Impact of Educational Interventions on Mitigating Skills Shortages in the South African Mining Sector

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ABSTRACT

The South African mining sector faces skills shortages due to a limited talent pool with specialised skills, such as engineers, auto-electricians, and mechatronics technicians, which are essential for mining operations. This is despite various educational initiatives put in place by the mines to ensure that the supply of talent meets the sector's skills demand. Therefore, this study investigates the effectiveness of educational interventions on mitigating the skills shortages, as the sustainability of the mining sector is important to the growth of the South African economy due to the pivotal role it plays to the gross domestic product (GDP) growth and employment in the country.

A qualitative approach was used for data collection through interviews with operational managers and beneficiaries of educational interventions in the mining sector. The analysis of the data was conducted through thematic analysis, which enabled the identification of patterns and themes.

The study's key findings revealed that educational interventions such as learnerships, bursaries, and training programmes have built leadership competencies and strong theoretical knowledge. However, practical training has been limited, resulting in a workforce that is not fully skilled to be immediately effective and efficient in mining operations. Furthermore, the educational curricula have not kept up with the technological advancements and rapid adoption of modern technologies, further contributing to the skills shortage challenge.

This study recommends enhancing training programmes with experiential learning methods, aligning educational curricula with modern technologies, and increasing collaboration between mining companies and government to promote STEM education in schools. These strategies aim to build a future-ready workforce, ensuring the sector's sustainability and competitiveness in an increasingly technology-driven environment.

KEYWORDS: Skills shortages, skills development, technical vocational education and training (TVET), autonomous operations, reskilling and upskilling

DECLARATION

I, Sinenhlanhla Randy Nhlapo, declare that this research report is my own work except as indicated in the references. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university.

21 February 2025

Signature

Date

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LIST OF ACRONYMS

4IR – Fourth Industrial Revolution

CEO – Chief Executive Officer

GDP – Gross Domestic Product

MQA – Mining Qualifications Authority

PGM – Platinum Group Metals

STEM – Science, Technology, Engineering, and Mathematics

TIMSS – Trends in International Mathematics and Science Study

TVET – Technical Vocational Educational and Training

CHAPTER 1. INTRODUCTION

1.1 Statement of purpose

This research aims to analyse the perceived impact of educational interventions on mitigating skills shortages in the South African mining sector.

1.2 Background of the study

The South African mining sector is a global leader in minerals such as platinum, manganese, and chrome ore. It continues to attract substantial domestic and international investments, further solidifying its global position in the market (Report Linker, 2023). In 2023, the sector contributed approximately R202.05 billion to the country's gross domestic product (GDP) and employed around 445,000 people, thereby playing a critical role in the country's economic wealth (CEIC, 2023; Cowling, 2024). However, the mining sector faces a significant skills shortage and declining skill levels exacerbated by inadequate mathematics and science proficiency levels and limited career awareness, access, and outdated curricula offered by technical vocational education and training (TVET) colleges (Dikgwatlhe & Mulenga, 2023; James, 2023; Ledwaba & Mutemeri, 2018; Lukhele & Laseinde, 2024). Technological advancements such as autonomous operations have increased the demand for skilled workers, highlighting the mismatch between the current workforce capabilities and industry needs (Leeuw & Mtegha, 2018; Lukhele & Laseinde, 2024; Ngepah et al., 2024).

Mvile and Bishoge (2024) and Ngepah et al. (2024) agree that the skills shortages in South Africa's mining sector necessitate the re-evaluation of educational and training programmes to better align with the industry's evolving needs. Additionally, the infiltration of technological advancements highlighted above necessitates the upskilling and reskilling programmes for rock drill operators and artisans to adapt to new mining processes and technologies (Mvile & Bishoge, 2024).

To address South Africa's mining sector skills shortages, mining companies are proactively engaging in a variety of skills development initiatives, such as learnerships; bursaries; portable skills training in mechanical, electrical, and construction trades; internships; and adult education programmes (Lukhele & Laseinde, 2024; Minerals Council South Africa, 2022). However, despite these efforts, the lack of foundational mathematical and scientific knowledge at the basic school level poses a considerable challenge to the advancement of the mining sector (Oshokoya & Tetteh, 2018). Leeuw and Mtegha (2018) concur that the current educational landscape in South Africa fails to adequately equip students with the requisite skills and knowledge tailored to the demands of the mining industry. While mining companies in South Africa have demonstrated commendable commitment to skills development, there remains a significant gap in skills shortages that threatens the sector's long-term sustainability (James, 2023).

1.3 Research problem

The skills shortages within South Africa's mining sector persist despite the proactive engagement of mining companies in skills development initiatives, as indicated by the Minerals Council South Africa (2022). Despite efforts such as learnerships, bursaries, portable skills training, internships, and adult education programmes, highlighted by the Minerals Council South Africa (2022), there exists a significant gap in the adequacy of mathematics and science education at the primary and secondary levels (Oshokoya & Tetteh, 2018). This deficiency poses a considerable challenge to the mining industry (Leeuw & Mtegha, 2018). Thus, there is an urgent need to address these educational deficiencies to ensure a skilled workforce capable of meeting the mining industry's demands.

1.4 Research questions

The core question in this study is, how effective are educational interventions in mitigating skills shortages in the South African mining sector? The following questions will further supplement this:

i. What is the perceived effect of educational policies on workforce development in the South African mining sector?
ii. What is the perceived effect of educational programmes on workforce development in the South African mining sector?
iii. What skills shortages are there in the South African mining sector?
iv. How do external factors affect skills shortages in the South African mining sector?

1.5 Rationale

In literature, various studies in mining have focused on skills development and training for mining automation (Chirgwin, 2021), skills development gaps in rural communities (Chidzungu & Wafer, 2023), and South Africa's readiness for future mining (Leeuw & Mtegha, 2018; Lukhele & Laseinde, 2024; Oshokoya & Tetteh, 2018). Given that the mining sector is a cornerstone of the South African economy, contributing significantly to GDP, export earnings, and employment (Stilwell et al., 2000), this study aims to examine the impact of educational interventions on mitigating the skills shortages in the mining sector.

1.6 Delimitations of the study

This study is specific in that it seeks to focus on the technical mining skill set at an operational level in the Limpopo province, excluding corporate-level skills and companies operating outside this region. Therefore, a limitation of this study is that it may not shed light on other issues faced within the mining sector.

1.7 Definition of terms

Table 1 provides a definition table relating to the keywords for this study.

Table 1: Definitions of keywords

Definition	Source
Skills shortages can be defined as a situation when there is an insufficient talent pool to fill existing vacancies. **Skills shortage** can be defined as not having enough qualified and experienced workers available for employers to hire for certain jobs or specialisations, leading to difficulties in filling open positions. **Skills shortage** or gap can be defined as the lack of adequately trained workers to occupy open job roles. **Skills shortages** can be defined as a complex and multifaced issue, which fundamentally revolves around the notion that there is a greater demand for certain skills than the available supply.	Thasi and Van der Walt (2020) Xingwana et al. (2019) Balwanz and Ngcwangu (2016) Daniels (2007)
Skills development and training refers to enhancing specific job-related abilities and competencies.	Motsoeneng et al. (2015)
Technical Vocational Education and Training (TVET) colleges are institutions that were established to provide technical skills-based education, enabling students to play a crucial role in the economic landscape of South Africa.	Lukhele and Laseinde (2024)
Autonomous operations refer to technologies that have the highest level of automation and minimal human intervention is required.	McNab and Garcia-Vasquez (2011)
Reskilling can be defined as an initiative undertaken by an organisation to re-train their employees to be potentially employable for current and future needs.	Leeuw and Mtegha (2018)
Upskilling can be defined as the training of employees to acquire new skills, enabling them to take on additional tasks and responsibilities in their existing roles, often as a pathway to career advancement.	De Holanda Araujo (2024)

1.8 Assumptions

The following assumptions were made in this study:

i. Mining companies' skills development initiatives are assumed to be proactive and well implemented based on the Minerals Council South Africa Report (Minerals Council South Africa, 2022).
ii. The primary and secondary education system's inadequacy in mathematics and science education, as highlighted by Oshokoya and Tetteh (2018), is assumed to contribute significantly to the skills gap within the mining sector. The link between inadequate mathematics and science education and skills shortages in the mining sector is rooted in the technical and engineering nature of mining operations. Mining is a highly specialised industry that relies on a workforce skilled in Science, Technology, Engineering, and Mathematics (STEM) disciplines.
iii. Addressing the educational deficiencies in mathematics and science is assumed to be crucial for bridging the skills gap and ensuring a skilled workforce capable of meeting the mining industry's demands.

1.9 Report outline

Chapter 1 is the introduction to the study. It presents the background, research problem, objectives, research questions, rationale, and scope of the study.

Chapter 2 reviews relevant literature and theoretical frameworks, providing context for the study.

