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Enabling Digital Transformation of the South African Coal Mining Industry Through Digital Skills Development

Moketla, Sewela P.

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Enabling Digital Transformation of the South African Coal Mining Industry Through Digital Skills Development

Student: Sewela P Moketla

Supervisor: Prof. René Pellissier

A research proposal submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business

Johannesburg, 2024

ABSTRACT

The South African coal mining sector is transitioning from labour-intensive methods to digitally enabled work environments to boost productivity, efficiency, and safety. However, recent studies and literature highlight that the workforce's digital skills remain a significant challenge.

This qualitative study explored the factors influencing the development and enhancement of digital skills within the South African coal mining industry. It sought to identify industry-specific barriers to digital skill development and provide a framework for improving workers' digital competencies.

The study employed focus group discussions to explore the factors influencing the development of digital competencies. Employees from company X in the coal mining sector participated in three focus groups. Due to participant availability, each focus group consisted of three to four participants and lasted between sixty and seventy-five minutes, with the researcher acting as the moderator.

Thematic analysis of participant responses revealed industry-specific determinants of digital skills development. The results highlighted both enablers and hindrances, including the type and rate of technology adoption, its impact on work methods, and the resulting skills gap in the workforce. Human factors such as mindset, motivation, and language proficiency were also significant. Additionally, the organisational environment, rewards, and incentives greatly influence employees' motivation to develop digital skills. Key tactics identified as foundational include the need for industry collaboration with stakeholders and the availability of tailored training and development programs.

KEYWORDS

Digital Transformation, Competency Development, Digital Skills, Workforce Enablement, Coal Mining, South Africa

DECLARATION

I, Sewela Portia Moketla, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Sewela Portia Moketla Signature:

Signed at **Secunda**

On the …….. day of February 2025

DEDICATION

This report is dedicated to my father, Patamedi Moketla, my little flower and my loving Son, Thato Moketla. May this be a token of appreciation for all the love and support.

To my siblings, friends and loved ones, thank you for being my support system and being so understanding when I could not be there.

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LIST OF ACRONYMS

4IR	Fourth Industrial Revolution
CEO	Chief Executive Officer
DC	Dynamic Capabilities
DT	Digital Transformation
HCT	Human Capital Theory
IOT	Internet of Things
MQA	Mining Qualification Authority of South Africa
RBV	Resource-Based View
ROC	Remote Operating Centres
ROM	Run of Mine
RPA	Robotic Process Automation

CHAPTER 1. INTRODUCTION

1.1 Statement of purpose

This qualitative study investigates the potential for digital transformation (DT) in the South African coal mining sector through digital skills development and enhancement. The study aims to identify industry-specific digital skills, evaluate current competencies, and explore industry-specific determinants to digital skills development for successful digital transformation. The study aims to develop a framework for fostering and improving digital skills within the workforce.

1.2 Background of the study

Globally, the energy and utilities sector (including mining) is often considered the laggard of digital technology adoption. The industry faces significant challenges in driving digital technology adoption and tends to lag sectors such as finance, health care, and media in integrating digital technologies into their operations (Wade et al., 2023). The South African mining sector is no exception and faces significant challenges in adopting and incorporating digital technologies.

Coal is the most plentiful and economically viable energy source in South Africa, currently supplying about 70% of the nation's primary energy. Despite efforts to diversify and transition from coal as a significant energy source, coal continues to dominate due to its abundance and low cost. Current expectations are that coal will remain a strategic resource beyond 2050 (Majola and Langerman, 2023).

In South Africa, coal is extracted using surface (open-cast) and underground (primarily Room and Pillar) mining methods. The preferred method of producing coal employs mechanised methods assisted by human-centred technologies. These methods of extraction are labour-intensive and expose employees to hazardous environments. As a labour-intensive sector, its continued success will be determined by its ability to ensure employees are safe and capable of delivering on their objectives (Onifade et al., 2022).

According to the data from the Statista Research Department (2024), the South African coal mining sector employed nearly 91,000 individuals in 2022 while creating opportunities for thousands more throughout the coal value chain. This workforce is perceived as low- and/or semi-skilled with low levels of education. This perception has led to the notion that the skills level within the coal sector workforce is an inhibitor of digital transformation (Davrajh et al., 2023).

Mining executives and stakeholders have identified digital transformation as a key enabler for sustainable development and modernisation of the South African mining industry. The readiness of the industry to adopt technologies introduced by the Fourth Industrial Revolution (4IR) is based on the readiness of its workforce to transition to new ways of work and task completion. A prerequisite to workforce readiness is developing and advancing digital skills (Chirgwin, 2021). Ensuring the workforce is appropriately skilled to excel in a digitally transformed environment will promote sustainable technology adoption and improve the industry's overall competitiveness.

Skills development in South Africa is legislated as part of the Mine Health and Safety Act 29 of 1996 and the Skills Development Act 97 of 1988. Under this legislation, the minerals and mining sector must invest in employee skills development to ensure long-term sustainability (Minerals Council, 2018). The Mining Qualification Authority (MQA) acts as the sector administrator and assists in developing learning programmes to build a skills base for the sector. Previous MQA has been focused on ensuring sufficient technical skills (Fitters, mechanics, welders, engineers, etc.) to meet the needs of mine operators. Current legislation and regulations have not yet evolved to address the necessity of developing complementary digital skills within the industry.

Karolia-Hussain and Fourie (2021) reviewed the significance of labour law in digital transformation in the context of the South African mining industry. Their analysis shows that digital technologies and their adoption make mining companies less labour-intensive, resulting in job losses within the industry. This view further exacerbates technostress within the sector, leading to strike action by the trade unions. The authors assert that workers' skills should be reinforced

and augmented to retain their jobs. Minimal efforts have been made to assess how workers' skills and competency may be strengthened in the industry.

1.3 Research Problem

In interviews with top management at South African mining companies, most CEOs acknowledge the inevitability of introducing digital technologies into mining operations. Additionally, top management is currently focused on "the how" of digital transformation (PWC and Minerals Council, 2023). In understanding the "how", mining CEOs wish to accelerate DT in the sector, allowing organisations to enhance safety, efficiency, and productivity.

Despite top management highlighting the need to accelerate DT, the sector lags other industries in digital technology adoption. Prior studies have postulated that the delay in integrating digital technologies is due to a lack of digital skills and competencies within the workforce (Olaitan et al., 2021). Studies on DT's human aspects have often focused on leadership and management as the primary drivers. This management-centric approach has resulted in a notable oversight of the industry's core: the workforce (Ullrich et al., 2023).

Due to the limited focus on the workforce, there has been a significant lapse in understanding the impact of the lack of skills and competencies on DT. Consequently, there is a substantial gap in the literature addressing the specific factors determining digital skills development within the workforce (Nkomo and Kalisz, 2023). This gap is critical because the success of DT initiatives heavily relies on the workforce's ability to adapt to new technologies.

Several studies have highlighted the importance of digital skills for successful DT but have not delved deeply into the determinants of these skills. For instance, Ullrich et al. (2023) emphasise that DT is a people-centred endeavour, and that ensuring employees have the right skills and competencies is essential for success. However, they do not provide a detailed analysis of the factors that influence the development of these skills. Similarly, Chatterjee et al. (2023) argue that introducing digital technologies changes how work is conducted, requiring employees to adapt their skills and competencies. Nevertheless, their study does

not explore the specific determinants that facilitate or hinder this adaptation and how organisations can address these.

The lack of detailed research on the determinants of digital skills development suggests inadequate guidance on effectively upskilling and reskilling the workforce. This gap in the literature leaves mining organisations without a clear framework to address the digital skills shortage, which is a significant obstacle to successful DT.

This study addresses the gap in understanding the specific digital skills required, the determinants of digital skills development, and the strategies necessary to upskill and reskill the workforce to implement DT in the South African coal mining industry successfully. The outcome will be the development of a digital skills framework to support the sector's digital transformation efforts.

1.4 Research Questions

The research questions which underpin the study:

RQ1. Which digital technologies will likely be adopted by Company X, a coal mining company operating in the Emalahleni Municipality?
RQ2. How do these technologies impact the skills profile for mining employees?
RQ3. What are the determinants of digital skills and competency development within the coal mining industry?
RQ4. What are the appropriate strategies to enhance digital skills and competencies within the industry?

1.5 Rationale

Coal remains the cheapest and most abundant source of energy for South Africa. Approximately 70% of the country’s electrical power is generated from coal. Current projections indicate that the country’s reliance on coal will likely persist for the next 5 decades (Eskom Generation, 2021). Challenges related to global warming and pollution make it imperative for the sector to find sustainable ways to produce coal. The adoption of technological and the accompanying

digitalisation process is critical to achieving sustainable coal mining (SARDJONO et al., 2023).

Mining CEOs and Executives have realised that digitalisation will transform the mining industry. Digitalisation can transform companies and how they interact with stakeholders across the value chain (Lazarenko et al., 2021). In mining, it is accepted that the introduction of technology can enhance productivity, efficiency, and the health and safety of the workforce. Technology not only changes the way work is conducted but also allows for changes in where work takes place (Onifade et al., 2023).

Researchers have, in the past, researched the inhibitors of digital transformation in South Africa. Amongst these, the lack of digital skills across the workforce has been identified as a key inhibitor for digital transformation in the industry (Davrajh et al., 2023; Ediriweera and Wiewiora, 2021; Mistry, 2022; Nkomo and Kalisz, 2023; Olaitan et al., 2021). From the findings and recommendations made by researchers, it is evident that their findings support the argument by Armstrong and Lee (2023) who contend that the workforce's digital skills are a foundational enabler for digital transformation and achieving digital maturity.

Although frameworks exist for developing and driving a digital transformation, the need to reskill and upskill the existing workforce has been mentioned without elaborating on how this can be achieved. In their, Young and Rogers (2019) highlight that the sustainability of the mining industry will be determined by the ability of the labour force to develop new skills related to the use of technology (data management, analytics, digital literacy, etc.). In addition, a new curriculum needs to be developed, which will be appended to the mining engineering discipline.

The significance of this research study is to identify industry-specific digital skills, evaluate current competencies, and explore industry-specific barriers and enablers to digital skills development for successful digital transformation related to the coal mining industry in South Africa. This will provide insights on overcoming digital skills as an inhibitor for digital transformation and provide actionable steps for the organisation. Overcoming this as a barrier will enable

organisations to accelerate their efforts to transform the industry using technology (Zhironkina and Zhironkin, 2023).

1.6 Delimitations of the study

The research study is limited to a single operation of the selected coal mining company X in the Emalahleni municipality in South Africa. Limiting the study to a specific organisation means the outcomes may differ from those performed for other operations and/or sectors. However, the study will provide useful indicators for reskilling the labour force.

1.7 Definition of terms

Digital Transformation: “Represents an organisational response to the ever-evolving landscape of technology and business, enabling companies to use digital technologies to enhance operations, improve customer experiences, and remain competitive. It is more than technological upgrades; it can profoundly impact an organisation’s culture, mindset, and business framework.” (Kao et al., 2024, pg.18)

Digitisation: The first step in an organisation's digital transformation (DT) journey. In the context of DT, digitisation refers to the efforts of an organisation aimed at converting analogue data/information into digital formats (Thi Lan Anh et al., 2022; Verhoef et al., 2021).

Digitalisation: Verhoef et al. (2021) describe digitalisation as the transformation of current business processes using ICT or digital technologies to ensure efficiency and cost effectiveness. Thi Lan Anh et al. (2022) assert this definition, adding that digitalisation transforms day-to-day operations, impacting how interactions are managed within the system.

1.8 Assumptions

It is assumed that the participants in this study have a basic understanding of digitalisation and DT.

1.9 Chapter Outline

This research study seeks to enhance knowledge about the factors determining digital skills development within the mining industry. Chapter 2 reviews existing literature on DT within the mining sector, taking a global view rather than a sectoral review. It further defines digital skills and develops a basis for investing in their development within the mining industry. It concludes by reviewing theoretical frameworks that may provide a foundational basis for the study. The theoretical frameworks considered are: Human Capital Theory, Resource-Based View, and Dynamic Capabilities. The chapter concludes with the conceptual framework guiding the study.

Chapter 3 considers the methodology to be used for the study. It introduces the research paradigm, design, and methods to answer the research questions. The chapter outlines an interpretivism paradigm employing qualitative research methods. Furthermore, the data collection and data analysis methods are outlined, including a brief description of the research instrument. Methods to safeguard the quality of the study are included in Chapter 3. The ethical considerations for the research conclude the chapter.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

This chapter begins by reviewing the status of digital transformation (DT) within the global mining industry. It provides an overview of the technologies likely to drive the need for digital skills within the industry. Following this, existing literature on the impact of DT on job profiles and workforce responsibilities is reviewed. Additionally, the chapter examines existing research into the antecedents and determinants of digital skills development among workforces. This review establishes guiding principles for selecting the theoretical framework underpinning the study. The study considers Human Capital Theory, the Resource-Based View, and Dynamic Capabilities, ultimately establishing Dynamic Capabilities as the foundational theory for the research. The chapter concludes with a conceptual framework outlining the assumed variables determining digital skills development within the workforce.

2.2 Digital Transformation in Mining

Mining is undergoing a revolution, instigated by the advent of digital technologies into the mining environment. The introduction of digital technologies into mining operations stems from the need to optimise operations to promote employees' safety. Deploying modern technologies into the mining environment has always been challenging (Abdellah et al., 2022). The complexities of the mining environment and extraction methods mean that for technologies to be adopted in mining, they must be customised to achieve their intended purpose. This need for customisation lends itself to sluggish technological adoption. Coupled with this sluggishness is the need to consider the changes required in the organisation to facilitate the transition to the new ways of work introduced by the technology (Young and Rogers, 2019). Regulatory and social expectations are significant considerations before introducing innovative technologies into mining operations.

Adopting digital technologies adds to the complexity of mining operations and the expected capabilities of the proposed technologies.

Because of the challenges noted above, the digital transformation of mining operations has been lagging. However, the sector cannot ignore the benefits and value derived from digital technologies. Embracing digital technologies as part of mining operations may alleviate some of the prevalent challenges in the industry. Amongst the challenges which may be addressed by technology, the most prominent are (Chirgwin, 2021; Lööw et al., 2019; Onifade et al., 2023):

1) Removing employees from a hazardous environment and enabling remote operation of mining equipment.
2) Addressing sustainability and environmental issues through the deployment of intelligent systems which monitor and prevent environmental crises.
3) Improving efficiencies by introducing systems which reduce the administrative burden on employees.
4) Allowing for visualisation of mining activities in real-time to improve productivity and effectiveness.

Sánchez and Hartlieb (2020) note that to overcome the inherent challenges of mining, organisations need to innovate to enhance their processes and improve productivity throughout the entire value chain. Mining organisations can ensure business continuity and sustainability by identifying suitable technologies and solutions that alleviate inefficiencies in the value chain.

2.2.1 *The Adoption of 4IR Technologies in the Mining Industry*

A research study by Ulewicz et al. (2022) proposed various 4IR technologies which could facilitate the digital transformation of the mining industry. **Error! Reference source not found.** illustrates the proposed integration of 4IR technologies within the mining industry and highlights DT's reliance on IOT, automation, and robotics. As the study highlighted, the focus was optimising mining processes by integrating digital technologies. The authors acknowledge

the need for enhanced data management and processing to enable the integration of the technologies.

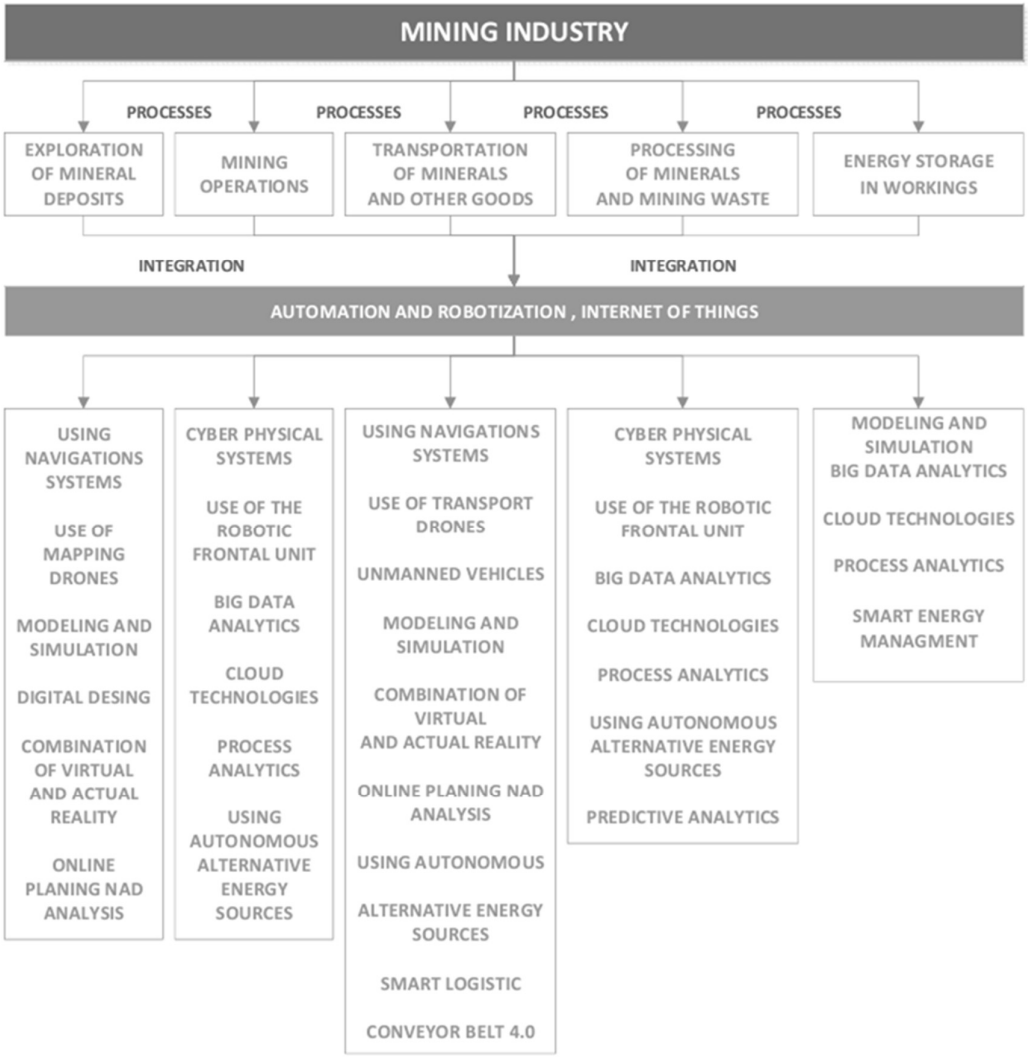


Figure 1: Illustration of proposed 4IR technologies for the mining industry (Ulewicz et al., 2022, pg. 294)

Similarly, Sishi and Telukdarie (2020) reviewed 4IR technologies that could integrate operations management systems within the mining industry. The study focused on the use of digital technologies to monitor, assess, and gather real-time data from various operational systems in a mine. The study identified IOT technologies such as sensors, actuators, and Human-Machine Interfaces as technologies that could facilitate the transition to smart mining operations. The introduction of IOT systems and technologies would require enabling

technologies such as data storage and computing, data management, and processes to ensure optimal technology integration.

