implementing and leveraging new technologies. Organisations needed to equip employees with the necessary skills to operate complex machinery and interpret data generated by advanced systems (Ng'andu, 2022). Furthermore, effective training programs helped mitigate the risks associated with new technologies, ensuring that employees were not only capable but also confident in their roles. For example, a survey conducted by Kadzamira and Chanda (2021) revealed that organisations investing in employee training experienced a 25% improvement in technology adoption rates, leading to increased productivity and reduced operational risks.

At First Quantum Minerals Trident, various training programs were implemented to prepare employees for the integration of new technologies (FQM Annual Report, 2022). These programmes aimed to enhance technical skills, promote safety awareness, and foster a culture of continuous learning. Specific initiatives included hands-on training sessions, workshops on the latest technologies, and mentorship programs designed to support skills development. By investing in these training initiatives, FQM Trident aimed to create a workforce that was not only proficient in using new technologies but also adaptable to future advancements.

2.1 Literature Review

2.1.1 Global context

Globally, the mining industry faces increasing pressures to innovate and improve operational efficiency in response to rising operational costs, regulatory demands, and the need for sustainable practices. As the industry evolves, the integration of advanced technologies such as automation, artificial intelligence, and data analytics has become essential for maintaining competitiveness and operational resilience. Countries like Australia and Canada have recognized the importance of equipping their workforce with the necessary skills to utilize these technologies effectively.

For instance, the Mining Industry Human Resources Council (2018) reports that Australian mining companies have developed targeted training initiatives focusing on both technical skills and safety protocols associated with advanced machinery. These programmes have resulted in improved operational efficiency and a reduction in workplace accidents, underscoring the importance of a well-trained workforce in leveraging new technologies. Additionally, a study by McKenzie and McKenzie (2020) highlights that companies investing in employee training have seen a marked increase in innovation and productivity, further supporting the case for comprehensive training strategies.

2.1.2 African Context

In Africa, the mining sector is pivotal to economic development, contributing significantly to GDP, employment, and foreign exchange earnings. Despite its importance, the sector often grapples with inefficiencies and skill gaps, which hinder its capacity to adopt new technologies and compete on a global scale. Research by the African Development Bank (2019) highlights that many mining operations across the continent struggle with outdated practices and a lack of skilled personnel capable of utilizing advanced technologies. This issue is particularly pronounced in countries with extensive mineral resources but limited investment in human capital.

The challenges faced by the African mining sector are multifaceted. For instance, the reliance on traditional mining methods and equipment can lead to operational inefficiencies, resulting in increased costs and reduced productivity. Moreover, a lack of training programs that focus on new technologies exacerbates the problem, as employees may not possess the necessary skills to adapt to the evolving landscape of the industry. The African Development Bank (2019) emphasizes that inadequate training not only affects technology adoption but also poses safety risks, as employees may be ill-equipped to handle advanced equipment safely.

Countries like South Africa have begun to address these challenges by investing significantly in workforce development initiatives. The Minerals Council South Africa (2020) reports that the country has launched various programs aimed at enhancing the skills of its mining workforce. These initiatives include partnerships between mining companies, educational institutions, and government agencies to create a robust training framework that aligns with the technological advancements in the industry. Such collaborations have resulted in training programs that focus on critical skills such as data analysis, equipment operation, and safety management.

2.1.3 Zambian Context

In Zambia, the mining industry remains a cornerstone of the economy, contributing significantly to both GDP and employment. The sector is particularly vital given that Zambia is one of the largest producers of copper in Africa, with the mineral sector accounting for a substantial portion of the country's export earnings (Zambia Chamber of Mines, 2021). However, despite its importance, the industry faces persistent challenges, particularly concerning skill shortages and the slow adoption of advanced technologies.

One of the primary challenges hindering the Zambian mining sector is the shortage of skilled labour. Many mining companies report difficulties in finding employees with the requisite technical skills to operate modern mining equipment and technologies. This skills gap is exacerbated by the educational system, which often fails to align closely with the practical needs of the mining industry (Chibanda, 2020). As a result, mining companies frequently invest in training programs to develop their workforce, recognizing that an adequately trained team is essential for maximizing productivity and safety.

2.1.4 Ethical and Social Implications

The study of the impact of employee training and development on the adoption of new mining technologies at FQM–Trident requires careful consideration of ethical and social implications. Ethically, the research must ensure voluntary participation, informed consent, and confidentiality of employees' responses, particularly because the study involves workplace practices that could influence perceptions of management or job security. Participants should be assured that the information collected will be used strictly for academic purposes and reported in aggregate form to avoid identifying individuals. Socially, the findings may have implications for workforce development, job adaptation, and technological inclusion, as effective training can reduce resistance to change, improve safety, and enhance productivity, while inadequate training may contribute to skills gaps, job displacement fears, or inequality among employees. Therefore, the study should be conducted in a manner that respects participants' rights, promotes fairness, and acknowledges the broader role of training in supporting sustainable employment and community development within Zambia's mining sector.