Chapter 3 outlines the research methodology, design, data collection methods, sampling strategy, and data analysis techniques used in this study.

Chapter 4 presents the research findings and discussion, linking them to the research questions and literature while identifying key themes and insights.

Chapter 5 provides a consolidated conclusion to the findings of the study in relation to the research questions. It further discusses the recommendations of

the study and provides suggestions for future research, given the limitations of this study.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

This chapter discusses the existing literature and theoretical frameworks relevant to understanding the effectiveness of educational interventions on skills shortages in the South African mining sector. These insights form the foundation of the study, guiding the analysis and interpretation of the research findings.

2.2 Educational policies on workforce development in the South African mining sector

The South African Department of Basic Education highlights that South Africa's educational reforms, anchored by the South African Schools Act of 1996, aim to provide equitable, quality education for all, focusing on eliminating disparities and improving completion rates (Lawrence, 2022). An education system that prioritises quality and accessibility ensures that all individuals, regardless of their background, can contribute effectively to the economy (International Labour Organization, 2021).

By emphasising STEM education amid these reforms, South Africa could address the critical skills gap in sectors that are pivotal for the country's economic development and competitiveness on a global scale (Pols, 2019). A well-educated workforce with a strong foundation in STEM subjects from a young age is essential for fostering innovation, driving technological advancements, and supporting infrastructure development (Fomunyam, 2020; Moyo, 2019). The South African Schools Act's emphasis on reducing educational disparities and enhancing completion rates is expected to result in a workforce that is not only larger but also more diverse and skilled, thereby supporting the country's growth and development objectives (Pols, 2019).

2.2.1 *Proposition 1*

Educational policies that prioritise equitable access to quality education, with an emphasis on STEM subjects, are effective in addressing the critical skills gap in the South African mining sector.

2.3 Educational programmes and workforce development in the South African mining sector

The Minerals Council South Africa (2022) states that skills development initiatives in the South African mining sector have been instrumental in addressing skills shortages and improving workforce capabilities. Studies and reports have also shown that targeted training programmes, learnerships, and upskilling efforts not only enhance the technical and operational proficiency of the workforce but also strengthen safety, environmental awareness, and technological adaptation within the mining operations (Hilson et al., 2019; Mvile & Bishoge, 2024; Serfontein-Jordaan & Dlungwane, 2022). The national government of South Africa points out that the Mining Qualifications Authority (MQA) was established to play a pivotal role in setting standards and frameworks for skills development to improve workforce competency levels across various roles within the sector. Xingwana et al. (2019) agree that corporate-led initiatives have demonstrated success in fostering a more skilled and adaptable workforce, highlighting the importance of industry-wide collaboration in skills development. However, challenges in matching skills training with evolving industry needs and ensuring equitable access to training opportunities remain critical areas for ongoing attention within the sector as the skills shortages persist (Oshokoya & Tetteh, 2018).

2.3.1 *Proposition 2*

Educational programmes are partially effective, leading to slight improvements in technical skills, but they fall short of advanced competencies and holistic workforce development needed to fill the persistent skills gap.

2.4 Skills shortages in the South African mining sector

The South African mining sector is confronting a severe shortfall in essential occupational skills, driven by a demand for qualified professionals that significantly exceeds supply (Thasi & Van der Walt, 2020). This shortage began in 2007 and persists, affected by the limited availability of qualified engineers and artisans, who are crucial for maintaining operational efficiencies (Musingwini et al., 2013). The skills shortage not only burdens current employees, leading to decreased job satisfaction and organisational performance but also threatens the country's economic growth (Abenov et al., 2023; Thasi & Van der Walt, 2020). Nearly two-thirds of mining CEOs believe that these shortages will significantly affect industry profitability over the next decade (Jackson, 2023). Addressing this critical issue is essential amid the increasing automation and digitisation of mining operations to ensure the sector's resilience and competitiveness.

The Fourth Industrial Revolution (4IR) has now impacted the mining sector with innovation that has changed how technology is applied in the processing of minerals and metals (De Holanda Araujo, 2024). De Holanda Araujo (2024) further argues that 4IR has led to a demand in evolved skills of miners and changed job descriptions. These positions now require a workforce that is highly knowledgeable in technology and well trained professionally. In the future, mines are expected to be entirely autonomous, utilising a variety of advanced technologies, analytical tools, and machines capable of engaging with the rock and the environment (Oshokoya & Tetteh, 2018). This increased level of automation also requires an advanced technical skill set, which will further exacerbate the skills shortages issue in the mining industry (Xingwana et al., 2019).

2.4.1 *Proposition 3*

The rapid adoption of modern technology has transformed the South African mining sector, creating a skills shortage of workers with advanced technological expertise and proficiency in analytical tools.

2.5 The effect of external factors on skills in the South African mining sector

The structural challenge faced by many mining companies, especially in remote areas, includes a lack of important facilities such as private hospitals, schools, and places for entertainment, which makes these areas less attractive for families and the younger generation (Abenov et al., 2023). Additionally, mining jobs are often seen as physically tough and risky (Lane et al., 2015). Abenov et al. (2023) further points out that once someone is employed in the industry, other problems often arise, such as limited skills and development training opportunities beyond what the current role requires and few clear paths for career advancement beyond middle management exist.

The mining industry experiences cycles, with shifts in supply, demand, and pricing, which influence business conditions. These fluctuations lead to periods of high and low activity, commonly referred to as “booms” and “busts” (Baskaran, 2021). A recent example is the downturn in the platinum group metals (PGM) market, leading Anglo-American Platinum to retrench 3,700 employees from its South African operations in response to declining market prices (Mining Review Africa, 2024). Such instability highlights the sector’s volatility and contributes to its unattractiveness to a skilled workforce seeking job security.

2.5.1 *Proposition 4*

The mining industry’s structural and cyclical challenges contribute to its struggle to attract and retain a skilled workforce. This highlights the need for improved infrastructure, training programmes, and job security measures to enhance its appeal.

2.6 Analytical framework

This study draws on three established theoretical frameworks to provide a scholarly foundation for understanding how educational interventions can address skills shortages in the mining industry: experiential learning theory, constructive alignment theory, and Self-efficacy theory.

2.6.1 *Theoretical framework*

Experiential learning theory emphasises the importance of a hands-on approach, which is critical for skill acquisition (Clausen & Binder, 2017). It supports the idea that effective education must go beyond theoretical learning, offering real-world applications through internships, simulations, and practical training. In the mining sector, where operational experience is vital, experiential learning equips learners with first-hand exposure to industry practices, enhancing job readiness.

Constructive alignment theory highlights the need for coherence between learning outcomes, teaching methods, and assessment strategies (Nightingale et al., 2007). It ensures that educational programmes are deliberately structured to produce graduates whose skills align with industry requirements. Within this study, constructive alignment provides a basis for evaluating whether current curricula effectively address the competencies demanded by the mining sector.

Self-efficacy theory introduces a psychological dimension, focusing on the learners' belief in their capabilities, which is instrumental in their engagement and success in skills development (Tannady et al., 2019). Self-efficacy is the belief in one's ability to succeed in specific situations. Applied to education, it suggests that learners with higher self-confidence are more likely to persist, perform, and apply their skills effectively. This theory explains why educational interventions must also address psychological dimensions, such as motivation and learner support, to be truly effective.

Together, these theories provide an integrated foundation that not only identifies educational shortcomings but also explains their root causes. They support the formulation of targeted, evidence-based strategies to mitigate the skills gap. Practical learning experiences, well-aligned educational objectives, and enhanced learner confidence collectively contribute to developing a workforce that is better equipped to meet the evolving demands of the mining industry.

These theoretical frameworks will guide both data interpretation and the development of recommendations, offering insights for mining companies and policymakers on strengthening skill acquisition and retention within the sector's labour market.

2.6.2 *Conceptual framework*

Figure 1 shows the conceptual framework.

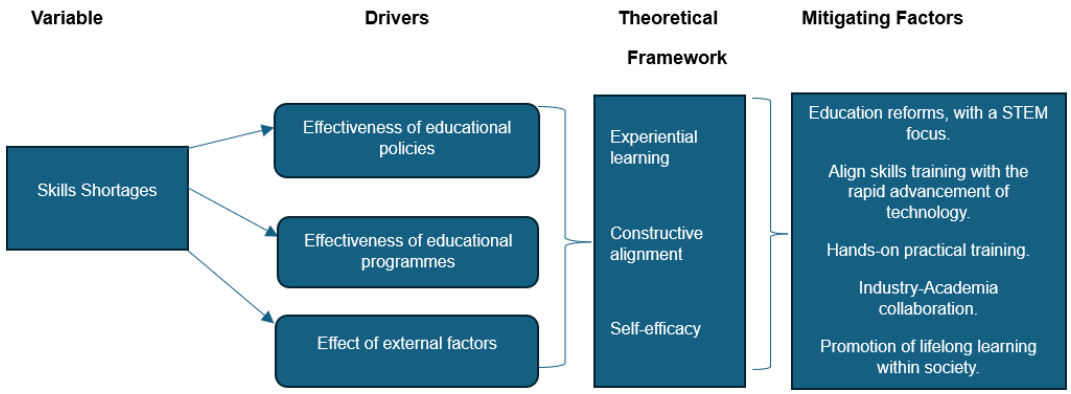

Figure 1: Conceptual framework

Source: Adapted from Baskaran (2021), De Holanda Araujo (2024), Pols (2019), and Thasi and Van der Walt (2020)

Based on the theories outlined above, the conceptual framework illustrates the relationship between the main variable (skills shortages), its drivers, and potential mitigating strategies.