Barnewold (2019) investigated trends of digital technology adoption in the mining industry. The study identified trends toward adopting IOT, big data, automation, and AI in the industry. The author further elaborates that the technology trends highlight the need for readily available and reliable data sources to support mining operations. A study conducted by Molaei et al. (2020) sought to review the impact of IOT on mining operations. The study reinforces the findings of Barnewold (2019) and highlights wireless sensors, automation, and database management as key digital technologies to enable innovative mining processes. Integrating IOT technologies in mining enables the deployment of connected machines and workers into the work environment, allowing people and machines to be tracked to enhance safety and performance.

In their study into 4IR technology adoption in mining, Zhironkin and Ezdina (2023) found that digital technologies with a high probability of adoption in mining included artificial intelligence, big data, smart sensors, and robotics. This was further supported by the results of the study conducted by Zhironkina and Zhironkin (2023) which sought to identify application areas for the 4IR technologies, to assist mining organisations in selecting innovative technologies. The study's results are summarised in **Error! Reference source not found.** highlighting the area of application and considerations to be made when implementing 4IR technologies.

Table 1: Proposed 4IR technologies for adoption in the mining industry.

Solution	Area of Application	Considerations
Autonomous Mining Machines	Mining methods, Transport of the Run-of-Mine (ROM) materials, Removing employees from hazardous areas	Efficiency, costs, workforce reduction, specialised staff
Sensor and tracking devices	Continuous monitoring of mining Equipment	Costs, Qualified employees
Big Data Analytics and Processing	Real-time data on mine operations, equipment performance and production data	Data processing, analytics software and tools, and maintenance costs
Data Storage on the Cloud	Process digitalisation and data storage for accessibility	Cyberattacks, data security, IT support, and implementation costs
Smart sensors	Security, data collection	Implementation conditions, maintenance costs, and technical capabilities
Electronic Chips and trackers	Monitoring employees	Adoption and maintenance costs, employee acceptance, and lack of privacy
Innovative modelling software	Modelling of mineral deposits	Staff skills, reorganisation of work, and additional requirements
3D scanning systems	Drilling and Blasting operations, Surveying	Costs, training requirements, and work reorganisation
GIS Systems	Mapping of mining operations and geo-positioning of equipment	Data analytics, implementation, and maintenance costs require Specialised personnel
Virtual and Augmented Reality	Training, Equipment maintenance manuals	Costs, technical limitations, and staff capabilities
Cybersecurity	Digital systems	High maintenance costs, continuous support
Digital mine	Interdisciplinary application	Qualified staff, costs, and integration

2.2.2 *Technologies suitable for adoption in Coal Mining*

As noted by Fedulova et al. (2020) coal mining is associated with introducing significant risks to humans and the environment. The authors argue that innovative, compatible, and cost-effective digital technologies should be

considered to eliminate some of the dangers inherent in the mining processes. Furthermore, suitable technologies must be identified to optimise process and operations management activities. In reviewing technologies which would be ideal for underground coal mining operations, the authors proposed the introduction of technologies to address particular challenges and needs, namely:

- Enabling connected machines and tracking personnel locations through deploying IOT technologies.
- Creating digital flow charts and models which allow for the collection of mining process data, which can be used to improve productivity and cost-effectiveness.
- Introduce Ethernet, Wi-Fi networks, and sensors to ensure the existing ICT infrastructure supports IOT connectivity.

Ren et al. (2023) considered intelligent mining systems to address the challenges related to low-seam coal mining. The study recommends the adoption of fully mechanised coal mining, supported by automation and robotics, remote centralised control, IOT sensors and remote visualisation.

Offering IOT and remote monitoring/control as a solution to the challenges of air quality monitoring and control, Damayanti and Khairunnisa (2023) suggest that deploying IOT sensors and integrating a remote-control centre will empower mines to analyse and visualise air quality data, thus ensuring decision-making.

Nikitenko et al. (2021) look at the safety applications of DT in mining and propose a multifunctional safety system (MFSS). The system comprises connected worker/machine sensors, which track the position of personnel and machines, remote control and monitoring of equipment and integrated safety systems. Overall, the study proposes IOT as a digital technology facilitating DT mining.

2.2.3 *Summary of Digital technologies likely to be adopted in the coal mining industry.*

The studies presented thus far suggest that digital transformation in mining depends on the industry's ability to integrate 4IR technologies as part of the management and operational process. The digital technologies likely to facilitate

DT in the coal mining industry may be categorised as process and operations management technologies.

Table 2: Digital technologies are likely to be adopted in coal mining.

Area of Application	Technological Solution
Process Management	Data Analytics
	Cloud Storage and Computing
	Data Management
	Artificial Intelligence Systems
Operations Management	Internet-of-Things
	Remote Control Centres
	Connected Worker
	Connected Machines
	Automation and Robotics

2.2.4 *Proposition 1*

Company X, a coal mining company in South Africa, will likely adopt digital technologies such as data management, IOT, automation, and AI to improve operational efficiency, safety, and productivity.

2.3 Impact of DT on the job profile of the coal mining workforce

Technological disruption has emerged as the most significant driver of change for organisations globally. Digital technologies are revolutionising every aspect of organisations, introducing new processes and methods of work. Recently, organisations have had to adapt their strategies to address the challenges posed by technological disruptions. Across industries, digital transformation has become a top priority for executives and leadership teams (Armstrong and Lee, 2023).

Digital transformation can be defined as an organisation's response to technological advancements and changes in the business landscape. This transformation process enables organisations to optimise operations, enhance performance, and maintain their competitive edge. Organisations that adopt a transformative strategy will likely experience changes in how work is conducted as they transition to a new operating model (Kao et al., 2024).

As with any transformative process, digital transformation (DT) fundamentally alters the nature of work, necessitating new skills and capabilities. One consequence of DT is the transformation of work activities, enabling employees to discover new methods for executing tasks, thereby enhancing effectiveness and efficiency (Chatterjee et al., 2023) Additionally, DT often changes job roles and responsibilities, expanding the scope and introducing new tasks and accountabilities.

Ferreira et al. (2023) argue that as the process of DT transforms the workplace, the range of skills required to succeed also evolves. They suggest employees must identify digital skillsets that complement their technical capabilities and knowledge. Similarly, Storey et al. (2024) note that digitalisation will profoundly affect mining operations, altering how work is performed, where it is carried out, and by whom. As a consequence of DT, new roles and responsibilities are likely to emerge, requiring employees to adapt to new processes and operating procedures.,

Chirgwin (2021) examines the skills required for workers whose roles evolve due to the adoption of automated control rooms. The study highlights changes to job descriptions and requirements for mine controllers. A notable recommendation is that employees must be adaptable to rapid technological changes and align their skill sets with the needs of a technology-intensive work environment. Similarly, Achoki (2023) contends that innovative technologies alter the skills landscape, emphasising the need for new skills associated with technology. The author advises that the emphasis on technology-compatible skills is becoming more prominent, as seen in job market listings.

Supporting the findings that technology impacts job profiles, roles, and responsibilities of the mining workforce, Lööw et al. (2019) claim that digitalisation can provide employees with opportunities to work in safe environments, removed from hazardous workplaces, enabled by interaction with digital technologies.

Considering the evidence provided by the literature, a fair conclusion is that implementing digital technologies in the mining environment will change how work is carried out, requiring new skills and capabilities from the workforce. Additionally, when executed correctly, DT can improve the workforce's effectiveness, productivity, and efficiency (Ulewicz et al., 2022).

2.3.1 *Lack of skills and the resulting skills gap*

A study performed by Gao et al. (2019) identified the following as barriers to DT within the mining industry:

1) Lack of competencies (obsolete skills).

2) Technological constraints (e.g., applicability of technologies)

3) Goal ambiguity (lack of focus)

4) External constraints (e.g., legislation, safety standards, social responsibility)

Radebe and Chipangamate (2024) contend that the future of mining requires workers with the skills to interact with new technologies. The authors note that as industries transition toward digitalisation, most economies (countries) face challenges addressing the need for digital skills and new competencies. As a result, organisations cannot equip themselves with the skills required to adopt digital technologies successfully.

Olaitan et al. (2021) argue that the lack of technological infrastructure and shortage of skills amongst the workforce have contributed to the country's lack of adoption of digital technology. Reinforcing this finding, Nkomo and Kalisz (2023) noted that South African organisations have maintained a low level of digital maturity, partly owing to the lack of digital skills and competencies, particularly in

industries such as mining. Both studies highlight the need for organisations to address the lack of digital skills as part of the planning for digitalisation. They emphasise the need to ensure that the organisational culture supports the need to enhance the workforce's skills through training and skills development programs. This is further confirmed by Young and Rogers (2019), who assert that the mining industry must review its skills development efforts and align training strategies with technological developments if it is to address the lack of skills within the industry. Ngobese et al. (2023) highlighted that the trend for modernisation of the mining industry requires concerted efforts to ensure the advancement of digital through concerted efforts to mitigate the skills shortage amongst the mining workforces.

According to a paper by Chetty et al. (2018) the prominence of the digital divide is due to a lack of digital literacy amongst the lower-skilled/ low-income communities. They argue that improving digital literacy in these communities will enhance employability and thus increase job prospects. This view is emphasised by Weritz (2022) who asserts that the nature of work is changing, thus requiring a rethink of skills development within the workforce. Additionally, the author believes that digital skills will become a prerequisite for employment in future. Amongst others, the following authors support this view: Audrin et al., 2024; Marhraoui, 2023; Stofkova et al., 2022. These studies support the notion that digital skills are essential to employee performance and success in a digital workplace. Thus, understanding the key aspects of digital skills is required when considering skills development for the workplace.

Studies conducted by other researchers indicate that the lack of workforce/employee skills and inadequate training programs have significantly hindered DT within the mining industry (Audrin et al., 2024; Mistry, 2022; Onifade et al., 2023; Ullrich et al., 2023). Overall, these studies support the hypothesis that, to accelerate digital transformation (DT) in the mining industry, organisations must recognise the existence of a skills gap and develop effective strategies to address it.

2.3.2 *Proposition 2*

Digital transformation in the coal mining industry leads to the evolution of job roles and responsibilities, requiring workers to adapt to new technologies and processes. This increases skills deficiencies and creates a skills gap.

2.4 Determinants of Digital Skills Development

2.4.1 *Human Factors*

It has been postulated that lifelong learning will be a key enabler for digital agility in organisations (Gorski et al., 2023). This entails motivating employees towards self-development and knowledge attainment. The authors argue that any transition from traditional to digital work processes must be communicated to employees in a timely manner. Furthermore, communication and engagement are crucial strategies for minimising technology-induced stress and alleviating existing fears. Other factors to be considered when engaging employees relate to the need to adapt to the new ways of work, leaving behind their existing processes and competencies. Similarly, Pedota et al. (2023) argue that digital technologies introduce complexities that need to be accounted for theoretically and practically. They point out the need for a broader skillset complemented by traditional technical skills, which may be accomplished through lifelong learning.

Van Laar et al. (2020) emphasise the concept of a transition from the technical definition of digital skills to a broader definition, requiring higher-order skills. Through a systematic review, the authors synthesise the determinants of the higher-order digital skills, landing on the following:

1. Demographic and socioeconomic factors such as age, gender, and educational level
2. Personality and psychological: such as the ability to communicate, problem-solve, and retrieve information (ICT self-efficacy and academic achievements)

3. Temporal determinants which address issues related to ICT use and ICT experience.
4. Material determinants relating to access to digital technologies and/or ICT devices.
5. Mental and motivational, including problem-solving abilities.
6. Social determinants emanating from issues such as social support.
7. Cultural: Individual and organisational cultural artefacts.

Furthermore, the authors highlight the need to account for learning styles and the sources used for learning as essential elements when considering the development and evaluation of individuals' digital skills.

Considering the research above, it is evident that the development of digital skills requires a concerted effort to address human factors. These include aspects related to motivation, mindset, demographics, and psychological factors.

2.4.2 *Technological Factors*

A secondary view suggests that job-redesign and task review should form the basis for introducing modern technologies (Chatterjee et al., 2023). Linked with this is the concept of "technology-induced" skills, indicating that most learning occurs when employees are empowered to advance and develop as they interact with technology (Achoki, 2023). In reviewing the enablers of digital literacy development in the construction industry, Gledson et al. (2024) recommend that organisations consider technological aspects when deploying digital systems. This includes considering ease of use and piloting new systems before full-scale rollout.

Workplace digital skills have been the source of controversy in academic literature. Researchers in the field have tried to define and clarify the meaning of digital skills. However, the effort has resulted in a continued lack of clarity. The terms digital skills, literacy and competency are often used interchangeably, implying that they relate to the same things (Iordache et al., 2017; Lang and Triantoro, 2022; Tinmaz et al., 2022). Considering its importance to the current situation, it is evident that a review of the terminology related to digital skills is required.

Deriving a definition from previous studies, Lang and Triantoro (2022) define digital skills as a set of skills which enable an individual to operate and use digital devices. They highlight that digital skills are dynamic and evolve with technological advancements and development. Elaborating on this, the authors note that future employment opportunities will emphasise the need to interact with digital devices and media. Another definition, proposed by Iordache et al. (2017), defines digital skills as the application of specific expertise and abilities in a measurable manner to the use of digital technologies. Further, the authors distinguish digital competencies as the ability to apply digital skills in different contexts, whether personally or professionally. The definitions proposed in these studies provide a foundation for understanding digital skills as they relate to work.

Van Laar et al. (2017) classified digital skills under seven categories: technical, information management, communication, collaboration, creativity, critical thinking, and problem solving. According to the authors, this categorisation provides a broad overview of the skills required to be proficient in applying digital technologies. A similar approach was taken by Audrin et al. (2024), who developed a framework highlighting eight dimensions of digital skills, namely: Technology use, Cybersecurity, Content management, Communication and collaboration, Critical inquiry, Responsibility, Well-being, Identity, and development. Studies by Sousa and Rocha (2019), Tinmaz et al. (2022), Weritz (2022) and others follow this approach in seeking to define digital skills in a broader sense, beyond individual capabilities. Overall, these studies indicate the complexity inherent in defining digital skills requirements in addressing the needs of individuals and organisations.

In contrast to the ideas of the previous authors, Schlegel and Kraus (2023) argue that digital skills should be defined in line with the technology being implemented. Supporting this view is the assertion by Lloyd and Payne (2023) that most frameworks do not account for the complexity encountered in the industry or work environment. The need for digital skills must be contextualised by considering the use of the skills in a particular job setting and the accessibility of the intended technology. This view emphasises domain knowledge and elevates the need for the workforce to be exposed to the digital systems they must interact with.

2.4.3 *Organisational Factors*

A study conducted by Leon (2023) suggests that the culture, organisational structure, and availability of technology influence skills development to a large degree. They note that a culture encouraging employee growth and independence often builds trust and commitment towards DT. Furthermore, an organisation's culture, which acknowledges the interdependence between human and organisational factors, tends to positively impact the development of digital skills in the workforce.

From the perspective of Jamal et al. (2024), an organisation's ability to respond in an agile manner has a direct correlation to the upskilling and reskilling of its people. Organisational agility allows for a rapid but considered response to technological advancements and thus considers the need to develop digital skills in the workforce.

An organisation may only be considered agile when it has effective organisational change management structures and practices, which allow for integrating new technologies and processes with minimal disruption to business outputs. Suharto (2024) found that organisations on the DT journey need to change their business model and practices to align with the organisation's aspirations. This reinforces the need for a culture that allows change leaders to be proactive, communicate with, and support employees through the journey. Butt et al. (2024) support thus notion, arguing that organisations undertaking DT need to consider ways of refreshing their culture, by adopting a thoughtful and strategic approach to merging technology with the social system already established in the organisation.

Leadership and management support are essential to driving the DT strategy within an organisation. The role of leadership in DT is to ensure that the organisation has the necessary resources to address the challenges arising from the transition to digitalisation (Kringelum et al., 2024). The leaders and top management of the organisation are responsible for ensuring strategic alignment of DT initiatives and that the skills being developed are relevant and valuable to the business.