3.1 Objectives

1. To identify new technologies being implemented by FQM and assess whether the training programs are adequate.
2. To evaluate the challenges and opportunities in adopting new mining technologies.
3. To explore the relationship between training and technology adoption at FQM Trident.

4.1 Methods

This research adopted a mixed-methods approach, integrating both qualitative and quantitative techniques. The study specifically focused on FQM Trident, a key player in Zambia's mining sector. This site was chosen due to its significant involvement in adopting new technologies and its commitment to employee training. The target population for this study consisted of 200 employees at FQM Trident, as indicated in the FQM Annual Report (2024). The group included individuals involved in various aspects of training program development, delivery, and technology implementation. The population consisted of approximately 30 managers, 50 trainers, and 120 operational staff from various departments. A purposive sampling technique was employed to select participants who were directly involved in the training and technology adoption processes at First Quantum Minerals (FQM) Trident. The sample size for the quantitative surveys was established at 100 employees, a figure ascertained to guarantee statistical significance with a confidence level of 95% and a margin of error of 5%. For the qualitative data collection, 30 to 50 participants were selected for semi-structured interviews. This selection was based on participants' direct involvement in training and technology adoption, ensuring that the insights gathered were relevant and informed. A structured questionnaire was distributed to a sample of 100 employees to gather quantitative data on training programs, perceived effectiveness, and technology adoption rates. There were 30 to 50 people in the semi-structured interviews, including managers, trainers, and operational staff. Quantitative data from the surveys was analysed using statistical software, such as SPSS. The qualitative data from the interviews was transcribed and analysed thematically. Thematic analysis was conducted to identify key themes and insights related to the research objectives.

5.1 Results

5.1.1 Profile of respondents

The statistical analysis of the respondents' characteristics shows that the majority of participants were operational staff, accounting for 18 (45%), followed by managers at 12 (30%) and trainers at 10 (25%), indicating that operational-level employees formed the largest proportion of the sample. Most of the people who answered the survey had between 4 and 6 years of work experience (15 or 37.5%), while 10 (25%) had 1–3 years and another 10 (25%) had 7 years or more. Only 5 (12.5%) had less than one year of experience, which means that the study mostly got opinions from people who had been working for a while. Regarding educational qualifications, the largest group held Certificate or Diploma qualifications at 14 (35%), followed by Bachelor's degrees at 12 (30%), High School Diplomas at 8 (20%), and Master's degrees at 6 (15%). Overall, the results indicate that the respondents were predominantly operational staff with moderate work experience and mid-level professional qualifications, providing a balanced perspective from both skilled and experienced employees.

Table 1: Demographic Information of the Participants (n=40).

Variables	Frequency	Percentage (%)
Job Title		
Manager	12	30%
Trainer	10	25%
Operational	18	45%
Total	**45**	**100%**

Work Experience		
Less than 1 year	5	12.5%
1-3 years	10	25%
4-6 years	15	37.7%
7 years or more	10	25%
Total	**40**	**100%**
Level of Education		
High School Diploma	8	20%
Certificate/Diploma	14	35%
Bachelor's Degree	12	30%
Master's Degree	6	15%
Total	**40**	**100%**

5.1.2 To identify new technologies being implemented by FQM and assess whether the training programs are adequate.

4.3 Training Programs Implemented at FQM Trident

The findings indicate that a majority of employees at FQM Trident have participated in training programmes related to new technologies, with 30 respondents (75%) reporting participation compared to 10 (25%) who had not, suggesting a relatively high level of exposure to capacity-building initiatives. Among those trained, Technical Skills Training was the most common, reported by 18 respondents (60%), followed by Safety Protocols Training with 15 (50%), and Continuous Professional Development (CPD) with 12 (40%), indicating that the organisation emphasises both operational competence and workplace safety. Regarding the effectiveness of these training programmes in preparing employees for technology adoption, most respondents expressed positive perceptions, as 12 (40%) rated the training as effective and 10 (33.3%) as very effective, while smaller proportions were neutral 5 (16.1%) or considered the training ineffective 2 (6.2%) and very ineffective 1 (3.3%). Overall, these results suggest that training initiatives at FQM Trident are widely implemented and generally perceived as effective in supporting employees' readiness to adopt new technologies.