Table 2: Consistency table: Research questions and propositions

RQ #	Research question	Prop #	State proposition
i.	What is the perceived effect of educational policies on workforce development in the South African mining sector?	1	Educational policies that prioritise equitable access to quality education, with an emphasis on STEM subjects, is effective in addressing the critical skills gap in the South African mining sector.
ii.	What is the perceived effect of educational programmes on workforce development in the South African mining sector?	2	Educational programmes are partially effective, leading to slight improvements in technical skills, but they fall short of advanced competencies and holistic workforce development needed to fill the persistent skills gap.
iii.	What skills shortages are there in the South African mining sector?	3	The rapid adoption of modern technology has transformed the South African mining sector, creating a skills shortage of workers with advanced technological expertise and proficiency in analytical tools.
iv.	How do external factors affect skills shortages in the South African mining sector?	4	The mining industry's structural and cyclical challenges contribute to its struggle to attract and retain a skilled workforce. This highlights the need for improved infrastructure, training programmes, and job security measures to enhance its appeal.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides a discussion of the research design and methodology used for conducting this study. The methodology includes the research approach, data collection methods, sample population, research instrument, and analysis strategies. Potential limitations, quality and ethical considerations are also covered.

3.2 Research approach

This study adopts a qualitative approach to gain an in-depth, contextual understanding of the implementation and effects of educational interventions in the South African mining sector, allowing for the exploration of emergent themes and capturing perspectives, which are crucial for assessing the subjective effectiveness of interventions (Peterson, 2019).

3.3 Research design

A cross-sectional design was adopted, which involves collecting data at a single point in time to analyse the current state of educational interventions and their impact on skills shortages in the South African mining sector. This approach enabled a snapshot of the assessment of educational interventions and their effectiveness in workforce development. The main advantage of cross-sectional design is that many findings can be used to create an in-depth research study, and the disadvantage is that it is susceptible to biases (Wang & Cheng, 2020).

3.4 Data collection methods

Primary data sources were used for this study to gain a comprehensive understanding of the topic. The data was obtained through semi-structured interviews.

3.5 Population and sample

The study population included operational managers and beneficiaries of educational interventions within the mining sector in South Africa, providing a dual perspective on both the operational challenges and outcomes of educational interventions. The unit of analysis for this study is the individual, representing their own perspective.

3.5.1 *Population*

The population of operational managers in South Africa is approximately 268 (Association of Mine Managers of South Africa, n.d.) and approximately 20,000 beneficiaries of educational interventions initiated by the mines (Masuku, 2023).

3.5.2 *Sample and sampling method*

Judgemental sampling was used to identify participants for this study. The choice of sample was guided by the need to target individuals who possess the relevant knowledge and experience on the subject, ensuring that the sample aligns with the research objectives and provides meaningful insights (Mocănașu, 2020).

The sample included five operational managers, working across various departments in the mine, as they deal with the day-to-day operational challenges brought about by the skills shortages, and five educational programme beneficiaries who have gone through bursary schemes, learnerships, or company-driven skills development initiatives, as they represent the direct targets of educational interventions. Therefore, the total sample is ten participants.

This non-probabilistic sampling method employed allowed for a deep dive into the target, allowing for contextual understanding that is likely to uncover nuanced influences of the interventions (Tekin & Akyol, 2019).

3.6 The research instrument

Interview protocol was used as a procedural guide in directing this qualitative research (Jacob & Furgerson, 2012). Two interview protocols were developed, one for the operational managers and another for the beneficiaries of the educational interventions, with an emphasis on building trust and rapport (Jacob & Furgerson, 2012).

Interviews with open-ended questions were the primary research instrument, designed to capture the experiences of participants, which contributed valuable qualitative data (Jacob & Furgerson, 2012). The interview guide has two sections, each with its objectives. Section 1 was meant to collect demographic data of participants, while section 2 collected data to answer the research questions (refer to the interview guide in Appendix A).

3.7 Procedure for data collection

The interviews were conducted online via Microsoft Teams for the convenience of the participants. Requests for participation in the online interviews were sent via email and telephone to the operational managers who have experience with workforce development and beneficiaries of educational interventions who have first-hand experience with educational programmes within the mining sector. Each interview lasted approximately 30 minutes and was conducted in a semi-structured format, allowing for both guided questions and open-ended discussions. Follow-up questions were used to clarify responses and gain deeper insights where necessary.

3.8 Data analysis strategies and interpretation

Thematic analysis was used to analyse the data collected for this study. According to Braun and Clarke (2006), thematic analysis is a method for analysing qualitative data that involves reading through a set of data and looking for patterns in the meaning of the data to find themes. It is an active process of reflexivity in which the researcher's subjective experience is at the centre of making sense of the data. Thematic analysis is suitable when the study tries to understand a set of thoughts, experiences, or behaviours in a data set. This approach ensured that the data presented was in a systematic manner, presenting credible responses to the research questions and objectives (Thomas & Harden, 2008). Guest et al. (2012) emphasise the importance of following a series of steps to analyse research data, identifying key themes and patterns that respond to the research questions. The following steps were followed in the data analysis process:

- The researcher transcribed the interviews verbatim into a Microsoft Word document.
- Each transcript was manually read through multiple times to identify recurring patterns and emerging themes related to the research objectives.
- A thematic analysis approach was applied, allowing the researcher to systematically uncover key themes that emerged naturally from the data.
- Responses were manually coded and categorised into distinct themes that arose from the interviews.
- The themes associated with each interview question were organised and compiled into an Excel workbook for a structured analysis.
- The Excel data was then exported into the R statistical software (R Core Team, 2024) to quantify the frequency of themes and generate bar graphs illustrating the percentage distribution of key findings.

3.9 Possible limitations and challenges of the study

The limitation of this study was its reliance on a limited sample, which may not fully represent the broader South African mining sector.

3.10 Quality assurance

Quality assurance measures such as data triangulation and reflexive journaling were implemented to enhance transferability, dependability, credibility, and confirmability to ensure that qualitative findings are both reliable and valid (Dado et al., 2023).

3.10.1 *Transferability*

This study's insights were designed to be transferrable to similar contexts, providing valuable insights for future research on educational interventions undertaken by South African mines to mitigate skills shortages (Peterson, 2019). To enhance transferability, a detailed description of the study setting, participants, and the nature of educational interventions was provided, allowing for future researchers to determine the applicability of the findings in similar context.

3.10.2 *Dependability*

This study applied careful consideration by selecting participants through judgemental sampling of individuals who are directly impacted by the educational interventions initiated by the mining sector in South Africa. This approach ensured that the findings accurately reflect the real-world effects of these interventions, thereby enhancing the dependability of the research outcomes (Lawrence, 2022).

3.10.3 *Credibility*

This study made use of data triangulation to enhance the trustworthiness of the data, analysis, and findings by capturing different perspectives that reflect the true impact of these initiatives (Peterson, 2019). The following steps were taken:

- Primary data triangulation: The study collected data from both operational managers and beneficiaries of educational interventions to provide multiple perspectives on the impact of training programmes. This helped cross-verify findings and mitigate biases.
- Researcher reflexivity was maintained through a reflexive journal, documenting the researcher's thoughts, biases, and decisions throughout the data collection and analysis.
- A peer debriefing process was conducted, where another researcher with expertise in qualitative research reviewed the coding and theme identification process to ensure consistency.
- Detailed descriptions of participant responses and the operational context of the mining sector were included in the findings. This provides transparency and allows readers to assess the applicability of the results in similar contexts.

3.10.4 *Conformability*

The researcher kept and maintained a reflexive journal when collecting and analysing the data to ensure that personal biases and subjective interpretations were acknowledged and mitigated, thereby enhancing the conformability and integrity of the research findings (Dado et al., 2023).

3.11 Ethical considerations

The researcher followed ethical practices that guided the researcher-participant relationship, ensuring transparency, respect for the participant's confidentiality, and the integrity of the research process (Peterson, 2019).

Consent forms were sent to participants prior to the interviews taking place, confirming their agreement to participate in the study. Participants were also informed of their right to withdraw at any time should they wish to do so. Confidentiality of the participants was also maintained, as their names and other personal information were not disclosed in the study, as indicated in the consent forms that they signed.