2.4.4 *Environmental Factors*

Fareri et al. (2023) conducted a study that reviewed how changes in the aspirations to transition to net zero impact workers' skills in the manufacturing sector. The authors highlight that the drive to net zero is enabled by adopting advanced technologies, which require workers to develop digital skills. The study's findings highlight how changes in the operating environment impact job profiles and thus the skills needed by the workers.

Regulatory and legislative requirements imposed on an organisation contribute significantly to the ability of an organisation to enact new policies aimed at promoting the development of digital skills (Ayeisha and Anggoro, 2024). The regulatory environment aims to ensure conformity and compliance with standards and targets set by the government. As these are often external measures of success, they can impose limitations on organisations, limiting how resources may be distributed to various projects (Dragičević and Bošnjak, 2019). Likewise, Lööw et al. (2019) hold the view that mining legislation plays a crucial role in defining the parameters for technology adoption, frequently focusing on the need to remove employees from harsh and hazardous environments.

The economy under which an organisation operates has a notable impact on the success of its DT strategy (Stofkova et al., 2022). Economic factors such as the education and literacy levels of citizens and the availability of technology and ICT infrastructure in a country may hinder or promote the development of digital skills. Adopting a similar position, Shibambu and Mojapelo (2024) argue that levels of education and literacy in South Africa hinder the development of digital skills in the employable majority, contributing to the slow pace of DT.

2.4.5 *Proposition 3*

Human factors, including employee motivation and beliefs, propel the development of digital skills and competencies in the coal mining industry. Furthermore, the availability and accessibility of advanced technologies, as well as a supportive organisational environment, greatly aid the development of digital skills.

2.5 Strategies for Digital Skills Development

Strategic alignment of DT with the organisational systems for human resource management is crucial to addressing the human elements of digitalisation and DT. Recent studies have noted that incorporating strategies to reiterate the need to develop digital skills positively impacts employees' actions toward reskilling and upskilling (Leon, 2023). Strategies recommended by the literature include:

1. Collaboration and Knowledge Sharing: Encouraging collaboration and knowledge sharing with industry partners, stakeholders, and knowledge communities. This could entail creating communities of practice, and the use of collaborative tools can facilitate the process of learning and upskilling (Achoki, 2023; Padmaja and Mukul, 2021; Sawant et al., 2022).

2. Rewards and Incentives: Employees are more likely to be motivated to learn and develop new skills if they perceive that such efforts will lead to future career success. This perception is influenced by the organisation's incentives, recognition, and career development opportunities. Organisations that align their incentive structures with the strategic objectives of digital transformation tend to be more successful in encouraging employees to develop digital skills (Klein et al., 2024; Stephany and Teutloff, 2024; van Laar et al., 2020).

3. Formal Training and Skills Development Programs: Structured and well-organised training programs tailored to the technology earmarked for implementation are essential. These programs should include both formal education and informal learning opportunities, such as workshops, online courses, and hands-on exposure to technology (Chirgwin, 2021; Kao et al., 2024; Lang and Triantoro, 2022).

4. Educational Programs and Policies: The quality and focus of educational programs play an essential role in promoting the development of new skillsets and competencies. Policies that emphasise digital literacy and integrate technology into curricula can better prepare the workforce

for a digitalised work environment (Gorski et al., 2023; Olaitan et al., 2021; Rêgo et al., 2023; Rubene et al., 2021)

The evidence indicates that effective upskilling and reskilling strategies should encompass more than formal training. An appropriate approach will employ various methods and techniques to achieve success.

2.5.1 *Proposition 4*

Practical strategies to enhance digital skills and competencies within the South African coal mining industry include implementing continuous development and training programs and fostering partnerships with industry stakeholders.

2.6 Analytical Framework

2.6.1 *Theoretical Framework*

Human Capital Theory

Human Capital theory advocates for the education and training of employees to improve operational efficiency. It posits that there is a correlation between investments in education and training and the capabilities of its employees. It asserts that the skills and capabilities encapsulated in its employees significantly impact the organisation's sustainability and profitability. At its core, human capital theory advances the idea of employees' skills, knowledge, and capabilities as a strategic resource for developing a competitive advantage (Tan, 2014)In addition to the skills developed through education and training, human capital theory encompasses the intrinsic and learned characteristics that contribute to employee productivity. HCT proposes a holistic view of employees' skills, knowledge, capabilities, and attributes. Furthermore, HCT proposes that organisations invest in developing skills and attaining knowledge to ensure maximal utilisation of their human resources.

HCT has its roots in economic theory, attributing an individual's earning potential to their skills and knowledge. This view limits the extent to which it can be applied

to complex situations, with interrelations to the external environment and availability of tangible resources in an organisation. (Tan, 2014; Wuttaphan, 2020)Thus, to maximise the value of HCT, it must be combined with other theories that address inherent complexities within an organisation.

Resource-Based View

According to the resource-based view (RBV), an organisation's success depends on the value, imitable nature, rarity, and non-substitutability of its resources, including tangible and non-tangible assets. An organisation's observable and quantifiable resources are referred to as tangible resources. The converse is true of non-tangible resources, which are those that exist in the non-physical domain and include things like intellectual property, employee knowledge, skills, and capabilities, the organisational culture, leadership potential, and its reputation amongst its customers(Cooper et al., 2023)Furthermore, it is argued that for an organisation to differentiate itself from its competitors, its resources should be diverse. Diversity of resources is viewed as a characteristic that facilitates innovation and learning.

A key aspect of RBV is its inward-looking approach to determining an organisation’s ability to create value from how it organises its resources. This approach aims to establish the extent to which an organisation's resources can be exploited to derive a competitive advantage. To exploit these resources efficiently and effectively, the organisation must organise them to promote innovation and value creation (Lockett et al., 2009; Pereira and Bamel, 2021).

In summary, RBV allows for exploring the inter-rationality of resources within an organisation. RBV provides a resource-based perspective on the resources of an organisation. Critics of RBV note that the rapid pace of change introduced by technological advancement requires a broader view into the factors which sustain an organisation's competitive advantage (Bleady et al., 2018)For a study on the availability of digital skills within an organisation, RBV may offer a broad overview of how resource positioning impacts digital skills development.

Dynamic Capabilities Theory

As defined by Teece (2010) Dynamic capability (DC) may be defined as the ability of an organisation to adapt, integrate, and redesign its resource structure in response to a change in its operating environment. The theory of dynamic capabilities highlights the need for agility within an organisation to reconfigure resources (internal and external) in response to externally stimulated changes. Dynamic capabilities are an extension of the resource-based view (Bleady et al., 2018; Eisenhardt and Martin, 2000)DC theory attempts to compensate for the limitations of the resource-based view in addressing the dynamic nature of the business environment.

DC theory hypothesises that for an organisation to maintain its competitive advantage, it must have capabilities that allow it to sense, seize, and transform to capture value from forthcoming opportunities. Extending on this hypothesis, DC views lifelong learning within an organisation as a precursor to sustained competitive advantage. From the perspective of strategy, dynamic capabilities drive innovation, intrapreneurship, and adaptability (Eisenhardt and Martin, 2000).

Alkhamery et al. (2021) conducted a case study analysis from which they identified six dynamic capabilities which an organisation with DC exhibit to ensure the success of their digital transformation effort, namely: (1) capabilities absorptive capacity, (2) agility and flexibility, (3) cross-functional collaboration, (4) innovation capability, (5) market orientation, and (6) relational capability. In addition, they contend that a firm's ability to access dynamic capabilities internally and externally enables tactics for aligning resources with the overall strategy.

Conforming to the statements made above Warner and Wäger (2019) who contend that DC calls for an organisation that values collaboration. Moreover, an organisation characterised as possessing DC invests in its employees' digital readiness.

This study adopts the insights provided by the dynamic capabilities theory, which is explained above. DC theory considers both external and internal variables that

could impact an organisation's capacity to reallocate its resources in response to environmental changes.

2.6.2 *Conceptual Framework*

A conceptual framework provides an overview of the researchers' interpretation of the factors, variables and constructs which underpin the research problem. It details which elements will be considered as part of the study. In providing a conceptual framework, the researcher identifies the variables, constructs and related assumptions gathered from literature and observation (Matthew. Miles and Huberman, 1994).

Error! Reference source not found. illustrates the proposed conceptual framework for this study, as a visual representation of the determinants of digital skills development in the mining industry.

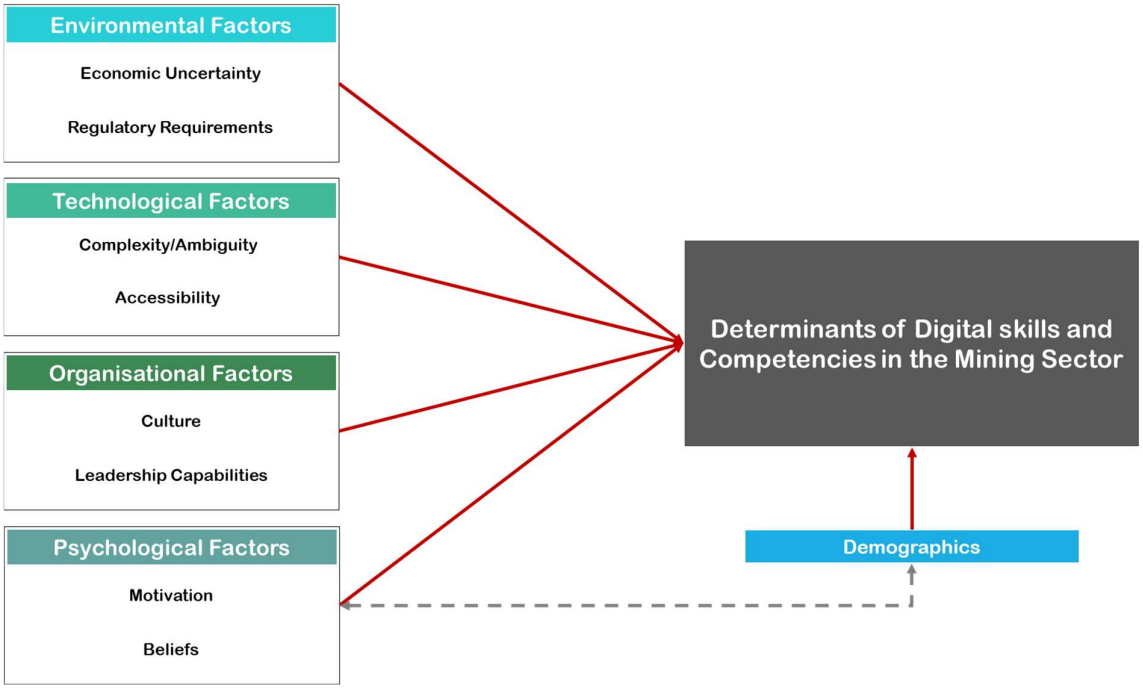


Figure 2: Conceptual framework underpinning the current research.

2.7 Conclusion

This literature review took a holistic approach. First, literature on the current state of digital transformation within the mining industry was reviewed, which provides an overview of the industrial and organisational determinants of digital skills development. Second, a review of the definition of digital skills as it applies to digital transformation was undertaken to contextualise the meaning of digital skills. Finally, the literature on the determinants of digital skills development was reviewed, which provided the basis for selecting the theoretical and conceptual framework.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Introduction

A research methodology outlines how research will be conducted to answer the research questions or address the objectives. This chapter provides an overview of this study's research paradigm, approach, and data-collection methods. Moreover, the chapter justifies the use of focus groups and provides an overview of the population and samples addressed by this qualitative research. Finally, an overview of the research instrument is provided, followed by the methods applied to ensure quality and the ethical points to be considered in executing the research.

3.2 Research Paradigm

Pervin and Mokhtar (2022) contend that research paradigms reflect the worldview from which the researcher interprets and perceives information gathered from the study. Ugwu et al. (2021) offers the view of a research paradigm as an introduction to the researchers' philosophical orientation, guiding the methodological choices for the research study. The authors also highlight the idea that the paradigm forms the foundational base on which the study is built, and it develops the study's intent, motivation, and expectation. Supporting this view, Kivunja and Kuyini (2017) assert that a research paradigm should be selected with care, considering the study's expectations, as it defines the methodological framework for the research process. Thus, the choice of a research paradigm is fundamental in ensuring consistency of the research methods with the study objectives.

Technological developments and the adoption of innovative technologies introduce many opportunities and challenges for human beings. The introduction of innovative technologies into our personal and work lives presents the need for skills transformation. Skills developing, lifetime learning and training are more effective when the individual takes accountability for their personal development (Achoki, 2023) For this study, it is argued that to understand the nuances of skills

and competencies development an Interpretivism Paradigm is appropriate, centred in the need to understanding the subjective perspectives of the participants. This view is further substantiated by the claim made by Fodouop (2024) that Interpretivism is suitable for researchers seeking to understand how experiences, worldviews and interpretations perpetuate particular issues evident in society. Interpretivism incorporates aspects of human interest, allowing for the interpretation of subjective views and the opportunity for the research to delve deeper into people's unique perspectives and experiences (Melnikovas, 2018).

3.3 Research Approach

Adopting an interpretivist paradigm for the current study allows for incorporating qualitative research methodologies. Qualitative research methods are best suited for when a study attempts to examine dynamic processes, which are likely to evolve based on the current environmental circumstances (Dhobi, 2022) This study's approach follows a qualitative research methodology intended to explore the barriers and enablers of digital skills/competency development in the South African Coal mining industry.

The qualitative research methodology allows researchers to explore several aspects of a complex phenomenon, where the observed variables are often non-numerical. The need for understanding phenomena as they relate to a particular setting or social context is best understood through the qualitative approach (Johnson et al., 2020). Case studies, Interviews, observations, and focus group discussions are the most common methods employed for qualitative research.

3.4 Research Design

This qualitative study employs the principles of cross-sectional studies, in which data is collected through observations of the participants at a single point in time. This approach offers the researcher an opportunity to measure the prevalence of a specific phenomenon based on a particular context and period (Wang and Cheng, 2020). This cross-sectional study employs focus group discussion as the primary data collection method.

3.5 Data Collection Methods

Plummer (2017) emphasise the role of focus groups in qualitative research as a method for exploring people's perceptions about a particular topic. Coupled with this is the ability to stimulate dialogue and prompt justification of the participants' views in a social setting.

A focus group may be defined as a group of individuals, limited to six to ten, who gather to discuss a particular topic of interest to the researcher. The value of a focus group as a research method relies on the ability of the moderator (in this instance, the researcher) to facilitate discussions and debate on the topic. To ensure the effectiveness of the focus group, the participants must be selected taking into account experience with the subject of interest (Gundumogula, 2020).

Generally, focus groups are used in qualitative research to gain in-depth insights into the prevalence of a specific phenomenon. Focus groups offer researchers an opportunity to gather information of a subjective nature, considering the social context under which the phenomena being studied occur. A fundamental advantage of focus groups is that open-ended questions allow participants to share different views, ideas, and perspectives on the issue under discussion. In this setting, the researcher assumes the role of a moderator, guiding the conversation while ensuring not to actively participate in the discussion. The researcher merely facilitates the conversation (Nyumba et al., 2018).

Tumen Akyildiz and Ahmed (2021) offer that using focus group data collection methods is particularly advantageous in answering research questions about phenomena about which little literature or no data exists. In studies on human behaviours, attitudes, and beliefs, focus group interviews often reveal greater insights into the barriers and/or enablers underpinning the issue being studied. The authors further highlight that another key benefit of using focus groups is the ability to generate large quantities of data over a brief period instead of one-on-one interviews. The data collection strategy of the current research is rooted in the focus group discussions.

3.6 Population and Sample

3.6.1 *Population*

The mining industry includes a sizeable number of organisations, operators, suppliers, and individuals. As such, the industry's broadness poses a challenge for researchers to sample or address the entire population. For this research, the population is limited to a single operation of the coal mining company X in the Emalahleni municipality in South Africa. Organisations must have a publicly available strategy that outlines their intention to employ digital technologies within their operations.

3.6.2 *Sample and sampling method*

Focus groups are adopted as a data collection technique when a research study seeks to provoke debate on a specific topic. The purpose of focus group interviews in qualitative research is to gather rich data, indicative of the participants' beliefs, perspectives, and experiences. Purposive sampling of research participants is crucial to ensure rigour and quality in qualitative inquiry (Johnson et al., 2020). This suggests that the selection of participants should be based on the quality of ideas they are expected to bring to the research findings. A purposeful sampling technique to be considered for a study seeking to identify and understand determinants of digital skills developed as proposed in the conceptual framework is maximum variation sampling. This sampling technique employs the principles of diversity to gather insights into a range of factors driving a phenomenon as experienced by different stakeholders (Suri, 2011)Assessing the focus group's heterogeneity implies that the research participants have been selected with consideration for the attributes and characteristics likely to foster discussion and introduce different perspectives within the group. To this end, the researcher will attempt to ensure that the composition of each focus group maintains diversity concerning demographic characteristics and job descriptions.

Onifade et al. (2023) assert that introducing digital technologies in the mining industry is likely to profoundly affect how mining operations are executed. This

implies that the skills and capabilities of the operational staff are key determinants of the success of DT initiatives. Thus, understanding the perceptions and insights of operational-level staff is crucial to answering the research questions posed in this study. This study proposes focus group interviews with Company X's employees who are mining machinery and equipment operators. These are defined as employees employed at a Paterson job grade of C-upper to D-upper, with the titles of Engineers, Head of Maintenance, Operator, Shift-boss, and/or Technician.

Tumen Akyildiz and Ahmed (2021) maintain that the qualitative process is iterative, often requiring repetition of the data collection process to thematic saturation. Thematic saturation is defined by Hennink and Kaiser (2022) as the point where no new insights or information is derived from the focus group discussions, therefore, implies that thematic saturation may be used to indicate the adequacy of the data collected. The authors further note that the saturation point cannot be pre-determined, suggesting that the required focus group interviews may only be determined during the data collection process. Additional considerations for determining the sample size include the purpose of the study, the complexity of the issues requiring discussion and the expected variation in the data. The current study proposes an initial sample of four focus group interviews, allowing the researcher to determine the minimum number of participants to be recruited (accounting for attrition and non-attendance). The interview data will be examined to determine thematic saturation and the need for additional interviews.