New Technologies

Implemented Technologies

One participant explained, *"The introduction of autonomous drilling has changed how we operate, but it requires different skills."*

Complexity of Technologies

As one participant stated, *"Some of the new systems are quite complex, and not everyone feels comfortable using them without proper training."*

Adequacy of Training

One participant remarked, *"The training is mostly theoretical; we need more hands-on experience to truly understand how to operate the new machinery."*

Training Effectiveness

Types of Training Received

One participant noted, *"We have sessions on safety, but we also need technical training specific to the new tools."*

Effectiveness of Training

As one participant observed, *"The training helped, but we could benefit from more tailored sessions for specific technologies."*

Suggested Improvements

One participant suggested, *"More practical sessions would make a big difference. We need to practice what we learn in a real-world setting."*

Table 2: Training Programs Implemented at FQM Trident

Statements	Frequency	Percentage (%)
Participated in any training programs related to new technologies at FQM Trident		
Yes	30	75%
No	10	25%
Total	**40**	**100%**
Types of training programs you have attended		
Technical Skills Training	18	60%
Safety Protocols Training	15	50%
Continuous Professional Development (CPD)	12	40%
Total	**40**	**100%**
Effectiveness of training programs in preparing for technology adoption		
Very Effective	10	33%
Effective	12	40%
Neutral	5	16%
Ineffective	2	6%
Very Ineffective	1	3%
Total	**40**	**100%**

5.1.3 To evaluate the challenges and opportunities in adopting new mining technologies

The findings indicate that the major challenge in adopting new technologies was lack of training, reported by 12 respondents (30%), suggesting that inadequate skills and knowledge remain the primary barrier to effective technology use. Resistance from colleagues and technical issues were each cited by 10 respondents (25%), showing that both human factors and system-related problems equally affect technology adoption. Insufficient resources were reported by 8 respondents (20%), indicating that financial and infrastructural limitations also contribute, though to a lesser extent. Regarding opportunities for improving technology adoption, the most frequently suggested strategy was improved training programs, which were identified by 16 respondents (40%), reinforcing the importance of capacity building. Better resources were mentioned by 10 respondents (25%), while leadership support accounted for 8 responses (20%), highlighting the role of management in facilitating change. Enhanced communication was the least cited opportunity, reported by 6 respondents (15%), though it still represents a meaningful factor in supporting successful technology implementation. Overall, the results suggest that strengthening training initiatives, resource allocation, and leadership engagement could significantly improve technology adoption outcomes.

One participant stated, *"We often do not have the tools or resources needed to practice what we learn in training."*

A participant suggested, *"If management could allocate more resources to training, it would significantly improve our ability to adopt new technologies."*

Table 3: Challenges and Opportunities in Adopting New Mining Technologies

Statements	Frequency	Percentage (%)
Challenges in adopting new technologies		
Lack of training	12	30&
Insufficient resources	8	20%
Resistance from colleagues	10	25%
Technical issues	10	25%
Total	**40**	**100%**
Opportunities for improving technology adoption		
Improved training programs	16	40%
Better resources	10	25%
Leadership support	8	20%
Enhanced communication	6	15%
Total	**40**	**100%**

5.1.4 To explore the relationship between training and technology adoption at FQM Trident.

4.5 Relationship between Training and Technology Adoption

The findings indicate a high level of adoption of new technology among employees following training. Out of 40 respondents, 28 (70%) reported adopting new technology, while 12 (30%) indicated that they had not adopted it, suggesting that training has contributed positively to technology uptake but that a notable minority still faces barriers to adoption. Furthermore, among the 28 respondents who had adopted new technologies, 23 (82%) reported being confident in using them, whereas only 5 (18%) indicated a lack of confidence, demonstrating that training not only facilitates adoption but also strengthens user competence and self-efficacy in applying new technological systems. The statistical data indicate a robust correlation between training and both the adoption and confidence in utilising new mining technologies. However, the existing proportions of non-adopters and less confident users highlight the necessity for ongoing capacity-building and subsequent support.

Table 4: Relationship between Training and Technology Adoption

Statements	Frequency	Percentage (%)
Adoption of new technology		
Yes	28	70%
No	12	30%
Total	**40**	**100%**
Confidence in using new technologies post-training		
Confident	23	82%

Not confident	5	18&
Total	**28**	**100%**

A participant emphasized, *"I feel much more confident using the new systems after going through the training."*

One participant shared, *"After our training on the new haulage systems, we saw a noticeable improvement in efficiency and safety on site."*

6.1 Discussion

6.1.1 Training Programs and Their Effectiveness

The study revealed that 75% of participants engaged in training programs, primarily focusing on technical skills and safety protocols. This finding underscores the importance of structured training initiatives in enhancing employee competencies, which are essential for utilising new technologies. The alignment of training programmes with the needs of the organisation is critical, as previous research has indicated that effective training is foundational for successful technology adoption (Kadzamira & Chanda, 2021).

Participants reported that the training programmes at FQM Trident were generally well received, with a majority rating them as effective. This positive feedback suggests that the initiatives are beneficial in preparing employees for the integration of advanced mining technologies. Such training equips employees with the necessary skills and fosters a culture of continuous learning, which is vital in an industry characterised by rapid technological advancements.