Table 3: Consistency table: Research questions, propositions, data collection, and data analysis

RQ #	Research question	Prop #	State proposition	Data collection detail	Data analysis method
i.	What is the perceived effect of educational policies on workforce development in the South African mining sector?	1	Educational policies that prioritise equitable access to quality education, with an emphasis on STEM subjects, is effective in addressing the critical skills gap in the South African mining sector.	Interview guide questions Operation managers: Q1 Beneficiaries: Q1	Thematic analysis
ii.	What is the perceived effect of educational programmes on workforce development in the South African mining sector?	2	Educational programmes are partially effective, leading to slight improvements in technical skills, but they fall short of advanced competencies and holistic workforce development needed to fill the persistent skills gap.	Interview guide questions Operation managers: Q2 & Q3 Beneficiaries: Q2, Q3 & Q4	Thematic analysis
iii.	What skills shortages are there in the South African mining sector?	3	The rapid adoption of modern technology has transformed the South African mining sector, creating a skills shortage of workers with advanced technological expertise and proficiency in analytical tools.	Interview guide questions Operation managers: Q4 & Q5 Beneficiaries: Q5	Thematic analysis

RQ #	Research question	Prop #	State proposition	Data collection detail	Data analysis method
iv.	How do external factors affect skills shortages in the South African mining sector?	4	The mining industry's structural and cyclical challenges contribute to its struggle to attract and retain a skilled workforce. This highlights the need for improved infrastructure, training programmes, and job security measures to enhance its appeal.	Interview guide questions Operation managers: Q6 Beneficiaries: Q6	Thematic analysis

CHAPTER 4. RESEARCH FINDINGS AND DISCUSSION

4.1 Introduction

This chapter presents the data analysis and provides a discussion of the findings of the study obtained from interviews conducted with operational managers and beneficiaries of educational interventions in the South African mining sector. The results are presented using charts and are supported by verbatim quotes from the research participants to facilitate understanding of the findings. The chapter begins by presenting the profiles of the participants to contextualise their perspectives. This is followed by the analysis of interview findings. The discussion further explores the specific types of educational interventions initiated by the mines, such as leadership, bursaries, and training programmes. It evaluates their effectiveness in addressing the persistent skills shortages in the industry.

Based on the findings gathered during the interviews, key themes emerged that provided a detailed analysis of how these interventions impact workforce development, operational effectiveness, and the industry's readiness to meet technological and operational demands.

4.2 Participant profiles

Table 4 provides an overview of the ten participants interviewed to assess the role of educational interventions in addressing skills shortages within South Africa's mining sector. The group comprised five operational managers from diverse mine departments, each with direct involvement in educational programmes initiated by the mine. The remaining five participants were employees who benefitted from these initiatives, including bursary schemes, leadership training, and company-led skills development programmes.

Table 4: Participant profile

Operational managers		
Participant	**Position**	**Years in management**
P1	Plant manager	13
P2	Section manager	4
P3	Engineering manager	23
P4	Mineral resources manager	13
P5	Mining manager	5
Beneficiaries of educational interventions		
Participant	**Position**	**Educational intervention**
P6	Chief safety officer	Management development programme
P7	Mine overseer	Bursary and graduate in-training programme
P8	Metallurgist	Junior leadership development programme
P9	Consulting metallurgical engineer	Bursary
P10	Plant superintendent	Bursary

4.3 Analysis of findings from interviews

This section presents an analysis of the findings from the interviews conducted with the participants and is structured according to each research question.

Table 5: Overview of findings

Research question	Themes
i. What is the perceived effect of educational policies on workforce development in the South African mining sector?	• Access to quality education • STEM focus on educational policies • Government and industry collaboration
ii. What is the perceived effect of educational programmes on workforce development in the South African mining sector?	• Talent development • Sustainable talent pool • Limited practical training • Retention challenges • Leadership and management skills development • Experiential learning
iii. What skills shortages are there in the South African mining sector?	• Specialised technical skills • Instrumentation and auto-electrics expertise • Mechanisation and automation skills • Reduced machine availability • Productivity losses
iv. How do external factors affect skills shortages in the South African mining sector?	• Heightened skills shortages due to geographical and infrastructure challenges • Market volatility is a barrier to talent attraction • Technology advancements increase demand for specialised roles

4.3.1 *Findings on educational policies*

Participants were asked to provide their opinion on the effectiveness of educational policies on workforce development in the South African mining sector. A few of the direct quotations from the participants that highlight the key points raised during the interview are summarised below.

Quotes by participants
P1: "While educational policies promote access to education, children from rural and underprivileged communities do not have access to good quality education, especially maths and science, which limits their ability to enter the mining sector". *P3:* "Government support through initiatives like the MQA plays a critical role in supporting the mining industry through training and learnerships to develop a skilled workforce". *P9:* "South Africa's educational policies must place greater emphasis on strengthening STEM education, as deficiencies in this area are a key contributor to the skills gap in the mining sector."

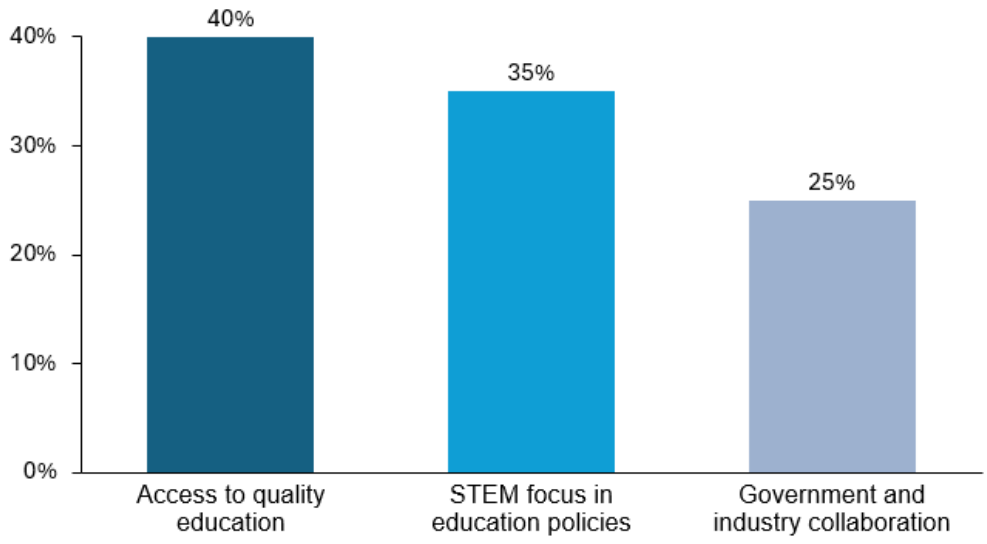

Figure 2: Educational policies

As illustrated in Figure 2, 40% of the participants indicated that access to quality education remains a challenge, 35% revealed that there should be a STEM focus on educational policies, and 25% highlighted that government and industry collaboration is required to effectively address the skills shortage issue. The themes that emerge from the findings are as follows:

- ***Access to quality education:*** Educational policies aim to provide access to education, but inequalities persist, mainly for students in rural areas. They have limited access to quality mathematics and science education, which restricts their ability to enter technical fields within mining.
- ***STEM focus on education policies:*** Existing policies do not sufficiently emphasise STEM education, which is necessary for equipping future professionals with the technical skills required in the mining sector.
- ***Government and industry collaboration:*** Government initiatives such as the MQA contribute to workforce development through training programmes and learnerships, helping in bridging the skills shortages in the mining sector.

The findings reveal that while educational policies in South Africa try to ensure access to education, disparities in quality persist, particularly in rural areas. Additionally, existing policies do not place sufficient emphasis on STEM education, which is critical for equipping students with the technical expertise required to meet the needs of the mining sector. However, collaborative efforts between government and industry, such as training initiatives led by the MQA, play a crucial role in bridging these gaps. By enhancing STEM education and strengthening industry-government partnerships, South Africa can create a more sustainable pipeline of skilled professionals to support the long-term growth and competitiveness of the mining industry.

4.3.2 *Findings on educational programmes*

Operational managers were asked to discuss what educational programmes have been put in place by the mines to address skills shortages.

Quotes by participants
P2: “The mine has implemented section 18.1 learnerships which are aimed at identifying skill-related talent from within the organisation and developing it into the required skill. The mine also has internships (18.2), which are open to external applicants as well. These are aimed at attracting individuals who already have the required qualification and providing in-house training to enhance the skill and facilitate job readiness.” *P3:* “The mine is actively working to bridge the skills gap by identifying talent within the local community and providing educational and technical training through tailored programmes. These initiatives focus on developing artisans, auto-electricians, and mechatronic engineers, addressing high turnover rates and ensuring a sufficient talent pool to meet operational demands.” *P5:* “Through the Corporate Social Responsibility programme, the mine established a private TVET college that offers technical training for artisan trades in engineering and mining, with the aim of being able to take these graduates in after completion of their studies.”