The focus group interviews conducted for this study will be limited to a maximum of five participants. Limiting the number of participants allows for robust discussion while ensuring a small enough group size to promote participation from each group member. The time allotted for each discussion will be limited to 90 minutes. Participants will be recruited using the researchers' networks and the snowballing technique, where participants will be asked to recommend individuals who could offer insights on the topic of discussion. Formal invitations will be shared with individuals who intend to participate in the discussions.

3.7 The research instrument.

A semi-structured interview guide is used in this study to ensure that focus group discussions align with the research questions. Using an interview guide allows for discussions to follow a semi-structured process while allowing for further probing of the participants. The proposed questions for the discussion are detailed in APPENDIX (C): Semi-Structured Interview Guide.

3.8 Procedure for data collection

Due to the challenges of locality, the focus group discussions will primarily be conducted online. The session will be recorded for facilitated transcription and data capturing. Alternative forms of data collection will be notes taken by the researcher during the focus group discussions.

3.9 Data analysis strategies and interpretation

The research proposes an inductive thematic analysis as the data analysis tool. Transcripts of the focus groups will form the basis for the data analysis and interpretation. The data analysis strategy employed is a thematic analysis process. This process aims to identify themes, codes and partners based on the information provided by the participants (Naeem et al., 2023). **Error! Reference source not found.** outlines a proposed strategy for conducting thematic analysis.

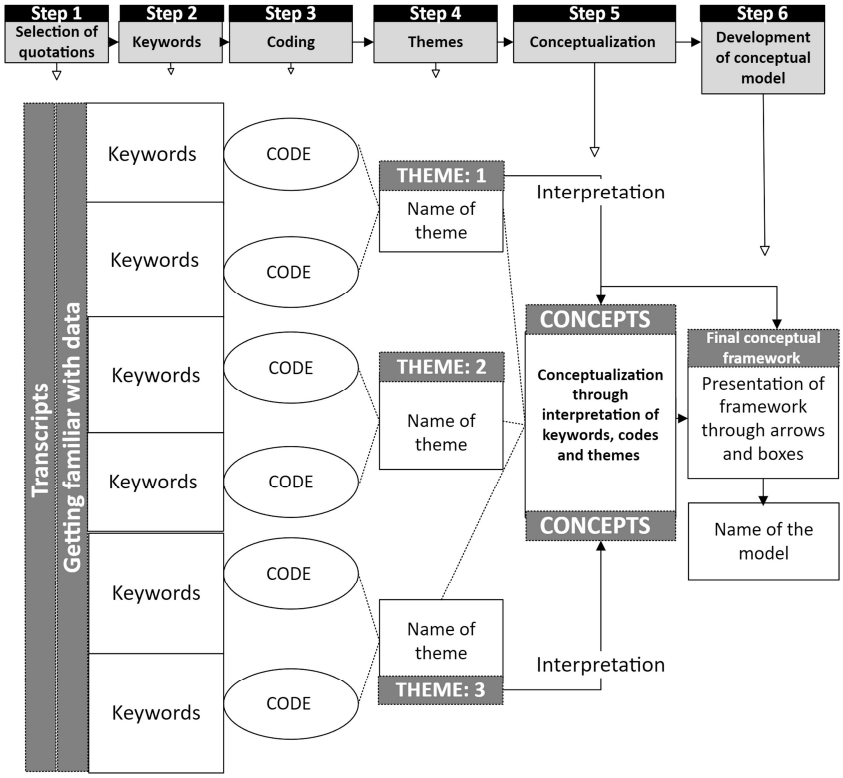


Figure 3: A systematic thematic analysis process (Naeem et al. (2023, pg. 4)

3.10 Possible limitations and challenges of the study

Limitations for this research study may arise from using focus groups as a data collection method. Participants of the focus group may not share their views openly in fear of judgement or ridicule. As a study based in the interpretivism paradigm, the role the researcher plays is significant. Thus, it is prudent that the researcher remains impartial to the discussion and endeavours to capture the information provide in a manner which best represents the intent of the participants.

3.11 Quality Assurance

Quality assurance in research provides a tool for assessing the quality of the research study. A proposed study to ensure the quality of qualitative research

studies is to assess the study's transferability, credibility, and dependability (Johnson et al., 2020).

3.11.1 *Transferability*

The notion of transferability establishes the extent to which the outcomes of the research study may be replicated using different participants under different circumstances (Anney, 2014)The research's use of “thick description” to describe key elements of the study in detail and the purposive selection of the participants facilitates transferability. Thick description implies that the methodology and context are described vividly, thus confirming its applicability to other contexts. This study seeks to address transferability issues through purposive sampling, documenting all data and reference material, and employing a code-recode strategy.

3.11.2 *Credibility*

Credibility defines the extent to which the study's conclusions can be relied upon as an accurate representation of the data submitted by the participants. Johnson et al. (2020) suggest that credibility may be achieved through data triangulation. Triangulation reviews data collected from multiple sources or data-collection methods to identify convergence. Convergence implies that the interpretation of themes and assertions made by participants or collected from other sources arrives at a similar conclusion, thus validating the findings. This study aims to ensure credibility by following the principles of triangulation when concluding the findings.

3.11.3 *Dependability*

Johnson et al. (2020) describe dependability as a strategy the researcher employs to ensure that others may repeat the research to confirm the findings. To ensure dependability, the researcher must provide sufficient details of the methods and processes to repeat the study. In the case of this study, dependability stems from a detailed description of the methods employed,

transcription of the focus group interviews and an outline of the data analysis methods.

3.12 Ethical Considerations

Authors, Sim and Waterfield (2019) identified three key challenges with the focus group methodology, namely:

1. Consent: A key consideration for conducting research with human participants is consent. Focus groups pose a risk to ethical conduct as participants are expected to provide candid views in full view of their peers.
2. Confidentiality and Anonymity: Ensuring that any information shared with the research maintains the level of confidentiality expected by the participants and scrubbing personal data that may be used to identify participants.
3. Risk to harm: Mitigating the risks of social and psychological harm as participants are asked to share information that may make them susceptible to stigmatisation, ridicule, and/or embarrassment.

The researcher's responsibility is to ensure that participants know their rights regarding the research study. Participants will be informed that participation is entirely voluntary and they can withdraw their consent at any time. In addition, the researcher will ensure that:

1. Participants are provided with an overview of the research study, detailing the purpose of the study, the objectives, process and expected outcomes during participant recruitment.
2. All participants are informed that participation is voluntary, and no incentives are provided.
3. All personal data will remain protected and secured as far as reasonably practicable to protect participants' privacy and anonymity.
4. Analysis of the information provided will seek to ensure participants are not misrepresented.

5. Ground rules regarding the focus interviews are enforced to mitigate the risk of harm to the participants. Participants will also be informed of their right not to answer any questions that may cause them discomfort.

3.13 Conclusion

Chapter 3 provides an overview of the research methodology employed to answer the research questions. This research is based on the interpretivism paradigm, employing inductive strategies to identify antecedents and determinants for digital skills development within the coal mining industry. The research approach stemming from the paradigm is based on qualitative research methods. Next, the chapter addresses aspects of the study population, purposive sampling, and the data collection methods. The study concludes with a review of the criteria for ensuring research quality and adherence to established ethical principles.

CHAPTER 4. PRESENTATION OF FINDINGS

4.1 Introduction

The following chapter presents an overview of the findings as gathered through 3 semi-structured focus group interviews aimed at exploring the barriers and enablers of digital skills/competency development in the South African Coal mining industry. As detailed in Chapter 3, the data analysis method as proposed in Chapter 3 was employed to contextualise the findings as they related to the propositions outlined in Chapter 2.

4.2 Data Collection Procedure

Invitations to participate were extended to 28 individuals via email or direct communication. Each potential participant was provided with a participant information sheet and a consent form to ensure informed consent. Of the invitees, 12 accepted the request to participate and were subsequently allocated to a focus group. Formal meeting invitations were sent to those who expressed their willingness to participate, utilizing Microsoft Teams for the virtual meetings. At the commencement of each focus group discussion, participants were reminded that the sessions would be recorded and that their participation was entirely voluntary.

Due to the limited response to the participation request and the availability of participants, three focus groups were scheduled, each initially consisting of four participants. However, due to various factors, two participants were subsequently unable to participate, resulting in two of the focus groups being composed of three members each. Subsequent efforts to recruit additional participants proved unsuccessful, and thus only three focus group discussions were conducted for the purpose of this study.

4.3 Demographic profile of Participants

The demographic profile of the focus group participants is detailed in Table 3. The table lists the participants according to their role, classification code used for transcription, years of tenure within the industry and the focus group of which they were a part of. The average tenure of participants within the South African mining industry is 6.4 years, indicating that they possess substantial sectoral expertise and knowledge. The participants' roles are diverse, ensuring a broad range of experiences and a comprehensive understanding of the sector.

Table 3: Demographic Profile and Coding of the Focus Group Participants

Count	Code	Role	Age Group	Gender	Tenure within the Mining Sector (Years)
1	P1FG1	Professional-in-Training – Mechanical	20 – 30	Female	1
2	P2FG1	Manager Functional Learning	30 – 40	Female	23
3	P3FG1	Senior Engineer, Projects 2	20 – 30	Male	8
4	P4FG1	Digital Value Chain Lead	30 – 40	Male	2
5	P1FG2	Professional-in-Training – Civil	20 – 30	Female	1
6	P2FG2	Senior Electrical Engineer	40 – 50	Male	14
7	P3FG2	Project Specialist, Community Development	30 – 40	Male	5
8	P1FG3	Lead Data: Business Improvement	30 – 40	Female	1
9	P2FG3	Senior Reliability Engineer	30 – 40	Male	8
10	P3FG3	Senior Engineer, Projects 1	30 – 40	Female	1
		Average Tenure:		**6.4**	

4.4 Thematic Analysis

Thematic analysis was conducted using inductive techniques to analyse the data, maintaining participants' perspectives and experiences to provide a rich and nuanced understanding of the data. Figure 4 shows how codes and themes were generated from the data, resulting in the key themes, as illustrated in Figure 5.

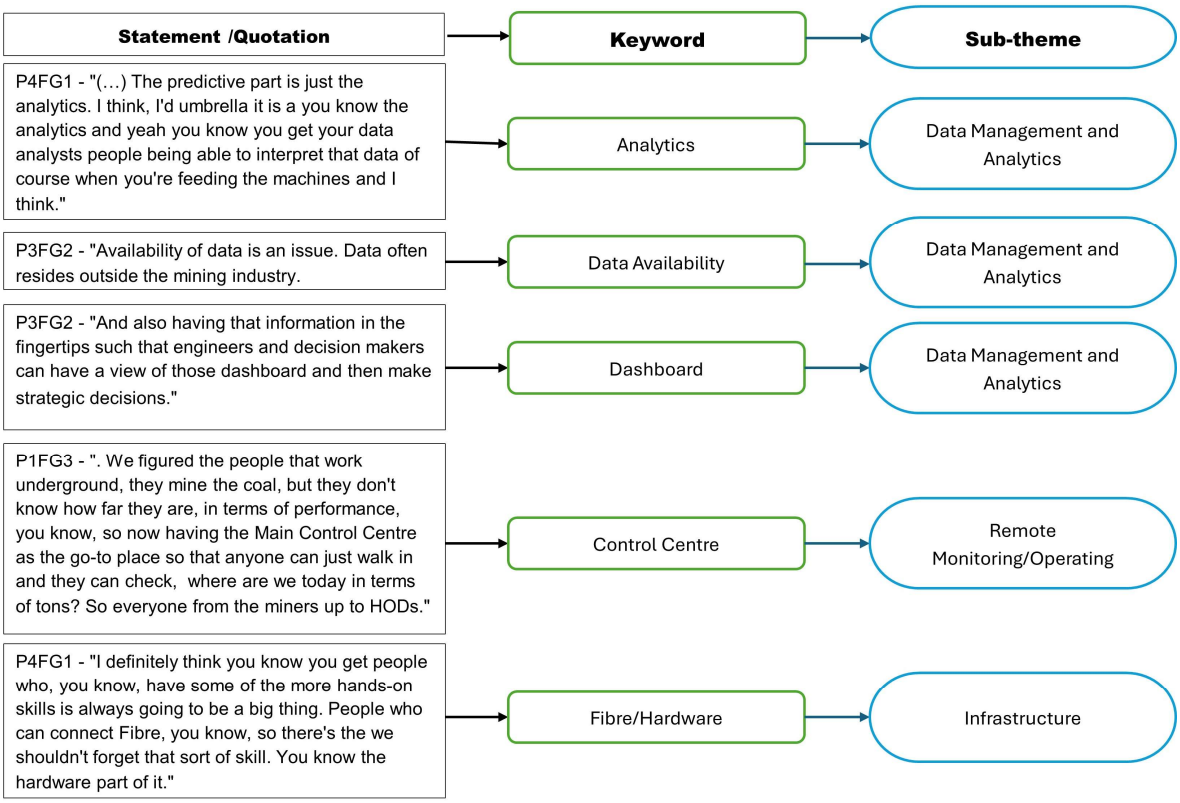


Figure 4: Sample coding using thematic analysis

A comprehensive overview of the data and subsequent analysis is provided in APPENDIX (D): Thematic Analysis.

4.5 Key Themes

Figure 5 provides an overview of the themes and sub-themes generated from the thematic analysis.

Proposition	Theme	Sub-theme	Key words
Proposition 1	**Technology Adoption in Mining**	Data Management and Analytics	A lot of data, Data interpretation, Analysis, Analytics, Data Availiability
		Remote Monitoring and Control	Control centre, centre, decision makers can have a view of those dashboard, many dashboards
		Infrastructure	Fibre, Wi-Fi, Connectivity, Cables, Equipment, Machines
Proposition 2	**Impact of digital technologies Employees**	Ways of work	Day-to-day, Make life easier, Do more with less, Efficiency and effectiveness, Productivity, Impact on individual activities
		Workforce Skills Gap	Lack of Skills, need skilled people, Skills Gap,
	Human Factors	Employee Mindset/Beliefs	Mistrust, Pain points, comfort, mindset, mentality
		Motivation	Very poor development activities, to be motivated,
		Language Barriers and Literacy Levels	Literacy, Language, Adult Education
Proposition 3	**Rate of Technological Adoption**	Pace of adoption	Trying to catch up, We are a bit behind.
		Historical challenges	Analog and very hands on history, we want ready-built stuff
		Accessibility	Accessibility is key, need for demonstration,
	Organisational Environment	Change Management Practices	Change management, manage change , More receptive to change
		Role of Management/Leadership	From the top, management, leadership, Creating a culture, Communication and Awareness, Budget and be intentional
Proposition 4	**Collaboration and Partnerships**	Industry Collaboration	Community pipeline, Other organisations, Government , to collaborate with other industries
		Vendor Partnerships	Vendors, Suppliers, Industry partners
		Educational Institutions	Schools, Training institutions
	Skills development and Training Programs	Skills development programs	Skills development programs tailored
		Training	Training is essential, courses, training, and awareness
	Rewards and Incentives	Value	Certificate, career progression
		Incentive	Having an incentive, get me more money

Figure 5: Thematic diagram of research findings

4.6 Findings pertaining to Proposition 1

Proposition 1: Company X, a coal mining company in South Africa, is likely to adopt digital technologies such as data management, IOT, automation and AI aimed at improving operational efficiency safety, and productivity.

Proposition one explores the technologies being explored in the coal mining industry as a basis for driving the need to upskill and reskill the workforce. Participants were asked to comment on which technologies they though were

driving DT and which technologies they believed were likely to be adopt as part of DT within the industry.

4.6.1 *Technology adoption in Mining*

The following recurring themes were noted as part of the focus group discussion on the digital technologies and capabilities required to enhance digital transformation within the industry.

a. *Data Management and Analytics*

The focus group discussion identified elements of data management as being a critical element of DT within the industry. Participants identified the need for the industry to develop data management/analytics frames, thus enabling data-driven decision-making. In developing data management capabilities, the industry would be laying the foundation for a transition to digitally enabled operations.

> "*I think we've implemented quite a number of projects here at Company X. So, one of them is basically called the primary equipment connectivity as you are able to get a lot of data from the machine and been able to make decisions on*." – P2FG2

> "*I think look on we we're moving from the how can I say it from where we never used to have digital systems in a mining industry, and we are moving obviously towards attaining all the data and information."* – P2FG2

> "*Availability of data is an issue. Data often resides outside the mining industry."* – P3FG2

Some participants highlight that although the need to have data management strategies within the industry, the was a need to develop the analytic skills to gain value from the data.

> *"Also, in terms of accessibility then, while we have all that data, the skills to analyse it, from basically from cleaning, exploring it and then analyse it*

such that decision can be made on the maintenance, are required for predictive maintenance." – P3FG2

"*When you take it a step further, now where you're looking at the analyst roles and the need for digital skills in the context of working with interface data and making use of it to the extent that it is beneficial to a business. I suppose there is some room for development."* – P2FG3

Another participant highlighted the importance of data in driving strategic decision-making.

"*And also having that information in the fingertips such that engineers and decision makers can have a view of those dashboard and then make strategic decisions.*" – P3FG2

b. ***Remote Monitoring and Control***

A common view amongst participants was that one of the digital technologies being considered for adoption in the industry is remote monitoring and control through remote control centres (ROC). Comments indicate that there is a strong belief amongst participants that ROCs would assist in promoting access to information, transparency, and continuous monitoring of performance.