However, the data also highlighted certain challenges that persist within the training framework. Notably, issues such as insufficient resources and resistance from colleagues emerged as significant barriers to effective technology adoption. These findings resonate with the conclusions of Mwanza (2019), who emphasised that resistance to change can significantly hinder the adoption of new technologies in the mining sector. This resistance may stem from various factors, including fear of the unknown, lack of confidence in new systems, and inadequate support from management.

6.1.2 Challenges and opportunities in adopting new mining technologies

The analysis revealed several challenges that employees faced in adopting new mining technologies at First Quantum Minerals (FQM) Trident. Among these, the most significant was a lack of adequate training, cited by 30% of participants. This finding indicates that, despite the company's efforts to implement training programs, there are gaps in their coverage or effectiveness. Employees may not be receiving the comprehensive training necessary to fully understand and utilise the advanced technologies being introduced. This aligns with existing literature that emphasises the importance of targeted and adequate training in facilitating successful technology adoption (Kadzamira & Chanda, 2021).

In addition to training deficiencies, resistance from colleagues emerged as another critical challenge, noted by 25% of respondents. This resistance often stems from a cultural barrier that can significantly hinder the integration of new technologies. Employees may feel apprehensive about adopting new systems, leading to a lack of cooperation and engagement. As Nyambe (2017) pointed out, fostering a culture that embraces change is vital for the successful integration of new technologies in the mining sector. Resistance can arise from fear of the unknown, a lack of confidence in one's ability to adapt, or previous negative experiences with change initiatives.

6.1.3 The relationship between training and technology adoption is examined.

A major finding of this study was the strong link between training and technology adoption at First Quantum Minerals (FQM) Trident. Specifically, 70% of participants reported successfully adopting new technologies,

and an impressive 82.1% expressed confidence in their ability to use them following their training. This notable relationship illustrates the vital function that structured training programmes play in facilitating the integration of advanced technologies within the mining sector.

The findings of this research align closely with the Technology Acceptance Model (TAM), developed by Davis (1989), which posits that perceived usefulness and ease of use significantly influence an individual's willingness to adopt new technologies. In the context of FQM Trident, employees who participated in training perceived the new technologies as beneficial and manageable, contributing to their willingness to embrace these innovations. This perception of usefulness is crucial; when employees believe that the technologies will enhance their job performance, they are more likely to engage with and adopt them.

Moreover, the results indicate that well-structured training programs can significantly enhance employees' confidence, which in turn facilitates smooth transitions to new technologies. This is particularly relevant in the mining sector, where operational efficiency and safety are paramount. The mining environment often involves complex machines and systems that require specialised knowledge and skills. As Kadzamira and Chanda (2021) noted, organisations that invest in comprehensive training initiatives see improved technology adoption rates, leading to higher productivity and reduced operational risks.

7.1 Conclusion

The study concludes that FQM Trident has made significant progress in introducing new mining technologies such as autonomous drilling and advanced haulage systems, supported by structured training programmes. With 75% of respondents having participated in technology-related training and 73.3% rating the training as effective or very effective, the findings demonstrate that the organisation has established a relatively strong foundation for capacity building. The high proportion of employees who adopted new technologies (70%) and the substantial majority of adopters who reported confidence in using them (82%) further confirm a positive relationship between training and technology uptake. These results suggest that training initiatives particularly in technical skills, safety protocols, and continuous professional development have played a critical role in enhancing employee readiness, competence, and self-efficacy in operating new systems.

However, the study also concludes that gaps remain in ensuring full and effective technology adoption. Lack of training was identified as the leading challenge (30%), alongside resistance to change (25%), technical issues (25%), and insufficient resources (20%), indicating that both human and structural factors continue to hinder optimal implementation. Qualitative findings further revealed concerns about the predominantly theoretical nature of training and the need for more practical, hands-on sessions tailored to specific technologies. Therefore, while FQM Trident's training programmes are generally adequate and positively linked to technology adoption, strengthening practical components, increasing resource allocation, and enhancing leadership support will be essential to address remaining barriers and maximise the benefits of new mining technologies.

8.1 Implications for practice

The following were the implications derived from the findings:

1. The need for more hands-on, technology-specific training implies that FQM Trident should enhance practical and simulation-based learning to improve competency and reduce skill gaps.
2. Resistance to change indicates the importance of stronger leadership support, communication, and employee engagement initiatives to foster positive attitudes toward technological innovation.
3. The presence of technical issues and insufficient resources suggests that additional financial and infrastructural investment is necessary to ensure smooth technology implementation.
4. The positive link between training and adoption implies that ongoing capacity-building programmes should be sustained and regularly updated to maintain high levels of employee confidence and performance.

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