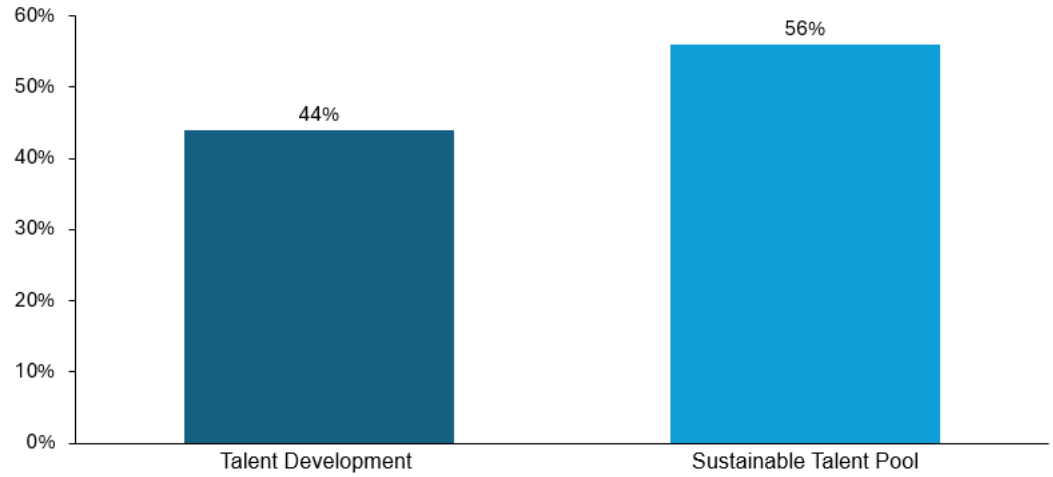

Figure 3: Educational programmes

As illustrated in Figure 3, 56% of the responses indicated that educational programmes are aimed at creating a sustainable talent pool within the community in which the mine operates, and 44% revealed that they are aimed at talent development. Therefore, the themes that emerge from the findings are:

- ***Talent development:*** The mines take prospective employees and currently employed individuals through learnerships, internships, and

TVET college training with the aim of creating a pipeline of skilled individuals who will be ready to join the workforce after completing their studies and in-house training programmes.

- ***Sustainable talent pool:*** Programmes targeting local community talent include tailored educational and technical training. These initiatives are designed to build a sustainable talent pool from within the community.

The findings demonstrate a strategic commitment by the mines to workforce development, focusing on cultivating the necessary skill sets to meet current and future operational needs.

Operational managers were further asked if they thought that the programmes were successful, and why? If not, where have they fallen short?

Quotes by participants
P1: "The programmes tend to be focused more on theory and when someone gets back, you find that they cannot apply what they have learned. So, there's still a need for practical training for the person to be fully ready for the job." *P3:* "The people that are put through the training programmes are given good theoretical knowledge, but the time given to practical exposure is very limited." *P5:* "The interventions have been successful in part, in that once the in-house training is completed, the mine has a wide pool of talent from which the required skill can be sourced, however, once appointed, it also becomes very difficult to retain the skill as there is always financially lucrative offers presented by external companies."

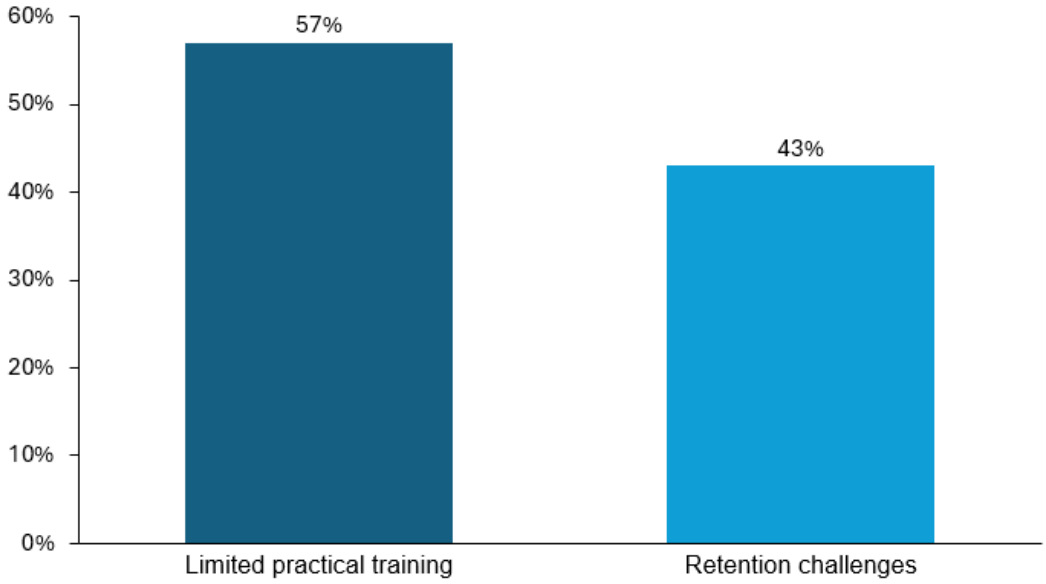

Figure 4: Effectiveness of the educational programmes

As shown in Figure 4, 57% of the responses implied that educational programmes comprised of limited practical training, while 43% highlighted retention challenges. Hence, the themes that emerge from the findings are:

- ***Limited practical training:*** Participants consistently highlighted that while educational programmes provide a strong theoretical foundation and create a pool of talent, workforce needs are not sufficiently addressed, as there is limited practical training.
- ***Retention challenges:*** When educational programmes succeed in developing skilled workers, retaining this talent proves challenging due to competitive offers from external companies who are also trying to fill the gap of skills shortages.

The findings reveal that while the programmes provide strong theoretical knowledge and help create a talent pool for the industry, they fail to offer sufficient practical training, leaving trainees underprepared for real-world job demands. Mining education at various institutions mainly focuses on theoretical studies and laboratory-scale experiments, offering little to no opportunities for practical training at mining sites (Mischo et al., 2020). Additionally, retaining skilled

employees remains a significant challenge, as external companies often present more lucrative opportunities. These insights highlight the need for a balanced approach that combines theoretical and hands-on training while addressing retention issues to maximise the impact of these programmes.

Beneficiaries of educational interventions were asked which educational programme they were part of and what specific skills and knowledge they gained through the programme.

Quotes by participants
P6: "Management development programme. Skills gained include general management and leadership skills". *P7: "Bursary* programme and subsequently acquired a BSc in Engineering, Mining and Minerals. Skills gained is exposure to all critical functions and methods of underground mining." *P8:* "Junior leadership development programme". The skills learned through the programme was that of leading and managing a team. We also learned problem-solving skills and how to tackle them as a team." *P9*: "Bursary programme, resulting in me getting a BSc in Metallurgy and an internship. Skills gained included theoretical work in metallurgy and the internship provided on the job training." *P10:* Bursary resulting in a Bachelor of Technology in Extraction Metallurgy. Skills acquired include theoretical and practical knowledge in metallurgical work."

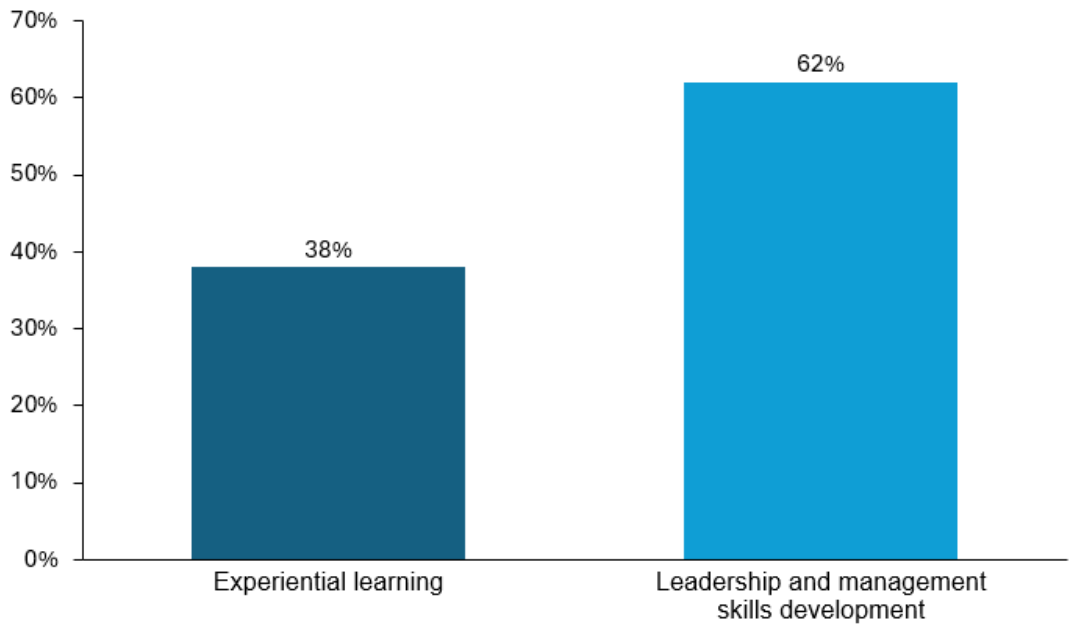

Figure 5: Types of educational programmes and their effectiveness

As shown in Figure 5, 38% of the responses suggested that the educational interventions comprised of experiential learning, while 62% of the responses suggested that they comprised of leadership and management skills development. Therefore, the themes that emerged from the questions include:

- ***Leadership and management skills development:*** Educational programmes initiated by the mines equip employees with essential leadership, team management, and problem-solving skills.
- ***Experiential learning:*** Bursary programmes, which often result in internships, combine academic learning with hands-on training, providing candidates with the foundational knowledge and practical skills needed for specialised roles in mining.