"We figured the people that work underground, they mine the coal, but they don't know how far they are, in terms of performance, you know, so now having the Main Control Centre as the go-to place so that anyone can just walk in, and they can check, where are we today in terms of tons? So, everyone from the miners up to HODs." – P1FG3

I think the introduction of the centre where the guys got to see the information, the digital team, I think obviously that's the move in the right direction where you find people that actually use that data that is coming (...)." – P2FG2

Monitoring of performance data and other systems could be managed through dashboard.

"*Also having that information in the fingertips such that engineers and decision makers can have a view of those dashboard and then make strategic decisions."* – P3FG2

"*I think the second one will be a one is so like with digital with a lot of initiatives that we've done with build, so many dashboards you know, but there will still be someone asking for the same report*." – P1FG3

c. ***Infrastructure***

Although there is a drive to digitally transform within the industry, participants felt that there is a need to address the challenges related to infrastructure. Participants highlighted challenges with connectivity and the skills to maintain the systems which enable DT.

"*We still have a challenge of connectivity; I mean the last time we saw the launching of that app and then we couldn't connect. And if we couldn't connect at surface, what? Imagine what is the condition underground. And then if we can't connect and we have real challenges*." – P3GF2

Two participants were more concerned with the skills required to ensure that the infrastructure remained functional.

"*We lack technicians to maintain the fibre and equipment that draw this data. We focus on getting the technology but often forget about maintenance and the holistic view of interconnected systems. We need skilled people to manage this.*" – P2FG2

"I definitely think you know you get people who, you know, have some of the more hands-on skills is always going to be a big thing. People who can connect Fibre, you know, so we shouldn't forget that sort of skill. You know the hardware part of it." – P4FG1

In part, participants felt that the lack of knowledge about the infrastructure and its purpose also leads fails in the system.

"*Certain cables in the machine get damaged or, but because I don't know what this machine or this cable is doing, what's its objective? I'll pull it out as long as the machine is going. I'm cool. Let's it's moving, right? I need to just get the machine to move. I've taken out an essential component for which we can enable data communication, Wi-Fi. You know, for argument's sake*." – P4GF1

4.7 Findings pertaining to Proposition 2

Proposition 2: Digital transformation in the coal mining industry leads to the evolution of job roles and responsibilities, requiring workers to adapt to new technologies and processes. This increases skills deficiencies and creates a skills gap.

Proposition two investigates how transition toward digital technology adoption will impact the roles and responsibilities of the workforce. In seeks to address the changes likely to be experienced by the workforce and the need to address any gaps or deficiencies in skills.

4.7.1 *The impact of digital technologies on the ways of work*

The consensus from participants is that the deployment of digital technologies within the coal mining industry will impact the way in which employees carry out their daily duties. The overarching views of participants is that cognisance should be taken to address the evolution in the ways-of-work when proposing new systems and/or technologies.

"*I think the impacts ("of DT") from my side it will be driving the change efficiency, right? (. . .) So yeah, efficiency, then also productivity and also the impact is on the way of work*." – P1FG3

"*Value chain integration and demonstrating the impact of digital systems on individual activities can help bring employees along. Understanding how different roles affect the overall operation is crucial."* – P2FG3

"When you look at digital implementation, it is basically to make your life easier." – P2FG2

The introduction of digital technologies into mining brings with it the opportunity to positively impact the efficiency and productivity of the workforce. Digital skills are the foundational building blocks on which employees can increase their effectiveness and efficiency.

"*I think, look, as much as much as we all want, you know, the technology and the digitization. But you know, the main thing is that we want this thing to work for us so that we can be effective, and you can do more with less effort."* – P3FG1

"*I think the impacts from my side it will be driving the change efficiency, right? So, for example the operators were using Excel and then now they are being migrated to Power app. So yeah, efficiency and then also productivity."* – P1FG3

4.7.2 *Workforce Skills Gap*

Participants highlighted the impact of DT on employee skills and capabilities. Sentiments shared indicate that gap in skills which arises because of haphazard introduction of digital technologies.

"*We focus on getting the technology but often forget about maintenance and the holistic view of interconnected systems. We need skilled people to manage this*." - P2FG2

"I think that there is definitely a gap there and I did want to say that as much as we pointed out that it is a problem that there is a gap, a skills gap, it is also an opportunity for us to develop other skills." – P1FG1

There is a shared belief among participants that there is value in ensuring compatibility of digital skills to the existing skillsets of the workforce.

"*It's important to bridge the gap between traditional skills and digital skills. Training and project exposure can help build intuition and understanding of digital tools.*" – P3FG3

"*I think that there is definitely a gap there and I did want to say that as much as we pointed out that it is a problem that there is a gap, a skills gap, it is also an opportunity for us to develop other skills*."- P1FG1.

"*Skills and tools are also lacking*." – P3FG2

From the data gathered it evident that the majority of participants see DT has having a profound impact on the skills profile of the coal mining workforce, and believe that there a skills gap has developed has a result of DT.

4.8 Findings pertaining to Proposition 3

Proposition 3: Human factors, including employee motivation and beliefs, propel the development of digital skills and competencies in the coal mining industry. Furthermore, the availability and accessibility of advanced technologies, as well as a supportive organisational environment, greatly aid the development of digital skills.

Literature places an emphasis on taking the human elements into account when planning or initiating DT. Proposition 3 seeks to determine the validity of this idea in relation to digital skills development in the coal mining industry.

4.8.1 *Human Factors*

The successful introduction of new systems, where digital or process, often relies on the psychological state of the workforce. Participants provided views on how psychological factors may determine the likelihood that the introduction of a digital system will be successful. The two major factors considered by the participants include: Employee mindset as well as the language barriers and literacy levels.

a. ***Employee Mindset/Beliefs***

Participants shared their sentiments that mindset, often characterised by mistrust and discomfort as being a stumbling for digital skills development.

> "*I suppose it has something to do with a mistrust of digital systems and what they are meant to do, right? So that you have a poor utilisation because there's that gap between the people who must benefit from them and what they think of those systems*." – P2FG3

> "*But I think it's also a bit of a trade, or rather it is comfort to employees because you don't know if technologies, if it's been introduced, how it's going to affect employment.* " – P2FG1

> "*I suppose it has something to do with a mistrust of digital systems and what they are meant to do, right? So that you have a poor utilization because there's that gap between the people who must benefit from them and what they think of those systems.*" – P2FG3

> **"***Given South Africa's employment landscape, right? And I think just touching on to then saying, you know, obviously the worrying part, people worry sometimes*." – P3FG1

Sharing a possible solution participant proposes that strategies must be employed to build trust in relation to digital systems.

> "*From our side ("DT initiators") to build trust, I think that people need to see value, right. So, if you are changing the way of work and then you are introducing this new digital solution, so you need to be able to convince those people to trust them.* " – P1FG3

b. ***Motivation***

Participants raised concerns regarding the motivation of employees and notes that employee a lack of motivation may hinder the drive for self-development should there be a lack of understanding in the benefits that arise from such activities.

"*The usual mindset is that if you've employed me with whatever little I know that it means that's the little you require from me. And usually there's been very poor development activities in as far as taking courses that help prepare individuals for digital systems or a digitally transformed mine and how digital systems are viewed by the business at large*." – P2FG3

If I were to be motivated to take a course, really obviously I will be a question of what value will it add on my day-to-day. How will it improve the way of work? And also, it needs to align really to my career vision." – P1FG3

Participants also pointed out that more emphasis needs to provide on ensuring end-users see the value of the systems and the associated digital skills in improving their efficiency.

"Value chain integration and demonstrating the impact of digital systems on individual activities can help bring employees along. Understanding how different roles affect the overall operation is crucial." –P2FG3

"Digital implementation is about making life easier. Look at personal pain points and find digital solutions to address them. There are many platforms available to help." –P2FG2

"We need to show the benefits and make their lives easier, similar to how cell phones were adopted." –P1FG2

"Effective communication and bringing value to people are essential." – P4FG1

P2FG3 further emphasis that ensuring that end-users perceive the value of digital systems is paramount to improving utilisation and comments: "There is also a need for better utilisation of digital systems and demonstrating their value to end users. "

c. ***Language Barriers and Literacy Levels***

Overall participants noted that literacy levels and issues of language would continue to hinder DT unless these are addressed at Macro levels as well.

> "*Language is a critical issue when it comes to accessibility and information capturing. So, if we can really make sure that even with introduction of all these initiatives, we don't lose that element of language.*" – P3FG1

> "*But in a country like or context like South Africa, there are language barriers. I believe that. We need to think about offering certain trainings in certain languages. Because to some extent it*. " – P3FG3

> "*Regarding the technology, but what are we now going to do with the older workforce that we have, you know, I mean, we still have adult education and training, which is still very big in the mining industry. So, when you introduce technology, how are you going to train those people? Because some of them can't even read and write.*" – P2FG1

4.8.2 *Rate of Technology Adoption*

Participants provide a view that the mining industry is playing catchup in trying to meet its goal for digitalisation and DT.

> "*Technology is there, but it's increasing at an exponential rate. The mine is trying to catch up with digitalisation, but it's not at the industry's pace*." – P1FG2

Participants also highlighted the current state of DT in mining, considering the historical challenges of the mining industry.

> "*We (the mining industry) come from a very analog and very hands on history. That you know, when we talk about in pillar mining or we talk conventional mining, you know it's mining philosophies that have worked and that have been inexpensive. And they continue to mine the same way, right. So, the mining? Methodologies have really not changed. But it's the value aspect of digital systems that are still for me, vague, like not for me*

personally, but in the aspect of mining when we are looking at people on the ground." - P2FG3

"*The thing about mining is that we want ready-built stuff, and we just want to implement a working way we don't go through the journey of learning, and you know when you go through the journey of implementing something from scratch and you know, playing around with it then*." – P2FG2

"*I think we are a bit behind. You know, when I look at the farming environment, they are basically 10 steps ahead of what we currently are in the mining and I think in terms of empowering the maintenance crew, the end users.*" – P2FG2

In addition to the complexities inherent in the mining industry, participants highlighted key issues associated with the lag in DT as being a result of the state of the South African labour market and the complexities that may arise from there.

"I mean, we still have adult education and training, which is still very big in the mining industry. So, when you introduce technology, how are you going to train those people? Because some of them can't even read and write." – P2FG1

According to the data, technological factors which impact on digital skills development relate to the ability be able to use the technologies, having access/exposure to them and lastly, understanding how the technology reflects the work environment.

"*Firstly, you need to be able to work with those technologies and understand them. The skills needed come from being able to use these technologies correctly and effectively to make an impact*." – P4FG1

"*Accessibility is key. People need access to the necessary equipment and resources."* – P4FG1

"*They want to see that a system does perform exactly what it promises to do, so if we bring so former. That would come from some level of*

understanding. That the system is a reflection of the environment they work in so. So, there's a need for demonstration." – P2FG3

The data indicates that when selecting digital systems, considerations must be made for how the technology will be use, accessed, and understood by the intended end-users.

4.8.3 *Organisational Environment*

Organisational factors play a major role in driving DT and providing a platform for employees to develop/enhance their digital skills. Participant expressed two main factors as being key aspects of DT and thus digital skills development amongst the workforce: Change management and the role management/Leadership.

a. *Change Management Practices*

The views shared by the participants indicate that employees should be part of the DT through a change management process, as alluded by participant P3FG1 people need to be assured that technology is here to assist and improve jobs, not take them away. The gap between the previously disadvantaged and the new generation must be addressed to successfully drive DT. There is a need to ensure the older generation is not left out as the industry moves forward with DT.

"*An environment like this one, the mining industry, when you bring digital it's like a taboo sort of thing. So, when you introduce a solution or digital solution, you need to also do change management just to make sure that you are aligned with the people."* – P1FG3

"I think obviously the first thing that we need to do is to create awareness and say we need to create awareness and we have to manage the change because some people resist change and then train their employees, you know on whatever program that we are introducing to the system." – P2FG1

"*I think also it's just to prepare the employees for change. You know, just so that they are ready, and I think that preparation really is about*

introducing details slowly because you know they can be scared if you just like decide." – P1FG3

"*The first step is changing the mindset and aligning business interests with digital transformation. There is also a need for better utilisation of digital systems and demonstrating their value to end users. Training and involving end users in the development process can help build trust and improve adoption*." – P2FG3

"*Successful implementation of new initiatives builds confidence and makes us more receptive to change."* - P1FG1

b. ***The Role Management/Leadership***

In addition to the cultural aspects of the organisation participants highlighted the need for management/leadership support. Participants note where buy-in is not evident from top management level, challenges in DT arise.

"*It's difficult because there's scepticism from the top. We need to show the benefits and make their lives easier, similar to how cell phones were adopted."* – P1FG2

"*We learn well from our peers. Managers should lead by example and discuss how they use new technologies."* – P1FG1

"*The ability to explore and innovate is important. A supportive culture driven by leadership is crucial*." – P4FG1

"I think with change management, I think there's a leadership aspect in it that must insist on transformation." – P2FG3

Giving an example of the role of management in driving change participant P3FG1 notes "*Training and upskilling are embedded in Company X's culture. There's support from leadership and departments. We recently completed the MDP program, which was encouraged by our leaders.*"

One participant expressed that there was a need to consider the cost of DT and for the organisation to be intentional about availing funds to enable digital transformation.

> "*Going digital also cost a lot of money, so we need to include it on our budget and be intentional about it*." – P1FG3

4.9 Findings pertaining to Proposition 4

Proposition 4: Practical strategies to enhance digital skills and competencies within the South African coal mining industry include implementing continuous development and training programs and fostering partnerships with industry stakeholders.

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The dominant view of literature indicates that the development and upskilling of employee skills should not be undertaken as an after-thought. Literature advocates for sustainable strategies which promotes the upskilling and reskilling of the workforce. Proposition 4 explores strategies which could be effective for addressing challenges with the industry.

4.9.1 *Skills Development and Training programs*

Training and education are emphasised as essential for adapting to new tools such as AI, and automation. Participants provide a bold case for the development of skills development programs and/or initiatives for ensuring that the workforce is not left behind. Overall, sentiments indicate that skills development and training programs are key enablers for upskilling and reskilling of the workforce.

> "*Skills development programs tailored for new technology are necessary. Everyone needs to be trained on the new machines or technology.*" – P2FG1

> "*We need courses, training, and awareness for different users to understand these changes. More training on new platforms and*

environments is essential. We need to get rid of the old mentality and equip ourselves for the digital space. " – P2FG2

"*Training is essential, especially with new tools and automation."* – Participant P1FG3

"I think it's important that we start having courses and training as well as awareness in terms of all these changes that are coming in for the different user's skilling them and getting them knowledgeable on the different platforms and environments." – P2FG2*.*

Two participants offered a solution to challenges with training and skills development.

"An individual development program that is tailored to the required digital skills I think can help accelerate skills learning." – P2FG3

"*Training should be interactive and stress the end goal. It should show the impact and importance of the training, making it engaging and fun*." – P1FG2

4.9.2 *Rewards and Incentives*

A key enabler, often overlooked during DT adoption are the rewards and incentives associated with learning new skills and participant in upskilling/reskilling programs.

"*I know we spoke about communicating the value that the new technology adds, but also having something like a certificate or some kind of extra title helps. Some type of way to identify you as someone who is competent in the new technology that's being implemented is very encouraging*." – P1FG1

"*So that can be a motivation to get on the program for the purposes of also, you know, being proficient in skills that are on the spot and how they help in your career progression*." – P2FG3

"You mentioned salary. It was my answer. Yeah, people are even asking if system can check for you. If they are, what is that all about? So that's how important this thing is." – P3FG1

"*And then another thing that can maybe help a person to be more on board with the change management that was mentioned is having an incentive to learn these things*." – P1FG1

"*Personally, I prefer face-to-face interactions it takes a lot of motivation for me to switch on my computer and start a program and start learning, even on Udemy. Unless the certification that I'm going to get will get me more money.*" – P3FG3

4.9.3 *Collaboration with Stakeholders*

One participant shared the sentiments that the issues of industry readiness may be solved through collaborations and engagements with industries partners and stakeholders.

"*I think the last one is also just to collaborate with other industries that have made it already. So, if Seriti has the same solution and it's a success. I think it's also collaborating with them. Learning from them or adopting whatever that they know*." – P1FG3

One participant also argues that operating in silo's often hinders DT and shares the sentiment that integrating across the organisation structures would facilitate DT.

"*Integration of information across the organisation is important for making informed decisions*." – P3FG2

Involving the feeder community involved was also noted as an area where the industry to go to ensure a pipeline of digitally skilled employees.

"*We can develop skills development programs for the community to build a pipeline for the organisation*." – P2FG1

"*Because you are excluding the people at large. So, the communities where you employ from. So, if there are programs that help prepare communities to digital skills and technologies that operate at mines or at industry, that improves the skill base of your neighbouring areas*. " – P2FG3

Aligning with educational institutions was considered another area where the industry could influence digital skills development.

"*I think also have a look at school. School programs. Whether it be at a basic level or tertiary level in sort of technology awareness and skills associated. Can help also help prepare individuals that are employed to be readily skilled in digital aspects*. " – P2FG3

4.10 Summary of Findings

Based on the transcripts and the thematic analysis conducted, the insights gathered from the study indicate that implementation of digital technologies with the coal mining industry is ongoing, with a focus on improving productivity and decision-making. The implementation of digital technologies has a profound impact on the workforce and impacting job roles and create the need for new skills. The study further highlights the need for organisational readiness, including management commitment and the need to identify the unique characteristics of the coal mining industry, such as traditional methodologies, influencing digital transformation. The industry needs address the issues related the technological infrastructure, including the availability of digital tools and IT support, which are essential for successful implementation.