These themes reflect educational programmes' focus on building leadership and technical competencies while also emphasising the integration of theoretical learning with practical applications to prepare students for industry-specific roles. However, there are shortcomings, as only a few participants indicated the presence of experiential learning, which is critical for bridging the skills gap.

4.3.3 *Findings on skills shortages*

Operational managers were asked to discuss what skills shortages are present within their operational areas. The direct quotations from the participants that highlight the key points raised during the interview are summarised below.

Quotes by participants
P1: "Skills shortages are in instrumentation and mechanised functions." *P2: "*Engineering technical skills, particularly trackless mining machinery (TMM) artisans such as diesel mechanics and auto-electricians." *P3:* "We face a shortage of skills related to the latest machinery, particularly electric and battery-operated machines, which are more electronically and mechanically integrated. These modernised and mechanised systems require expertise in auto-electrics and mechanical and electronic engineering." *P4: "*Certified Rock Engineers and Senior Mine Planners with the required industry experience." *P5: "Auto electricians"*

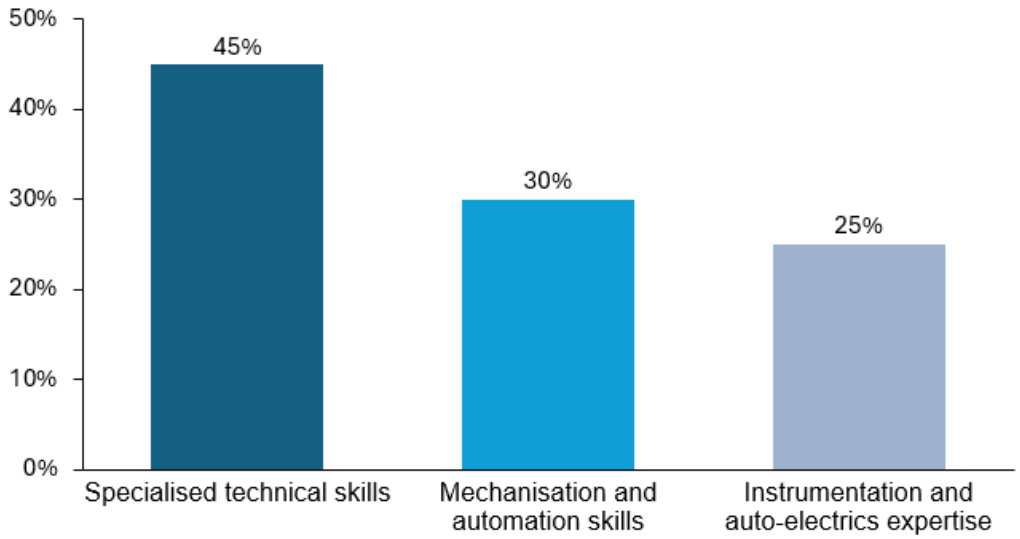

Figure 6: Skills shortages

As shown in Figure 6, 45% of the responses implied that skill shortages relate to specialised technical skills, 30% to mechanisation and automation skills, and 25% to instrumentation and auto-electrics expertise. Accordingly, the emerging themes from this question are:

- ***Specialised technical skills:*** A recurring theme is the shortage of specialised technical skills required for modern mining operations. Participants highlighted the need for trackless mining machinery (TMM) artisans, such as diesel mechanics and auto-electricians. Skills related to modernised and mechanised systems, particularly for machinery that integrates mechanical and electronic components.
- ***Instrumentation and auto-electrics expertise:*** Adopting advanced machinery, such as electric and battery-operated equipment, has created a demand for expertise in instrumentation and auto-electrics. This reflects the challenge of aligning workforce capabilities with evolving technological requirements in the mining sector.
- ***Mechanisation and automation skills:*** As operations become increasingly mechanised, there is a heightened demand for skills in mechanised functions, emphasising the need for workers who can effectively operate and maintain automated systems.

These themes highlighted the multifaceted nature of skills shortages in the mining sector, emphasising gaps in technical expertise and the need for alignment with technological advancements, which is essential for productivity and safety. De Holanda Araujo (2024) notes that the mining industry faces a shortage of skilled professionals to fill both the existing positions and the future roles created by the shift towards automation. This is evident in the findings that there is an ongoing challenge to equip the workforce with the specialised technical expertise required for modern operations. The growing reliance on mechanisation and automation further amplifies the demand for skilled professionals capable of adapting to new technologies and maintaining advanced systems (Vogt & Hattingh, 2016).

The next question was, how do these shortages impact the productivity of the mining operations?

Quotes by participants
P2: “The operation is fully mechanised and the shortage of TMM artisans always results in delays when it comes to equipment and machinery repairs. The ripple effect is an increased unavailability of machines and the subsequent inability to meet production targets.” *P3:* “About 70% of mining operations are mechanised, meaning insufficient labour significantly impacts production. For instance, a shortage of auto-electricians results in prolonged downtimes during machine breakdowns, as machines remain idle for hours awaiting repairs. This directly affects our mean time to repair and, consequently, underground production and overall productivity.”

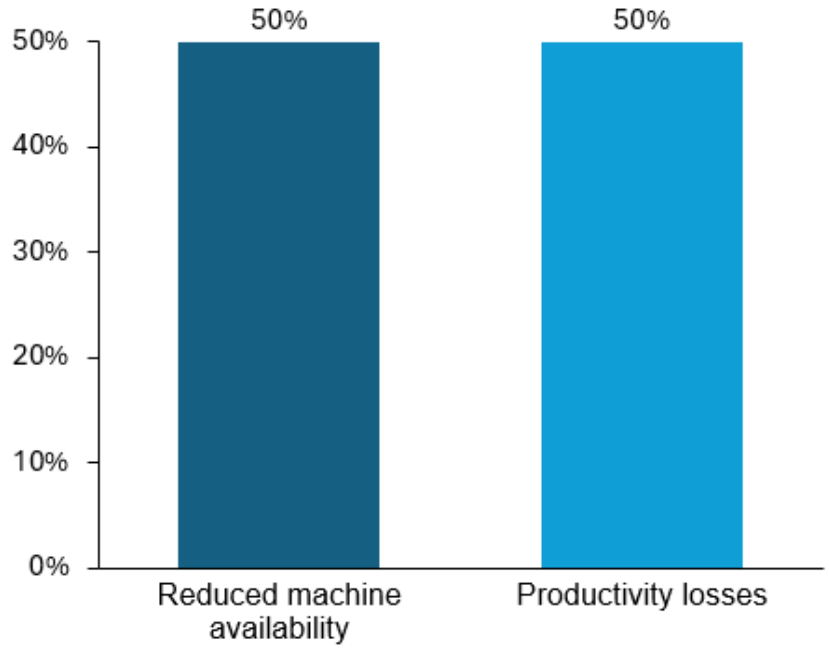

Figure 7: Impact on the productivity of mining operations

As shown in Figure 7, 50% of the responses indicated productivity losses, and the other 50% showed reduced machine availability as the impact of skill shortages, which hinders the productivity and efficiency of mining operations. Consequently, the emerging themes from this question are:

- ***Reduced machine availability:*** The shortage of skilled labour leads to delays in machinery repairs and prolonged downtimes. This reduces the availability of critical equipment, creating bottlenecks in mechanised operations and disrupting the production process.
- ***Productivity losses:*** Insufficient labour directly impacts key performance metrics, affecting operations. This results in inefficiencies that hinder the ability to meet production targets, significantly reducing overall productivity in mining operations.

The findings highlight two key impacts of skills shortages on mining operations. Firstly, operational delays and reduced machine availability lead to prolonged downtimes and disruptions in the mechanised processes. Secondly, these delays contribute to significant productivity losses, with critical metrics such as mean time to repair being adversely affected, ultimately hindering the achievement of production targets and overall operational efficiency.

4.3.4 *Findings on external factors and the effect on skills shortages*

Operational managers provided insights on how external factors, such as technology advancements and industry shifts, affect skills shortages.

Quotes by participants
P1: “The mine stays in close contact with the technology manufacturers and if there is a new technology out, the mine sends the relevant engineers where in the world to gather information and see how the machinery can be applied in our operations. Also, we rely on the manufactures to send people to train our employees in the new machinery that we purchase.” *P2:* “Modern day society is not attracted to the mining industry because the operations are in remote areas and it’s difficult to raise a family because in some areas there are no private schools.” *P5:* “The mining industry is volatile because the markets operate in cycles. When it’s a market downturn and profits are low, companies often resort to retrenchments which then scares people from the mining industry.”

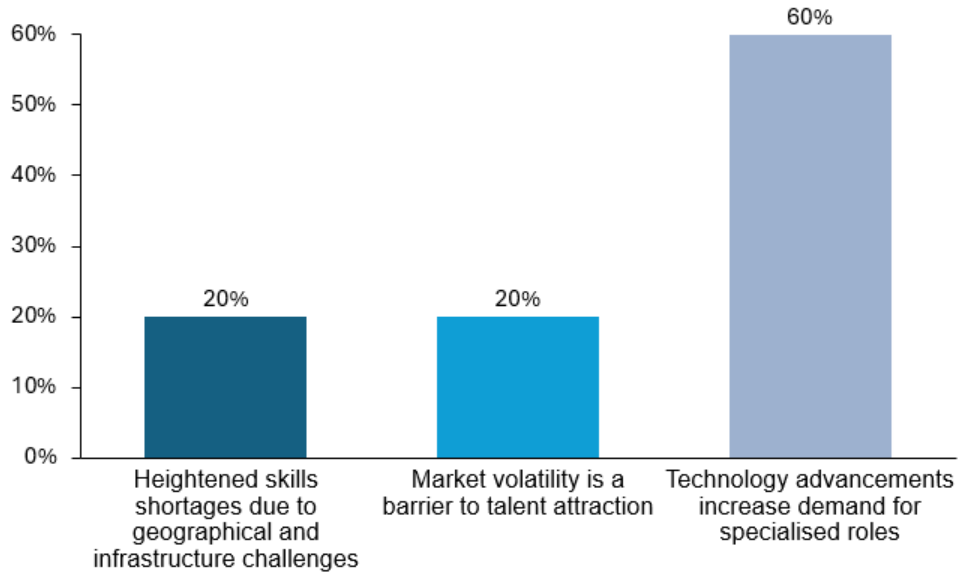

Figure 8: External factors

As shown in Figure 8, 20% of the responses indicated that external factors bring about heightened skills shortages due to geographical and infrastructure challenges, 20% highlighted market volatility as a barrier to talent attraction, and 60% noted that technology advancements increase demand for specialised roles. Therefore, the emerging themes from this question are:

- **Heightened skills shortages due to geographical and infrastructure challenges*:*** The remote locations of mining operations make it difficult for professionals to raise families, mainly due to a lack of essential services such as private schools and hospitals. This discourages skilled and well-educated individuals from pursuing careers in mining and therefore limits the skills available to work in the mining sector.
- ***Market volatility is a barrier to talent attraction:*** The cyclical nature of commodity markets creates instability and job insecurity. During economic downturns, companies often resort to retrenchments, making the industry less attractive to skilled professionals who seek stability in their careers.

- ***Technology advancements increase demand for specialised roles:*** The rapid adoption of technology drives a growing demand for specialised roles. These roles are anticipated to be critical for the future of mining.

The findings highlight the existing external factors that affect skills shortages in the South African mining sector. These include the unattractiveness of the mining sector due to its remote locations and lack of services found in affluent areas, such as private schools and healthcare facilities. This discourages skilled professionals from pursuing careers in mining. Market volatilities, which bring about job insecurity, are also a factor that contributes to individuals not entering or remaining in the industry. Technology advancements further create a demand for specialised roles, widening the skills shortages gap. Despite these challenges, mining companies are making efforts to stay aligned with technological advancements by collaborating with equipment manufacturers to provide up-to-date training on new machinery and automation processes. Dennison (2023) emphasises that the fast pace of technological advancements, evolving industry trends, and growing demand for specialised skills have made upskilling essential for career growth. Collaborative partnerships with government and industry stakeholders will be required to develop the mining towns so that they can attract and retain talent.

4.4 Discussion on the findings

This section will discuss the findings of the study.

4.4.1 *What is the perceived effect of educational policies on workforce development in the South African mining sector?*

The South African Schools Act of 1996 has done well in ensuring an educated society; however, it does not assist in addressing the skills shortages within the mining sector, which is reliant on STEM-focused subjects. The quality of education in these subjects has some shortcomings, especially in schools located

in rural areas. This is further supported by the Trends in International Mathematics and Science Study (TIMSS) 2019 Report for South Africa, which reveals that Grade 9 learners continue to trail behind global averages, with 41% in mathematics and 36% in science being attained, which demonstrates very basic knowledge and skills in these subjects (TIMSS SA, 2019). The TIMSS Report's findings emphasise the critical role of enhancing school resources, teacher quality, and instructional practices in boosting student achievement (Eriksson et al., 2018). Addressing the skills shortage necessitates a multifaceted educational reform, focusing on continuous monitoring, strategic resource enhancement, teacher training, and the development of non-cognitive skills such as self-efficacy in students (International Labour Organization, 2021). This comprehensive approach is vital for equipping South African youth with the necessary skills for the modern economy, as underscored by the TIMSS 2019 Report, which advocates for tackling both cognitive and non-cognitive barriers to student success.

4.4.2 *What is the perceived effect of educational programmes on workforce development in the South African mining sector?*

Educational programmes have had a mixed impact on workforce development in the South African mining sector, highlighting both successes and areas for improvement. On the positive side, programmes such as learnerships, bursaries, and in-house training programmes have successfully developed leadership, team management, and technical competencies, creating a pipeline of skilled individuals ready to meet operational demands (Mining Qualifications Authority, 2019). University-level curricula have also started incorporating emerging technological developments, which prepare participants for industry-specific roles and advance their career progression. Additionally, Kana and Letaba (2024) agree that community-focused programmes, such as TVET colleges, have been instrumental in cultivating a sustainable talent pool and addressing localised skills shortages.

The findings, however, also highlight significant challenges and limitations. Insufficient hands-on training leaves participants underprepared for real-world job demands, and mine-based training programmes often lag behind rapidly evolving technologies, creating gaps in workforce readiness for automation, mechanisation, and digitalisation. Retaining skilled workers is another critical challenge, as external competition frequently offers more lucrative opportunities. Although training content is relevant to participants' roles, gaps in advanced technical training for modern machinery persist.

4.4.3 *What skills shortages are there in the South African mining sector?*

Tholana and Neingo (2022) state that the 4IR significantly intensifies the problem of skills shortages in the South African mining industry. The rapid adoption of advanced technologies such as automation, mechanisation, and digitalisation has increased the demand for specialised roles, including auto-electricians, mechatronics technicians, and software engineers. However, training programmes at mines often lag behind these advancements, creating a misalignment between the skills provided and the skills required to operate and maintain modern machinery. This gap leaves the workforce unprepared for evolving industry needs and negatively impacts productivity, as critical machinery downtime increases due to a lack of skilled personnel. Black and Sandström (2021) also highlight that the mining industry acknowledges both the challenges and opportunities presented by adopting new technologies. While these advancements can enhance productivity, safety, and environmental management, it is crucial to invest in developing the necessary skills to fully realise these benefits, ensuring that individuals who currently lack "future skills" are not left behind.

4.4.4 *How do external factors affect skills shortages in the South African mining sector?*

Beyond technological factors, external factors such as inadequate infrastructure in areas where mines are located, including limited access to quality schools, healthcare, and housing, further discourage skilled professionals from pursuing careers in the sector (Abenov et al., 2023). Additionally, Musingwini et al. (2013) state that market volatility and employment instability caused by cyclical commodity price fluctuations make mining an unpredictable career choice, leading to talent shortages as professionals seek greater job security in other industries. These external challenges, combined with the slow adaptation of training programmes to the technological advancements, continue to widen the sector's skills gap and hinders workforce development.

4.5 Conclusion

The findings reveal that while educational interventions in the South African mining sector have made positive strides in developing leadership and technical skills, they fall short of bridging critical skills gaps. Specifically, insufficient hands-on training and outdated mine-based programmes fail to align with rapidly advancing technologies, leaving the workforce unprepared for automation and mechanisation. This necessitates long-term, adaptive, and comprehensive training strategies that align with the sector's demands and technological advancements. Addressing this gap will ensure a future-ready workforce and sustainability for the sector.