To drive digital skills development, identifying and addressing skill gaps is crucial for effective digital transformation. Organisations must demonstrate the value of digital skills as it helps in gaining employee buy-in. It should be noted that resistance to change and mistrust of digital systems are significant barriers to digital skills development.

Skills development programs and training may be considered avenues for promoting the enhancement of digital skills. However, workforce demographics, including language barriers, need to be considered when developing these programs. Collaboration with other industries and stakeholders is another aspect to consider for continuous learning and self-development.

Encouraging self-development among employees is imperative for continuous improvement and the effective implementation of digital technologies. Emphasising the value proposition for employees in enhancing their digital capabilities is essential. Additionally, rewards and incentives associated with acquiring new skillsets should be considered key motivators.

CHAPTER 5. DISCUSSION OF THE FINDINGS

5.1 Introduction

This chapter presents the results from three focus group discussions aimed at investigating the potential for digital transformation (DT) in the South African coal mining industry through the lens of digital skills development and enhancement. The results are discussed in relation to four propositions postulated for the research. The chapter contrasts the findings presented in Chapter 4 with the literature reviewed in Chapter 2 and is used to analyse the factors influencing digital skills development in the industry.

5.2 Discussion pertaining to Proposition 1

Proposition 1: Company X, a coal mining company in South Africa, will likely adopt digital technologies such as data management, IOT, automation, and AI to improve operational efficiency, safety, and productivity.

Consistent with the literature, this research found that although the industry is moving towards digitalised operations, the complexities and inherent challenges have delayed digital transformation (Abdellah et al., 2022). The study's results indicate that although there were efforts to adopt digital systems, the deployment of specific digital technologies was sluggish owing to challenges with infrastructure.

In their paper, Young and Rogers (2019) identified the need for mining companies to invest in the foundational elements of data storage and processing, connectivity, and digital systems to facilitate data-driven decisions before fully digitalising mining operations. The current study's findings support this notion and highlight the need for mining operations to invest significantly in ensuring that the technological infrastructure and IT systems support digitalisation. Key infrastructure highlighted in the discussion relates to optic fibre, Wi-Fi and other connectivity-related system as essential for successful DT. Ediriweera and

Wiewiora (2021) noted that the lack of infrastructure may serve as a significant barrier to digital technology adoption within the industry.

The study also revealed that the industry was making concerted efforts to deploy systems that would facilitate data-driven decision-making, such as data storage and analytics platforms, remote monitoring centres, and dashboards. This supports the results of Zhironkina and Zhironkin (2023), who identified these technologies as possible solutions to be adopted by the mining industry as part of the transition to 4IR operations. In adopting these technologies, the industry aims to develop capabilities to analyse data and identify patterns, which would be the foundation for the adoption of preventative maintenance practices.

Other digital technologies identified as suitable for industry adoption are AI, autonomous vehicles, and collision detection systems. However, these technologies were yet to be implemented as they have not reached their full potential and thus have not been widely adopted within the industry.

5.3 Discussion pertaining to Proposition 2

Proposition 2: D Digital transformation in the coal mining industry leads to the evolution of job roles and responsibilities, requiring workers to adapt to new technologies and processes. This increases skills deficiencies and creates a skills gap.

5.3.1 *The impact of digital technologies on the ways of work*

The authors Storey et al. (2024) argue that digitalisation can fundamentally change many of the established practices within mining. In particular, the authors indicate that digital technologies will profoundly change the way in which work is carried out, as well as the location of work activities. Several participants of this study indicate agreement with the findings of Storey et al. (2024), sharing sentiments which are indicative of technology impacting the way of work.

In addition, participants shared their views on how digital technologies could help improve the efficiency and effectiveness of the workforce. Thus, it allows

employees to explore and leverage digital systems to execute their responsibilities better. The participants' examples indicate how machine operators' actions are affected by digitalisation and require new individuals to adapt to additional or altered responsibilities. This finding supports the ideas of Chirgwin (2021) who reviewed the impact of shifting to automated control rooms on the roles and responsibilities of the mine controller.

Implicit in the discussions was the need for the workforce to develop an understanding of the solutions offered by digital technologies. One participant commented about the skills required for individuals to move from relying on Microsoft Excel to the Power BI platform. This sentiment implies that the ability of the workforce to adequately adapt and develop new skillsets, in line with the advancements in digital technologies, is pivotal to succeeding in a digitalised mine. These results confirm the observations made in literature by various researchers, emphasising the need to support employees in identifying and addressing the need for new skillsets as DT is being implemented throughout the industry (Ediriweera and Wiewiora, 2021; Lööw et al., 2019; Young and Rogers, 2019).

Skills emphasised by the participants related to the ability to gather, interpret, and apply data in a manner that promotes effectives. Other skills discussed pertain to using digital technologies to facilitate preventative measures, in contrast to the currently employed reactive approach. As noted by the participants, developing these skills could allow mining companies to adopt AI-backed, preventative philosophies and allow for strategic decision-making related to equipment maintenance.

One interesting finding, shared by two participants, is that the industry lacks the basic skills that enable the installation and maintenance of hardware required to operate digital systems. One participant referred to these skills as hands-on skills, encompassing a technician's capabilities, who could maintain digital components such as fibre connections, cabling, and sensors. This perspective is shared by Olaitan et al. (2021), who propose that South Africa to ensure its readiness to adopt 4IR technologies, there must invest in ensuring integration between the physical, digital, and biological elements of the business.

5.3.2 *Workforce Skills Gap*

In addition to the evolving nature of work, participants identified a skills gap within the industry. The participants' opinions reveal that in most instances, there seems to be a gap between the traditional skills and capabilities of the workforce and the skills required to operate in a digitalised environment. The findings further hint at the lack of digital skills and an overemphasis on traditional skills related to mining. Prior studies in the field of DT have noted the propensity of digitalisation to result in a skills gap, as employees struggle to keep up with the requirements of technological advancements (Davrajh et al., 2023; Nkomo and Kalisz, 2023; Ullrich et al., 2023).

According to Karolia-Hussain and Fourie (2021) one of the major factors hindering the DT of the South African mining industry is the skills gap introduced by the DT efforts. Thus, the shared perspective of key stakeholders within the industry is that DT will have a negative impact on the workforce because of the skills gap. When asked to explore how the skills could be addressed, one participant suggested recruiting digitally skilled individuals from other industries. This, however, would not alleviate the need to bridge the gap between the traditional skills of the workforce and the new skillset requirements introduced by DT.

5.4 Discussion pertaining to Proposition 3

Proposition 3: Human factors, including employee motivation and beliefs, propel the development of digital skills and competencies in the coal mining industry. Furthermore, the availability and accessibility of advanced technologies, as well as a supportive organisational environment, greatly aid the development of digital skills.

5.4.1 *Human Factors*

It has been well-established in literature that the people elements play a pivotal role in driving DT within an organisation. Amongst the elements considered to be significant in enabling DT are the psychological attributes of employees (Audrin et al., 2024; Nkomo and Kalisz, 2023; van Laar et al., 2020).

The current study found that for the South African Coal mining industry, the attributes of employees that are most likely to affect digital competency development are related to the levels of motivation, mindset/beliefs, and reading/writing proficiency of individuals.

a. *Mindset/Beliefs*

Kao et al. (2024)suggest that the beliefs and mindset embodied by employees play a notable role in promoting DT within an organisation. In supporting this perspective, Jamal et al. (2024) conclude that individuals' beliefs play a considerable role in determining whether they will be accepting of technological changes. Evident from the findings of this study is that the participants confirmed the notions proposed in the literature that mindset and beliefs remain a consideration for successful DT.

Expanding on this idea, participants indicate that feelings of mistrust may arise where communication about the purpose and impact of DT are not clearly communicated with employees. Participants indicate that the champions of DT initiatives need to provide comfort to the workforce, through continuous engagement and sharing of information. This finding is substantiated by Nkomo and Kalisz (2023) who assert that the haphazard implementation of DT often results in employee resistance and raises issues of technology-induced stress.

b. *Motivation*

Comments made by the focus group participants emphasised that motivation is critical in driving digital skills development within the industry. Participants highlighted that for individuals to participate in self-development activities, they must understand how these skills will address their most pressing issues. The

results indicate that employees will be motivated to learn new skills when they see benefits in their day-to-day work and are given opportunities for career progression. This result resonates with previously conducted studies by Gorski et al. (2023), which stressed the importance of motivating employees towards self-development and attaining new knowledge. The authors further state that to appropriately motivate employees, an effort must be made to demonstrate the value of the enhanced skillset and how it would complement existing competencies.

c. ***Language and Literacy***

Given the necessity to interact with digital systems, practical communication skills, both spoken and written, have been identified as a crucial factor for the successful implementation of technology (Audrin et al., 2024). The findings of this study are consistent with this and suggest that language and literacy proficiency substantially impact digital skills development in the mining industry. Participants noted that employees with limited proficiency in the primary language of instruction and technical documentation may face challenges when interacting with digital systems.

In addition, participants advocated for developing digital materials/systems that consider varying literacy levels to ensure inclusivity and effectiveness of digital technology adoption. Participants in the focus group discussion pointed out how language facilitates access to and processing of information. Shibambu and Mojapelo (2024) agree with this finding and note that the developing an individual's ability to locate and process information is vital to improve digital literacy.

5.4.2 *Rate of Technology Adoption*

Findings from several studies suggest that the rate of DT within the mining industry is indicative of mining being a technological laggard. The studies highlight that, although the industry is motivated to adopt digital technologies, operations' inherent complexities and scale have stalled progress (Abdellah et al., 2022; Chirgwin, 2021; Lazarenko et al., 2021). This study's results align with

those of previous studies, with participants indicating that the rate of technological adoption is lagging behind other industries. One participant compared the rate of agriculture to that of the coal mining industry and suggested that the industry is 10 times slower in advancing technological operations.

Furthermore, the study's findings indicate that a consequence of the delay in adopting digital technologies is limited access to digital technologies, thus denying employees the opportunity for on-the-job skills training. In addition, participants advised that with the introduction of technologies, there are opportunities to demonstrate how these systems are utilised. Overall, the findings suggest that with increased exposure and utilisation, the workforce's digital skills can be improved. This is consistent with the recommendation made by Audrin et al. (2024), stating that technology use improves digital skills within the workforce.

Other similarities between the attitudes expressed by the participants and literature are that substantiating the value and benefit of adopting DT is yet to be filtered through all the levels of the organisation (Ediriweera and Wiewiora, 2021).

5.5 Discussion pertaining to Proposition 4

Proposition 4: Practical strategies to enhance digital skills and competencies within the South African coal mining industry include implementing continuous development and training programs and fostering partnerships with industry stakeholders.

5.5.1 *Skills Development and Training Programs*

Participants emphasised the need to incorporate formal training programs to upskill and reskill employees in all the focus group discussions. Perhaps the most compelling finding is the emphasis participants placed on developing skills development programs, encompassing classroom training, hands-on practice sessions and on-the-job exposure. Participants considered these to be skills programs which would be tailored to the technologies being introduced. The discussion focused on ensuring that training created awareness of the new platforms and how they impact the work environment. These results corroborate

the ideas of Young and Rogers (2019) who suggested that the mining industry should align training and skills development strategies to the technologies earmarked for introduction.

Another important finding focuses on personal development to ensure that employees attain the necessary digital skills. Participants sought to include digital skills development as part of an individual personal development plan, so that attendance at training and/or skills development courses can be tracked. This highlights the need for personal accountability and initiative to pursue opportunities which promote digital skills development. As noted in the study by Achoki (2023) and another by Leon (2023), Individuals who take personal responsibility for developing the necessary digital skills tend to achieve their goals more effectively.

Foundational to training is the need to embed continuous learning as part of the organisation. The findings reveal the need to create spaces and occasions for the workforce to learn about new technologies. Suggested ways to achieve continuous learning are to create awareness and create projects which expose individuals to digital technologies, thus helping them build intuitive knowledge of how the systems operate. These results reflect those of Pedota et al. (2023) who also found that lifelong learning strategies are better suited to ensuring compatibility between current skills and the new skillsets to be developed by employees.

5.5.2 *Rewards and Incentives*

The research findings broadly support the idea that there is a link between the pursuit of digital skills development and the incentives offered by the organisation to enhance these. The study found that there is a need for organisations to improve on how they incentivise employees towards learning new skills. The sentiment shared by participants indicated a need to offer monetary and non-monetary incentives when an individual gained a new skill or achieved a new level of competency. This is in line with the findings of Kohnke (2016), who suggests that incentives positively influence learning and the rewards offered.

The author argues that to ensure the sustainability of skills development initiatives, the incentive system must be realigned to the objectives of DT.

Career progression and growth were also highlighted as essential in encouraging employees to develop/acquire new skills. Participants noted that it is challenging to get employees to invest time in acquiring new skills without the incentives that come with career growth and development. It seems that securing proficiency for the current role doesn't act as a significant motivator to explore new skills and competencies.

5.5.3 *Collaboration with Stakeholders*

Ediriweera and Wiewiora (2021) believe that for mining to improve on technological adoption, there must be collaboration between mining organisations and external stakeholders. This is supported by Storey et al. (2024) who argue that only through greater collaboration with industry partners can the full benefits of DT be realised within the mining industry. Similarly, the study participants expressed that partnerships with technology vendors and educational institutions were essential to fostering skills development within the industry. Participants were of the view that collaboration within the industry and with external partners would provide the industry with centralised learning platforms and allow for organisations to share their wins and losses.

5.6 Summary of the findings

A summary of the study's findings related to the propositions is presented below.

Proposition 1 investigates the coal mining industry's readiness and propensity to adopt digital technologies**.** The study results indicate that mining is not immune to the need to transform by adopting digital systems and technologies. It has been noted throughout this research that the mining industry is making strides towards digital transformation, introducing various systems and technologies to improve efficiency, productivity, and safety. In line with existing literature, the findings of this study indicate that digital technologies such as data analytics and remote monitoring and control systems are being adopted as part of the industry's

transformation. Furthermore, there is evidence that a significant hindrance to DT within the industry is due to a lack of digital infrastructure, which includes fibre connections and reliable connectivity networks.

Proposition 2 reviews the impact of DT on the roles and responsibilities of the workforce and whether employees will have to adapt their existing skills to develop digital competencies. The outcomes suggest that the introduction of digital systems into mining operations will greatly impact employees' roles and responsibilities. This means that employees will develop new skills and competencies to use digital systems proficiently. This outcome correlates significantly with the literature findings and reinforces the need for the industry to assess the impact of DT on the skills profile of the workforce.

Proposition 3 addresses the suggestion made in the literature that the people elements of DT can drastically impact DT and should be addressed for successful transformation. The findings identified that the mindset/beliefs of employees were considerable in determining their likelihood to engage in skills development programs. Coupled with this was the need to motivate employees and ensure they were aware of the personal benefits and value of enhancing their skills to address changes in the workplace. An industry-wide challenge was noted as being the literacy levels of the workforce. This, coupled with instances of employees lacking language proficiency sufficient to understand and utilise advanced technologies, was a significant barrier to advancing the workforce's digital skills.

Having reviewed the efforts of the industry towards DT, proposition 4 explored the strategies which could be implemented with the industry to promote digital skills development. This study found that skills development and training programs remain central to advancing skills development within the industry. Offering rewards and incentives was also highlighted as a strategy which could be used to motivate employees to engage in digital skills development initiatives. The findings also corroborate the ideas of the literature and indicate that industry collaboration and partnerships are vital to ensuring successful DT.

5.7 Theoretical review of findings

The study's findings further reveal that the South African coal mining sector recognises the need to adopt digital technologies to ensure the sustainability and productivity of its operations. This indicates that the sector has developed “sensing” capabilities, as the dynamic capabilities theory postulates. However, the findings suggest that the industry has yet to focus on external and regulatory factors, which DC theory emphasises as being critical to identifying opportunities and threats to transformation. Efforts by the sector to introduce AI, Data management systems and remote monitoring centres indicate that the sector can sense opportunities related to digital transformation.

In addition, the findings reveal challenges related to the readiness of the sector to introduce innovative technologies into its operations. The findings suggest that the industry needs to invest in foundational elements like optic fibre and Wi-Fi connectivity to facilitate the transition to digitalised operations. This aligns with DC theory, indicating the need for environmental scanning and “seizing” opportunities to improve the readiness of the sector to transform.

Furthermore, the findings highlight the need to transform the industry's resources to support digital transformation, indicating another key area of DC theory to be considered as part of the transformation process. The study reaffirms the findings of previous studies, highlighting human resources as key success factors for transforming an organisation. It is evident from the findings that digital transformation leads to changes in responsibilities, requiring workers to adapt to new tools and processes. These align with the transformation dimension of DC theory, focusing on the need to reorganise and adapt to rapid technological change.

5.8 Conclusion

This chapter examines the research study's outcomes and compares them with the findings reported in existing literature related to digital skills development in the South African coal mining industry.

The study's outcomes corroborate the ideas found in existing literature. The findings suggest that digital skills in the industry may be enhanced by adopting a proactive approach to addressing the determinants of digital skills development.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This qualitative study explored the factors affecting the growth and development of digital skills in South Africa's coal mining sector. It sought to identify industry-specific challenges that either facilitate or hinder the development of these skills. This chapter evaluates the study's findings and proposes a framework for the sector to improve workers' digital skills.

This chapter includes the recommendations, suggestions for future research and notable limitations of the study.

6.2 Digital Technology Adoption in the South African Coal Mining Industry

RQ5. ***RQ1.*** Which digital technologies will likely be adopted by Company X, a coal mining company operating in the Emalahleni Municipality?

Adopting digital technologies in the coal mining industry necessitates significant infrastructural changes to support these advancements. Modern mining operations require robust physical infrastructure which supports ICT and digital system integration. Infrastructure challenges need to be addressed to ensure the suitability of digital migration. To address these challenges, the industry needs to consider the complexity of its legacy infrastructure and the cost of upgrades/retrofits. Challenges that remain prevalent within the industry include a lack of stable and reliable connectivity and insufficient ICT infrastructure (Fibre, etc).

Adapting the infrastructure will promote the industry's efforts to adopt technologies, the following technologies as identified by the findings of the study:

i. ***Data storage and processing facilities:*** To become a data-driven operation, mining organisations need to establish facilities that support the

collection, processing, and analysis of large volumes of data. This requires dependable and high-speed data connectivity, including the installation of fibre optic cables, wireless networks, and satellite communication systems to support data processing. This is supported by robust IT infrastructure, including data processing servers, data storage solutions, and cloud computing capabilities.

ii. ***Advanced Analytical Platforms:*** Advanced data analytics platforms provide real-time insights into mining operations, enabling managers to make informed decisions quickly. This includes adjusting production plans, reallocating resources, and responding to unexpected issues promptly.

iii. ***Remote Operating Centre (ROC):*** Centralised facilities known as Remote Operating Centres (ROCs) allow operators to monitor, manage, and optimise mining operations remotely. Because of real-time data collection and analysis through the centralised data platforms housed in the ROC, operators can immediately make informed decisions.

The results signify the importance of digital technologies in facilitating the transition to digitalised operations in the industry. Only once these systems have been adopted can digital systems such as autonomous vehicles, equipment health monitoring, hazard detection, and wearable monitoring devices be introduced into the mining environment.

6.3 The Impact of DT on the Skills Profile of Employees

RQ2. How do these technologies impact the skills profile for mining employees?

As defined in literature, digital transformation (DT) is a process that changes all aspects of an organisation and profoundly impacts how employees execute their duties. The results of the current study support this notion, implying that DT changes the responsibilities and job profiles of the workforce. Specific areas impacted by DT include:

i. ***Interfacing with machines/digital systems:*** As mining organisations move to digitalisation, humans are expected to interact with machines

through digital systems. Employees will need to develop skills that allow them to operate machines through digital interfaces such as screens, remotes, and joysticks.

ii. ***Understanding and interpretation of data:*** The study indicates that DT's consequence is data generation. This implies that workforce members must develop skills that allow them to understand and interpret the data generated through their activities. These skills may be grouped under the umbrella of data analytics.

iii. ***Hands-on troubleshooting skills:*** As noted in the study, when deploying DT, the hands-on skills required to install, maintain, and upgrade the infrastructure and systems are often overlooked. These become the responsibility of existing employees, who are often not skilled enough to execute these new duties.

The implementation of DT will impact the ways of work, requiring employees to adapt to new ways of executing their tasks and responsibilities. Some of the ways work will be impacted include:

i. ***Changes in day-to-day task execution***: The adoption of digital technologies impacts how employees execute their day-to-day work, changing how they interact with the system and affecting the processes they follow to reach their objectives.

ii. ***Improvement in efficiency and effectiveness***: Deploying digital technologies is expected to improve employee effectiveness and efficiency. Digital systems allow employees to execute their tasks in simpler ways, which promotes efficiency. These systems may also contribute to eliminating human error when executing tasks.

The results suggest that industry organisations develop strategies for reviewing the impact of DT on employees' roles and responsibilities. There is a clear need to understand and review how DT will impact day-to-day activities and ensure that procedures and processes are updated to account for these changes.

A delay in reviewing the impact of DT on the workforce can result in a skills gap, where employees' skills do not match those required by the new work

environment. This skills gap will extend as new technologies are introduced, exacerbating the workforce's fears and mistrust of technology adoption.

6.4 Determinants of Digital Skills and Competency

RQ3. What are the determinants of digital skills and competency development within the coal mining industry?

Organisations must address human factors to drive digital skills development in the industry, ensuring that employees are aware and accepting of DT. The study found that employee mindset, motivation, and language proficiency were the top three human factors determining the success of DT within the industry. Another finding that stands out from the results is that the lack of forethought for these factors often led to mistrust and discomfort amongst employees when confronted with digital technology adoption.

Regarding the organisational environment, some of the issues emerging from the findings relate specifically to the change management strategy employed by the organisation to facilitate DT and empower employees to develop digital skills. The results indicate that strategies that promote open communication, awareness, and transparency would yield the best results when initiating DT.

Coupled with change management strategies is the role of leadership in ensuring that they build a culture of learning and self-development. Issues of driving an experimental and agile environment, where top management leads by example, were also highlighted as key leadership strategies for successful DT.

From a technological perspective, the study found that the rate of technology adoption was lagging behind other industries such as farming and marketing. This meant that industry employees lack accessibility and exposure to these technologies and thus will lag behind other industries in digital skills development. Another interesting finding relates to the need to demonstrate the effectiveness of new technologies to employees, such that the slow pace of adoption has a negative impact on digital skills development in the industry.

Surprisingly, the results indicated very little consideration for factors related to the external environment (such as regulations and economic uncertainty), which were not highlighted as significant determinants of digital skills development. The results suggest that external factors should be considered when addressing the need for industry and stakeholder collaboration.

6.5 Strategies to Enhance Digital Skills and Competencies

RQ4. What are the appropriate strategies to enhance digital skills and competencies within the industry?

The research found that the main strategies which the industry should employ to enhance digital skills development include:

- Create interactive and tailored digital skills development and training programs that address the immediate needs of the industry.
- Developing internal initiatives to promote upskilling and reskilling, including offering rewards and incentives.
- Collaboration with industry stakeholders and partners to understand and create awareness of the need for digital competencies. These partnerships should also allow for collaborative technology development.

6.6 Framework for Digital Competency Development

Table 4 proposes a framework for digital skills development within the coal mining sector. The framework's themes and sub-themes provide DT champions with areas for consideration when adapting it to suit their needs. By amending the recommendations, the framework can be customised to address specific challenges within an organisation.

Table 4: Suggested framework for upskilling and reskilling employees in the coal mining industry.

Theme	Sub-theme	Recommendation
Impact of digital technologies on Employees	Ways of work	- Establish systems and tools to help understand the impact of DT on the day-to-day activities of employees and the workforce's specific needs.
	Workforce Skills Gap	- Conduct a thorough assessment to identify current skill levels and gaps.
		- Develop a strategic plan that aligns with the company's digital transformation goals.
Human Factors	Employee Mindset/Beliefs	- Set clear objectives and timelines for DT initiatives, ensuring that the people elements are considered part of the implementation strategy. Consider adopting strategies which focus on employee participation.
	Motivation	- Highlight the benefit of self-development to employees, emphasise the value and positive impact of acquiring new skills.
	Language Barriers and Literacy Levels	- Develop digital materials and systems that consider varying language proficiency and literacy levels.
		- Offer employees opportunities to enhance their language proficiency and develop practical communication skills.
Rate of Technological Adoption	Pace of adoption	- Introduce new digital technologies gradually to avoid overwhelming employees.
	Historical challenges	- Create pilot projects where employees can experiment and learn.
	Accessibility	- Offer opportunities for employees to work on real-life projects using new technologies.
		- Improve accessibility by offering employees opportunities for hands-on experience as new technologies are introduced
Organisational Environment	Change Management Practices	- Communicate the benefits of digital skills and provide regular updates on progress.
		- Implement change management strategies to address resistance and build a positive attitude towards digital transformation.
	Role of Management/Leadership	- Promote continuous learning by supporting self-development and reviewing individual development programs.
		- Provide employees with the necessary access, resources, and financial support to help them navigate new technologies.
Collaboration and Partnerships	Industry Collaboration	- Collaborate with other companies in the industry to share best practices and resources.
	Vendor Partnerships	- Partner with technology vendors to provide specialised training and support.
		- Leverage vendor expertise to enhance the effectiveness of training programs.
	Educational Institutions	- Work with educational institutions and online platforms to develop suitable educational material.
Skills Development and Training Programs	Skills development programs	- Design and implement skills development programs focused on key digital skills.
	Training	- Provide training and support during the transition to new tools and systems.
Rewards and Incentives	Value	- Describe the career progression paths and opportunities available due to acquiring new competencies and proficiency in digital skills.
	Incentives	- Review internal incentive strategies that offer monetary and non-monetary rewards when individuals acquire new skills or reach new competency levels.

6.6.1 *Implications for the South African Coal Mining Sector*

Digital transformation offers the South African coal mining sector many opportunities to improve its operations and workforce working conditions. By addressing the barriers to digitalisation, the industry can see a significant improvement in productivity and safety performance.

The study's findings offer an overview of the challenges and opportunities related to digital skills development within the workforce. To fully embrace DT, the industry must address the challenges related to the skills gap, mindset and culture within the workforce. Ensuring that the workforce is adequately equipped and supported through the DT process will enhance the likelihood of success.

The framework, as proposed in Table 4 seeks to provide decision-makers with an overview of the areas likely to significantly impact addressing the industry's skills challenge. The recommendations aim to serve as a basis for developing strategies to upskill and reskill the coal mining workforce.

Considering the industry's slow pace of technological adoption, leaders may wish to incorporate a similar or customised framework for DT within their organisations. The industry could leverage collaboration with stakeholders, regulators and suppliers to identify the skills required for DT. Incorporating the framework's recommendations as part of the skills development strategy proposed by the MQA and Minerals Councils could offer the industry an opportunity to make considerable strides in promoting digital skills within the workforce.

Individuals within the industry may benefit from such a framework, which provides an overview of the industry's future and the challenges that need to be addressed to prepare the workforce. Lifelong learning, proactiveness and a willingness to take personal responsibility for their development will set employees apart in a digitalised environment.

The study’s findings underscore the need for a concerted industry effort to find solutions to the slow pace of technology adoption. Addressing structural and human inhibitors of DT must be at the forefront of the industry's technology development. Developing digital skills within the workforce has significant implications for improving safety, productivity and sustainability for the industry.

6.7 Significance of the Study

This qualitative study significantly contributes to the digital transformation of the South African coal mining sector by addressing people-related challenges. While digital transformation presents immense opportunities, its success depends on workforce preparedness and the strategic alignment of organisational initiatives. The study identifies key factors contributing to the digital skills shortage and proposes strategies to mitigate these issues. It also offers a practical framework for organisations to enhance digital skills development in the workforce. Bridging the skills gap, fostering a supportive environment, and implementing robust training strategies are imperative. Addressing these factors will ensure a seamless transition to a technologically advanced future while maximising the workforce's potential.

6.8 Limitations of the Study

The study's results cannot be generalised because all participants were employees of company X. Therefore, there may be biases related to the participants' experience and organisation.

In addition, the study collected data from three focus groups of ten individual participants. A larger and more diverse group of participants can provide different perspectives on the determinants of digital skills development in the industry.

6.9 Suggestions for Further Research

This research aimed to examine the factors that determine the development of digital skills in the South African coal mining industry. The study identified various factors and barriers to developing digital skills in the industry. It is noted that future research is needed to expand the possibility of generalising the results of this study. The following is recommended for future research:

- Future research could expand the sample to include a larger portion of the coal mining sector, suppliers, and industry partners.
- Future studies could address more broadly the type of intervention required to promote the successful development of digital skills. Considering on-the-job training, online training, and other forms of training can provide valuable insights to expand the proposed framework.
- Additional research is needed to contextualise better how regulatory and economic factors facilitate and/or hinder digital skills development in the industry.
- Future research should build on these results to further explore and validate the proposed framework.

6.10 Conclusion

Although digital transformation presents significant opportunities for the South African coal mining sector, its success depends on the workforce's readiness and competencies. Bridging the skills gap, cultivating a supportive environment, and implementing comprehensive training strategies are essential. By addressing these elements, the industry can facilitate a smooth transition to a technologically advanced future while optimising the potential of its workforce.

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APPENDIX (A): Participant Information Sheet

Dear Sir / Madam

My name is Sewela Moketla. I am a master's student Management at the University of the Witwatersrand, Johannesburg. My supervisor is Prof. Rene Pellissier. I am conducting a research study about digital transformation. The study title is Enabling Digital Transformation of the South African Coal Mining Sector Through Digital Skills Development.

I am inviting you to take part in a focus group discussion. If you decide to take part, your participation in this research study will last about 60 minutes. The interview/research activity will take place at online at a time to be advised.

During the research activity, I will need to ask for some personal information about you, including your employment status and employer.

The focus group discussions will be confidential and anonymous. When I share the results of the research study, I will not include your name or anything else that could identify you. With your permission, other researchers may use the data collected from this research study, but your name and any personal information will not be used or passed on.

If you decide to take part in the research study, it should be because you want to volunteer. You do not have to take part. You can stop being in the study at any time. You do not have to answer any questions if you do not want to. You will not get any direct benefits if you choose to join the research study. You will not lose any services, benefits, or rights you would normally have if you decide not to join. Taking part in the research study will not cost you anything. You will not be paid for being in this research study.

The risks for this research study are no more than what happens in everyday life OR some of the questions asked may make you feel sad or upset. If this happens, we can stop the discussion and continue another time.

This research study will be written up as a research report. The report will be available on the university library website. If you would like to receive a summary of this report, I will be happy to send it to you.

If you have any questions during or afterwards about this research study, feel free to contact me or my supervisor on the details listed below. If you have any concerns or complaints about the ethical procedures of this research study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Yours sincerely,

Researcher:

Sewela Portia Moketla

Email: Sewela.Moketla@students.wits.ac.za

Cell: 0825 37 6426

Supervisor:

René Pellissier

Email: Rene.Pellissier@wits.ac.za

APPENDIX (B): Participant Consent Form

Title of project: Enabling Digital Transformation of the South African Coal Mining Sector Through Digital Skills Development

Name of researcher: Sewela Portia Moketla

Name of Participant:

I, _____, agree to participate in this research project and 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 focus group discussion may be audio recorded.	Yes	No
I agree that direct quotations from my interview/focus group/other activity 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 focus group discussion (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on.	Yes	No

Participant:

_____	_____	_____
Signature	Name	Date

APPENDIX (C): Semi-Structured Interview Guide

Introduction and Research Purpose

As part of the master's studies, I am conducting research to assess the presence and /or lack of digital skills in the coal mining industry. The purpose of this research to assess what could be contributing to the perception that there is a lack of digital skills in the South Africa mining, and thus inhibiting digital transformation. In addition, this research study explores the challenges specific to mining which hindering digital skills development.

The intended outcome of the study is to develop a framework which proposes strategies which can be applied in the industry to enhance digital skills and capabilities. The purpose of this focus group discussion is to engage a group of peers who are knowledge in the topic of digitalisation and digital technology adoption at the mine. The purpose of this discussion is to capture your perspective, sentiments, lived experiences and overall view of digital skills within the mining industry. The facilitator will ask probing questions in-effort to elicit your ideas and thoughts as they relate to digital skills.

Please note that the session will be recorded, however the recording is strictly confidential and will only be used for the purpose of this study. As the discussion progress, notes will be taken for the purpose of assisting with data collection.

Please be assured that all information collected will be treated with the utmost care to ensure confidentiality and privacy. Your anonymity is assured, and no personal identifiers will be collected for this study other than the basic data required to categories and attribute statements made. In addition, the company and mining operation will not be named in any of the documentation.

Thank you for your participation and I look forward to the discussion.

Table 5: Interview guide for Focus Group Discussions

Research Question	What do we want to know?	Questions	
General	Introductory question	1	What do you understand digital transformation to mean and what is likely to be its impact on mining operations?
RQ1	Technologies currently being used or considered for adoption	2	Which digital/4IR technologies do you believe will be adopted in the mining industry soon? How do you see these being introduced?
		3	What impact does the regulatory environment have on digital technology adoption and how does this impact skills development?
RQ2	What impact do these technologies have on the skills profile of the mining workforce?	4	Have innovative technologies been adopted by the company which affect how you work? If so, how have these impacted your day-to-day work?
		5	What do you believe will be impact of digital technologies on mining processes and what skills should the workforce develop to facilitate the transition?
RQ3	What are the determinants of digital skills and competency development within the coal mining industry?	6	How do you approach learning about emerging trends and tools in your field?
		7	What organisational barriers or challenges do mine employees encounter when developing digital competencies?
		8	What are the perceived technological barriers to digital skills development among employees in the mining sector, and how do these perceptions influence their engagement with digital technology?
		9	How have the leaders enabled or encourage digital skills development amongst the workforces?

RQ4	What are the appropriate strategies to enhance digital skills and competencies within the industry?	10	What opportunities have you identified to improve your digital skills? Please elaborate on how you have taken advantage of these opportunities.
		11	What, in your opinion, would be effective strategies for facilitating digital skills development with the coal mining industry?

Next steps

Thank you for your time and contributions.

In terms of next steps, I will transcribe and record the points of view shared in this discussion. After which I perform data analysis to synthesis the recurring themes and notions. This data will then be complied into a framework detailing the determinants of digital skills development in the mining.

I may have some follow-up questions to clarify and ensure I have captured your sentiments honestly and they reflect you views and experiences.

The final report can be shared with you should you so wish. Thank you.

APPENDIX (D): Thematic Analysis

Theme	Key Words (Sub-themes)	Example Quotation
Data Analytics	Data Analysis	P4FG1 - "(…) The predictive part is just the analytics. I think, I'd umbrella it is a you know the analytics and yeah you know you get your data analysts people being able to interpret that data of course when you're feeding the machines and I think."
		P2FG2 - "I think we've implemented quite a number of projects here at Company X. So, one of them is basically called the primary equipment connectivity as you are able to get a lot of data from the machine and been able to make decisions on."
		P1FG1 - "I also think that we need to learn how to interpret the data. Because in school we learnt about proofs of theorems and things like that before we could actually use them."
		P3FG2 - "And also, in terms of accessibility then, while we have all that data. The skills to analyse it and from basically from cleaning, exploring it and then analyse it such that decision can be made on the maintenance, predictive maintenance. "
		P2FG3 - "When you take it a step further, now where you're looking at the analyst roles. And the need for digital skills in the context of working with interface data and making use of it to the extent that it is beneficial to a business. I suppose there is some room for development."
		P2FG3 - "you should be able to do if you know some level of analytics with available data in order to determine what the issue is either with the system or the machine. But in terms of so that, that skill is quite reactive"
	Data Availiability	P2FG2 - "I think look on we we're moving from the how can I say it from where we never used to have digital systems in a mining industry, and we are moving obviously towards attaining all the data and information."
		P3FG2 - "Availability of data is an issue. Data often resides outside the mining industry.
	Dashboards	P1FG3 - "So I think the second one will be a one is so like with digital with a lot of initiatives that we've done with build, so many dashboards you know, but there will still be someone asking for the same report."
		P3FG2 - "And also having that information in the fingertips such that engineers and decision makers can have a view of those dashboard and then make strategic decisions."
Smart Systems	AI	P1FG1 - "Using AI to look at certain factors and trends and then be able to predict when machinery needs to be when maintenance needs to be performed on certain machinery also. "
	Interfacing with machinery	P4FG1 - " . I mean some of these machines are fitted with computers, right? What I've experienced in the past is that you know, sometimes because the people don't understand, right. The basic of getting the machine to run is."
Remote Monitoring/Operating		
	Control centre	P1FG3 - ". We figured the people that work underground, they mine the coal, but they don't know how far they are, in terms of performance, you know, so now having the Main Control Centre as the go-to place so that

		anyone can just walk in and they can check, where are we today in terms of tons? So everyone from the miners up to HODs."
		P2FG2 - "I think in terms of the utilization. It is not 100% there, but at least you know you do have people trying to use the systems and understand the systems and I think the introduction of the centre where the guys got to see the information, the digital team, I think obviously that's the move in the right direction where you find people that actually use that data that is coming (...)."
Infrastructure	Fibre	Ne
		P4FG1 - "I definitely think you know you get people who, you know, have some of the more hands-on skills is always going to be a big thing. People who can connect Fibre, you know, so there's the we shouldn't forget that sort of skill. You know the hardware part of it."
	Wi-Fi	P4GF1 - "Certain cables in the machine get damaged or, but because I don't know what this machine or this cable is doing, what's its objective? I'll pull it out as long as the machine is going. I'm cool. Let's it's moving, right? I need to just get the machine to move. I've taken out an essential component for which we can enable data communication, Wi-Fi. You know, for argument's sake"
	Connectivity	P3GF2 - "We have also still have a challenge of connectivity. That we, I mean the last time we saw the launching of that app and then we couldn't connect. And if we couldn't connect at surface, what? Imagine what is the condition underground. And then if we can't connect and we have real challenges."
Efficiency and Productivity	Effective	P3FG1 - "I think. Look, as much as much as we all want, you know, the technology and the digitization. Of things. But you know, the main thing is that we want this thing to work for us so that we can be effective. And then so that you can be effective, and you can do more with less effort."
	Efficency	P2FG2 - "In terms of whether you are saving energy, you are utilising the equipment to the maximum efficiency."
		P3FG2 - "Also from that point of view and discuss the efficiency, the inefficiencies and the and benefits that have been introduced by the technology, even if they still use tech, they all use cell phones. But then they can then see the inefficiencies and the efficiencies of moving with the times and also the benefits of using technology from production maintenance and most importantly in terms of the safety."
		P1FG3 - "But I think the impacts from my side it will be driving the change efficiency right? So for example the operators were using Excel and then now they are being migrated to Power app. So yeah, efficiency and then also productivity."
Impact of Employee Skills	Skills gap	P3FG3 - "It's important to bridge the gap between traditional skills and digital skills. Training and project exposure can help build intuition and understanding of digital tools." From this comment, it is also evident that P3FG3 also believes that there is value in ensuring compatibility of digital skills to the existing skillsets of the workforce.
		P2FG3 - "But then maybe there is also you get a data scientist. But then again, data science in a mining environment, that's maybe that's where the gap is."
		P4FG1 - " You know you've got the next group who are also willing, essentially, and then essentially sometimes get that gap. There's a gap that happens right where people between those early adopters and then

		the gap between them and then the next people who are now in the latest stages now of adopting technologies."
		P1FG1 - “I think that there is definitely a gap there and I did want to say that as much as we pointed out that it is a problem that there is a gap, a skills gap, It is also an opportunity for us to develop other skills."
	Lack of Skills	P2FG3 - "Those skill sets are very much lacking. We almost have to rely on the developers to sort of understand what has gone into sort of a predictive notification or, you know, or a warning. But not so much that we have put it together ourselves. So there's almost like a middleman in really making use of digital systems"
		P3FG2 - " Skills and tools are also lacking."
	Skilled People	P2FG2 - “We focus on getting the technology but often forget about maintenance and the holistic view of interconnected systems. We need skilled people to manage this."
Ways of work	Day-to-day	P1FG3 - "If I were to be motivated to take a course, really obviously I will be a question of what value will it add on my day-to-day. How will it improve the way of work? And also it needs to align really to my career vision."
		P4FG1 - ": I think one of the biggest things that. Is important is the ability to explore, right? And I think it speaks to the whole culture thing, which has been mentioned now and I think quite a bit. When you're in a in a place that allows you to explore and look at new ways of doing something, it encourages people."
		P1FG3 - "I think the impacts ("of DT") from my side it will be driving the change efficiency right? (. . .) So yeah, efficiency, then also productivity and also the impact is on the way of work."
	Impact of digital systems on individuals	P1FG3 -"So yeah, so is efficiency productivity and also the impact is on the way of work, right. So we have like. You agile way of work, you know within our teams. "
		P2FG3 - "*Value chain integration and demonstrating the impact of digital systems on individual activities can help bring employees along. Understanding how different roles affect the overall operation is crucial."*
	Make life easier	P2FG2 - "When you look at digital implementation It is basically to make your life easier."
	Do more with less	P3FG1 - " But you know, the main thing is that we want this thing to work for us so that we can be effective. And then so that you can be effective, and you can do more with less effort. But then so you find it with the technology."
	Challenges in Mining	P2FG2 - "But most of the time, you know, you will find your mining industry saying that they are focused on research and development. They are here to produce coal, but you know these things are enablers, which makes it better in terms of production and improvements."
		P2FG3 - "We (the mining industry) come from a very analog and very hands on history. That you know, when we talk about in pillar mining or we talk conventional mining, you know it's mining philosophies that have worked and that have been inexpensive. And they continue to mine the same way, right. So the mining? Methodologies have really not changed. But it's the value aspect of digital systems that are still for me, vague, like not for me personally, but in the aspect of mining when we looking at people on the ground."
	Ready built stuff	P2FG2 contends that “The thing about mining is that we want ready-built stuff, and we just want to implement a working way we don't go through the journey of learning, and you know when you go through the journey of implementing something from scratch and you know, playing around with it then.”
	A bit behind	In addition, P2FG2 provides that view that " I think we are a bit behind. You know, when I look at the farming environment, they are basically 10 steps ahead of what we currently are in the mining and I think in terms of empowering the maintenance crew, the end users."

	Value chain intergration	P2FG3 - "A value proposition, for business wide sort of outlook. So if OK. So let me take it from the top. So I think with change management. I think there's a leadership aspect in it that must insist on transformation."
		P2FG3 - "A mine person could be working with so bringing. Employees along in that context. You know require. Sort of business exposure. From a value chain integration point of view, understanding how individual activities affect the bigger operation."
		P3FG2 “Integration of information across the organization is important for making informed decisions."
Technological Factors	Ability to use technology	P4FG1 - "Firstly, you need to be able to work with those technologies and understand them. The skills needed come from being able to use these technologies correctly and effectively to make an impact."
		P1FG3 - "I think yes on the upskilling of our existing employees and also bring in new resources should they be in need because like the mining industries did not have digital capabilities or those skills."
	Access to equipment and resources	P4FG1 - "But my biggest struggle is that I don't have access to a laptop for argument's sake. How do I make things accessible to people? Obviously, we live in a world of data now and I'm talking having, you know, the gigs to be able to surf the net or whatever it becomes accessibility."
	Understanding of digital tools	P2FG3- "They want to see that a system does perform exactly what it promises to do, so if we bring so former. That would come from some level of understanding. That the system is a reflection of the environment they work in so. So there's a need for demonstration."
	Poor Utilisation	P2FG3 - "You have very poor utilisation because there's a notion on the ground that I know the machine better than these numbers. I'm looking at but I don't know how I could put that. What that is but I suppose it has something to do with a mistrust of digital systems and what they are meant to do, right? So that you have a poor utilization because there's that gap between the people who must benefit from them and what they think of those systems. "
Psychological Factors	Mindset	P2FG2 - " I think you know the young minds in terms of PITs *(Professionals-in-Training*), you know, the ideas are there and you know they don't have that mentality that this has been working in and you know, those are the platform that you really need to harness in terms of coming with new developments. "
		P2FG3 - "The usual mindset is that if you've employed me with whatever little I know that it means that's the little you require from me. And usually there's been very poor development activities in as far as taking courses that help prepare individuals for digital systems or a digitally transformed mine and how digital systems are viewed by the business at large."
		P2FG2 - " Yeah, I think basically for what I foresee is you know more and more training on what is currently being introduced and you know getting the old mentality, you know, out of the way to say this is how we operated for 30 years, and you know. We are now moving into a different space and into the digital space and you know, get yourself equipped."
	Comfort	P2FG1 - "But I think it's also a bit of a trade, or rather it is comfort to employees because you don't know if technologies, if it's been introduced, how it's going to affect employment. "
	Pain points	P2FG2 - "Digital implementation is about making life easier. Look at personal pain points and find digital solutions to address them. There are many platforms available to help."

	Trust	P2FG3 - "I suppose it has something to do with a mistrust of digital systems and what they are meant to do, right? So that you have a poor utilization because there's that gap between the people who must benefit from them and what they think of those systems."
		P1FG3 - "From our side ("DT initiators") to build trust, I think that people need to see value, right. So if you are changing the way of work and then you are introducing this new digital solution, so you need to be able to convince those people to trust them. "
	Language Barriers	P3FG3 - "But in a country like or context like South Africa, there are language barriers. I believe that. We need to think about offering certain trainings in certain languages."
		P3FG1 - "Language is a critical issue when it comes to accessibility and information capturing. So, if we can really make sure that even with introduction of all these initiatives, we don't lose that element of language"
	Older Workforce	P2FG2 - " Obviously, you know the older generation were, you need to show the benefits in terms of you know how this is going to assist you as the end user. So, I think that that's the best approach to getting the. The older generation to say, look, we we're not trying to, you know, take away the way you operate and the way that you've been functioning. But what we're really trying to do is you know get you get, make your life much easier."
		P2FG1 - " Regarding the technology, but what are we now going to do with the older workforce that we have, you know, I mean, we still have adult education and training, which is still very big in the mining industry. So, when you introduce technology, how are you going to train those people? Because some of them can't even read and write."
	Literacy Levels	P3FG1 - " Given South Africa's employment landscape, right? And I think just touching on to then saying, you know, obviously the worrying part, people worry sometimes. It's obviously that thing of saying jobs. Will it be taken? "
Organisational Factors	Agile and Experimental	P1FG3 - "We also use agile ways of working within our teams."
		P3FG2 - "I think that's one thing because if we can experiment with some few technologies and then we learn quickly what works and then recover and go out and implement what works and leave out what doesn't work. And in a very short space of time. I think that will really distinguish us between us and the rest of the industry because, as P1FG2 said, with the example that she made, if for example, we have to wait six months in a technology space, six months is almost like six years. Now its things are moving at six weeks intervals"
	Communication	P4FG1 - “Effective communication and bringing value to people are essential."
	Culture	P3FG2 - “Creating a culture of collaboration and awareness is important.”
		P3FG2 - “We need a startup culture where ideas are nurtured and developed. We should invest in small projects and proof of concepts to see how technology can be rolled out. We need more appetite for experimentation.”
		P4FG1 - "Culture is essentially the driver of a lot of the things. If the culture is not one of which encourages such, you'll struggle."
	Intergration across the organisation	P3FG2 “Integration of information across the organisation is important for making informed decisions."

	Change Management	P2FG2 - "As much as you are implementing all these digital technologies, I think from an end user's perspective, you know getting them. As part of the, I think an element change management that you are doing things that are relevant and that are you know you're not just bringing in technology."
		P4FG1 - "You know the change management is by far the biggest or let me not say the biggest but one of the biggest things because you essentially bring in a new technology, right and obviously first and foremost that whatever technology you're bringing must bring value."
		P2FG3 -
		P1FG3 - " . The change management so. An environment like this one. The mining industry, when you bring digital, it's like a taboo sort of thing. So when you introduce a solution or digital solution, you need to also do change management just to make sure that you are aligned with the people."
		P2FG1 - " So, I think what is important for me is as much as training is important, I think to manage the change is the most important one because it doesn't help to have people in the class who are, you know, already negative towards what you're going to teach them. So yeah, change management is very key."
	Leadership	P2FG3 - " I think there's a leadership aspect in it that must insist on transformation."
		P1FG1 - “We learn well from our peers. Managers should lead by example and discuss how they use new technologies.”
		P3FG1 - "Training and upskilling are embedded in Company X's culture. There's support from leadership and departments. We recently completed the MDP program, which was encouraged by our leaders
		P4FG1 - "Of course, the cultural part, which is obviously always driven by leadership, I think is will always play a big role as well."
	From the top	P1FG2 - "Talking about. If it's coming from. That level where you would think that the transition should start from the top to the bottom. And they are also showing a bit of scepticism. It becomes difficult to even tackle the old madelas because. If what we perceive to be people who should be open to this innovation and investing in this innovation."
Personal Development and Continious Learning	Individual Development Plan (IDP)	P2FG3 - "So an individual development program that is tailored to the required digital skills I think can help accelerate skills learning."
		P1FG1 - "We also have a personal development plan that a lot of people have that they discuss with their supervisors, which is obviously very, very helpful. And then also, at Company X, we really do encourage mentorship. I have a lot of mentors on the mine that very much care about my development, which has helped a lot as well."
	Development Activities	P2FG3 - “The usual mindset is that if you've employed me with whatever little I know that it means that's the little you require from me. And usually there's been very poor development activities in as far as taking courses that help prepare individuals for digital systems or a digitally transformed mine and how digital systems are viewed by the business at large.”
	Learning	P2FG2 - " And you know, if you actually spend more time in, in the guys owning and learning from these things, then you know when you are finally. Implementing or rolling it out to the rest of then."

Collaboration with Stakeholders	Communities/neighbouring areas	P2FG3 - "Sometimes it's looked at as unfair. Right. Because you are excluding the people at large. So the communities where you employ from. So if there are programs that help prepare communities to digital skills and technologies that operate at mines or at industry, that improves the skill base of your neighbouring areas. "
		P2FG1 - "Maybe we can, like I said, the skills development programs that we can develop maybe for the community, you know, to build a pipeline of the organization."
	Other industries	P1FG2 - "Take the learnings or teachings from the Mine Expo and show these digital innovations into our spaces."
		P2FG2 - "So, what I can say is yeah, I think learn a bit more from other industries people who are moving ahead, who have done more than you see where those gaps are and what can you implement to make yourself better as well."
	School programs	P2FG3 - "I think also have a look at school. School programs. Whether it be at a basic level or tertiary level in sort of technology awareness and skills associated. Can help also help prepare individuals that are employed to be readily skilled in digital aspects. "
	Collaborate	P1FG3 - "I think the last one is also just to collaborate with other industries that have made it already. So, if Seriti has the same solution and it's a success. I think it's also collaborating with them. Learning from them or adopting whatever that they know."
Skills Development and Training programs	Skills Development	P2FG1 - "I think there has to be skills development programmes that are tailor-made for the new technology, you know, for the workforce. So, everyone has to be trained on the new machines or new technology that's been introduced."
		P2FG2 - "We need courses, training, and awareness for different users to understand these changes. More training on new platforms and environments is essential. We need to get rid of the old mentality and equip ourselves for the digital space."
	Program	P2FG1 - "Perhaps what they (*Government*) could do is actually to have a program that is more into technology from that level."
	Training	P1FG2 - "But also in terms of the training, it should be a bit more interactive and like. Kind of. Stress the end goal. That what? Influence what impact this has and break it down to everyone's different levels, so they see the importance of the training."
		P1FG3 - "Training is essential, especially with new tools and automation."
		P1FG3 - "I agree with the training definitely, especially that now there's a lot of technologies involving. It's new tools that are coming out, so we are training also automation."
		P2FG2 - "I think it's important that we start having courses and training as well as awareness in terms of all these changes that are coming in for the different user's skilling them and getting them knowledgeable on the different platforms and environments."
Rewards, Incentives and Value Proposition	Certificate	P1FG1 - " I know we spoke about communicating the value that the new technology adds, but also having something like a certificate or some kind of extra title helps. Some type of way to identify you as someone who is competent in the new technology that's being implemented is very encouraging."
	Benefits	P1FG2 - "We need to show the benefits and make their lives easier, similar to how cell phones were adopted."

		P1FG1 - "I'm currently doing an AI course. So, Once I am done picking up and now I'm intermediate so I can get acquainted with what AI is and what benefits it would add for me."
	Value	P1FG3 - “If I were to be motivated to take a course, really obviously I will be a question of what value will it add on my day-to-day. How will it improve the way of work? And also it needs to align really to my career vision."
		P2FG3 - “There is also a need for better utilisation of digital systems and demonstrating their value to end users.
		P1FG1 - “I know we spoke about communicating the value that the new technology adds, but also having something like a certificate or some kind of extra title helps. Some type of way to identify you as someone who is competent in the new technology that's being implemented is very encouraging."