CHAPTER 5. CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This final chapter provides a consolidated conclusion to the findings of the study in relation to the research questions. It further discusses the recommendations of the study, which are designed to address the identified gaps in educational interventions that inhibit the ability to build a sufficient talent for the South African mining sector. Additionally, suggestions for further research are provided, given the limitations of this study.

5.2 CONCLUSION

This study aimed to analyse the impact of educational interventions on mitigating skills shortages in the South African mining sector. There was a focus on understanding the effect of educational policies, educational programmes, and external factors on skills shortages within the sector. The research explored the perspectives of operational managers and beneficiaries of educational programmes. This provided insights into the successes, challenges, and limitations of initiatives initiated by the mines.

Findings demonstrated that educational policies are in existence that promote equitable education; however, they are not sufficiently applied in a manner that directly benefits the mining sector due to low levels of mathematics and science education in the country. Policies directed at improving STEM education would be most appropriate in ensuring that there is a pipeline of individuals who can be trained and skilled in the specialised technical roles that the mines have to fill. Educational interventions driven by the mines, which include learnerships, bursaries, and training programmes, have made positive strides in developing leadership and technical competencies, and have also created a pipeline of skilled individuals in the sector. However, gaps remain in aligning training content with emerging technologies and providing sufficient hands-on experience. As

automation and mechanisation continues to advance, the workforce does not feel fully prepared to meet these evolving demands. Furthermore, challenges such as retention of skilled workers, underdevelopment of mining towns and technological advancements further intensify the skills shortage problem in the sector.

5.3 RECOMMENDATIONS

The recommendations presented in this section are directed at key stakeholders involved in workforce development in the South African mining sector, including mining companies, government bodies, educational institutions and industry regulators. These recommendations are derived directly from the study's findings and aim to address the challenges identified in workforce development and skills shortages in the South African mining sector. The recommendations aim to bridge the gaps that exist by improving the effectiveness of educational interventions, aligning training programmes with technological advancements, and creating a sustainable workforce.

5.3.1 *Recommendation one: Enhance training programmes to address evolving industry needs*

Experiential theory was developed by David Kolb in 1984; it is a learner-focused approach that emphasises the role of experience in the learning process and encourages connections between classroom teaching and real-world applications (Malik & Behera, 2024). The findings of the study found this to be lacking, as most participants highlighted insufficient practical exposure during their training, which left them unprepared for operational roles. Therefore, training programmes should integrate experiential learning methods, such as simulations, on-site training, and real-world projects, to complement classroom-based theoretical teaching. This should include a collaboration between academic institutions and mining companies, where they co-design programmes that provide early and consistent exposure to the sector's operations. By providing hands-on learning opportunities, employees will be better equipped to meet the

practical demands of their roles, thereby improving their readiness and operational effectiveness.

5.3.2 *Recommendation two: Align training with technological advancements*

Nightingale et al. (2007) state that constructive alignment ensures that learning outcomes, teaching methods, and assessments are aligned with industry requirements. In this study, it was evident that mine-based training programmes often lag behind technological advancements, creating a misalignment between workforce skills and industry needs. Automation, mechanisation, and digitalisation demand specialised skills that many employees currently lack. Therefore, a regular update of training curricula to include emerging technologies and collaboration with technology manufacturers and industry experts is required to ensure training content is aligned with the evolving demands of the sector. This alignment will better prepare employees to operate and maintain modern machinery.

5.3.3 *Recommendation three: Collaboration between mining companies and government for STEM education in schools*

To address the persistent skills shortages in technical and engineering roles within the mining sector, collaboration between the industry and government is essential to support and drive STEM education in primary and secondary schools. Early investment in STEM education can build a future workforce proficient in technical subjects and confident in pursuing engineering careers. This aligns with the study's focus on workforce development by encouraging interest and competence in technical fields, preparing students for advanced engineering training needed in mining operations. The self-efficacy theory, developed by Albert Bandura, emphasises the role of belief in one's capabilities to achieve specific outcomes (Hayat et al., 2020). Therefore, enhancing STEM education in schools should focus on building students' confidence in their abilities to understand and apply scientific and mathematical concepts. This can be

achieved through hands-on projects, real-world problem-solving, and mentoring programmes that connect students with professionals in the engineering and technical fields. By increasing their self-efficacy, students are more likely to pursue and succeed in engineering-related educational paths and careers. The mining sector, in collaboration with educational authorities, should also enhance STEM curricula, provide resources for educators, and offer practical learning opportunities. An increase in scholarships and bursaries for high-achieving STEM students can further support this pipeline, ensuring a consistent supply of skilled individuals who will be able to meet the mining sector's future needs.

5.4 Suggestions for further research

This study had limitations, which offers an opportunity for further exploration that could guide future research. The study primarily gathered data from operational managers and beneficiaries of educational interventions. While this provided valuable insights into workforce challenges, it potentially overlooked the perspectives of policymakers, educators, and technology suppliers, whose contributions could provide a holistic view of the skills development ecosystem. Moreover, the study did not address the influence of fluctuating economic conditions and global market trends on the sustainability of educational interventions. These external factors can significantly affect the ability of mining companies to invest in workforce development and hinder the ability to adapt to changing industry needs.

A holistic approach addressing these limitations may provide a more comprehensive understanding of the skills challenges in the South African mining sector and will enhance the development of targeted and sustainable strategies to mitigate the persistent skills shortages.

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APPENDIX A: RESEARCH INSTRUMENT

Interview Guide for Operational Managers

Section 1:

- Introduction by researcher.
- Explanation of the purpose of the study and the interview.
- Provide assurance of the participant's confidentiality and how privacy will be protected.
- Request for permission to record on MS Teams and physical note taking.
- Engage in "small talk" (e.g. weather and how their day is going) to make participant feel comfortable.

Section 2:

Research Question	**Interview Questions**
i. What is the perceived effect of educational policies on workforce development in the South African mining sector?	1. In your opinion, how effective are educational policies on workforce development in the South African mining sector?
ii. What is the perceived effect of educational programmes on workforce development in the South African mining sector?	2. What educational programmes has the mine put in place to address skills shortages? 3. Would you say that these programmes are successful and why? If not, where have they fallen short?

iii. What skills shortages are there in the South African mining sector?	4. What critical skills are currently in short supply within your operation? 5. How do these shortages impact the productivity of the mining operations?
iv. How do external factors affect skills shortages in the South African mining sector?	6. What external factors are present and how do they directly affect skills shortages in the South African mining sector?

Interview Guide for Beneficiaries of Educational Interventions

Section 1:

- Introduction by researcher.
- Explanation of the purpose of the study and the interview.
- Provide assurance of the participant's confidentiality and how privacy will be protected.
- Request for permission to record on MS Teams and physical note taking.
- Engage in "small talk" (e.g. weather and how their day is going) to make participant feel comfortable.

Section 2:

Research Question	**Interview Questions**

i. What is the perceived effect of educational policies on workforce development in the South African mining sector?	1. In your opinion, how effective are educational policies on workforce development in the South African mining sector?
ii. What is the perceived effect of educational programmes on workforce development in the South African mining sector?	2. Which educational programme where you part of? 3. What specific skills and knowledge did you gain through the programme? 4. In what way has it impacted your professional development and your current role?
iii. What skills shortages are there in the South African mining sector?	5. How relevant do you find the training content in relation to your day-to-day job requirements?
iv. How do external factors affect skills shortages in the South African mining sector?	6. In your opinion, how effective are educational policies on workforce development in the South African mining sector?

APPENDIX B: PARTICIPANT CONSENT FORM

Title of project: Impact of Educational Interventions on Mitigating Skills Shortages in the South African Mining Sector

Name of researcher: Sinenhlanhla Randy Nhlapo

I, ……., agree to participate in this research project.

I agree to the following: (Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.	YES	NO
I understand that I can volunteer to take part in the study.	YES	NO
I agree that the interview may be video recorded.	YES	NO
I agree that direct quotations from my interview may be used by the researcher in their research report.	YES	NO
I agree that my participation will remain anonymous (my name or other identifying data will not be used by the researcher in their research report).	YES	NO
I agree that other researchers may use the information I provide in my interview (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on.	YES	NO

…… (signature)

…… (name of participant)

…… (date)

APPENDIX C: ETHICS CLEARANCE

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number:	WBS/BA537193/495

This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below).

Project title	Impact of educational interventions on mitigating skills shortages in the South African mining sector
Investigator / Researcher	Mrs Sinenhlanhla Nhlapo
Nature of Project	MBA (Research Article)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	04/07/2024
Expiry date	Date of submission of the project / research report
Chairperson	Dr Ayanda Magida ☎ +27 11 717 3953 ✉ ayanda.magida@wits.ac.za

Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Eth Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research an guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature

05. 07. 2024
Date: