Exploring the Inhibitors of Digital Transformation in the South African Mining Industry

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A research report 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

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ABSTRACT

While there is strong evidence for the drivers of technological disruption in the South African mining industry, understanding the industry's ability to transform digitally, including the adoption levels of digital technologies, becomes key in progressing its digital maturity. This qualitative research inquiry explores the concepts of digital transformation and digital maturity, its application to the South African mining industry, and identifies and explores the inhibitors of digital transformation based on relevant digital maturity and digital adoption models.

The research study population is focused on the South African mining industry, which includes various stakeholders. The sampling frame of this research study centres on three key stakeholder groups: mine owners/operators, the mining workforce, and mining contractors, all of whom have a direct influence and impact on the digital maturity and transformation of the South African mining industry at large. Semi-structured one-on-one interviews are used for data collection due to their flexibility in allowing in-depth analysis. This research is based on the perspectives of 15 individuals that are interviewed based on their skills, experience, knowledge, and exposure to digital transformation within the South African mining industry.

The unified model of digital maturity has been proven relevant and appropriate for organisations within the South African mining industry in pursuit of an increased level of digital maturity. The study acknowledges the current digital maturity, identifies an aspirational or to-be digital maturity, examines the resultant gaps between the two states of digital maturity, and proposes critical areas of improvement.

The significance of this research is to identify and investigate the challenges and complexities involved in developing, implementing, and maintaining digital transformation programs in the South African mining industry, and incidentally, provide critical insights to accelerate the transformation process and increase the industry's overall digital maturity thereby enabling safe, sustainable, and competitive mining that could reposition South Africa as a world leader in mining once again.

KEYWORDS

Digital Transformation, Digitalisation, Digitisation, Mining Industry, Digital Maturity, Digital Maturity Model, Inhibitors, Digital Adoption, Technology Acceptance, Fourth Industrial Revolution, 4IR

DECLARATION

I, Kamal Mistry, 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 Kamal Mistry Signature 

Signed at Johannesburg

On the 17th day of June 2022.

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4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
AIDS	Acquired Immunodeficiency Syndrome
BPM	Business Process Management
CMM	Capability Maturity Model
CSIR	Council for Scientific and Industrial Research
DMRE	Department of Mineral Resources and Energy
DSI	Department of Science and Innovation
ESG	Environment, Social and Governance
G20	Group of Twenty
GDP	Gross Domestic Product
HIV	Human Immunodeficiency Virus
ICT	Information Communication Technology
IM	Information Management
IP	Intellectual Property
IS	Information Systems
IT	Information Technology
IoT	Internet of Things
KM	Knowledge Management
KPI	Key Performance Indicator

MQA	Mining Qualifications Authority
NDP	National Development Plan
NGO	Non-Governmental Organisation
OT	Operational Technology
PC4IR	Presidential Commission on the Fourth Industrial Revolution
RO	Research Objective
ROI	Return on Investment
RSA	Republic of South Africa
SAMERDI	South African Mining Extraction Research, Development, and Innovation
SEI	Software Engineering Institute
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology model

CHAPTER 1. INTRODUCTION

1.1 Purpose of the study

This qualitative study explores the concept of digital transformation and its application and relevance to the South African mining industry. The approach of this study is two-fold, firstly to determine the extent of a digitally transformed organisation using an applicable digital maturity model and its associated dimensions and factors. Secondly, it identifies and explores the inhibitors of digital transformation within the South African mining industry based on the relevant digital maturity model identified.

1.2 Context of the study

Digital transformation can be defined as an organisation's combined efforts in responding to technological disruption and change brought upon by the fourth industrial revolution (Armstrong & Lee, 2021). According to Aslanova & Kulichkina (2020), digital transformation is defined by the use and usage of digital technology in business practices to accomplish strategic goals and overall organisational efficiency. Furthermore, Sacolick (2017) stresses that digital transformation goes beyond implementation of technology, and instead investigates business strategy via technological capabilities, business operating models, and revenue-generating prospects. Supplementary to this concept, *digital maturity* is a measure of an organisation's ability to achieve its strategic objectives using modern technology and processes. It explains what a company has already accomplished in terms of digital transformation activities, as well as

how a company prepares methodically to adapt to an increasingly digital world to remain competitive (Teichert, 2019).

Digital maturity models and frameworks are used to determine the digital status of an organisation structurally and objectively and to develop a roadmap outlining an organisation's aspirational digital transformation journey (Raza, 2020). In exploring digital maturity models, it is essential to identify or formulate a relevant maturity model and to understand the purpose of its application. Identifying such models requires an organisation to recognise the dimensions and factors of the digital maturity model, the inter-connectedness of the two, the measures associated with each factor, as well as insights on how to turn the dial of each factor, thereby improving overall business performance (Armstrong & Lee, 2021). Digital maturity models are made up of elements that specify areas of action and measures at various levels defining the path to maturity (Berghaus & Back, 2016). The application of a digital maturity model can be diagnostic, normative, or prescriptive. The diagnostic application of a digital maturity model allows an organisation to determine its current state of digital maturity, while the normative application of the model enables an organisation to analyse and compare itself with other organisations, industries and markets, and the prescriptive application of the model looks at how an organisation can recover and develop its current overall digital maturity status (Armstrong & Lee, 2021).

The rise of new technology adoption and the increase in new disruptive threats are transforming businesses across all industries causing conventional business methodologies to change radically or even disappear (Armstrong & Lee, 2021). The value of digital transformation has affected all facets of business operations,

driving organisations to harness customer networks, develop platforms with products, convert data into assets, innovate using agile and lean methodologies, and adapt their value propositions (Rogers D. L., 2016). The impact of digital transformation cannot be overstated, having significant effects on organisational culture, customer requirements, product and service enhancement, and collaborative innovation (Schwab, 2016). Modern technology has the potential to shift the economic dial of all industries, creating value for all shareholders, including customers, society, government, and the environment (World Economic Forum, 2021).

In 2019, South African president Cyril Ramaphosa established the Presidential Commission on the Fourth Industrial Revolution, aimed at developing a multi-stakeholder conversation and strategy to increase the adoption of technology and related solutions presented by the fourth industrial revolution, thereby increasing the overall digital maturity of South Africa (4IRSA, 2021). Despite having one of the most significant Gross Domestic Product in Africa, South Africa continues to face economic, political, and social challenges. This is reflected in South Africa's current readiness for the future world of production, being far behind other G20 countries (World Economic Forum and A.T. Kearney, 2018).

The South African mining industry contributed approximately 9% to the country's Gross Domestic Product in 2020 despite the continuous political and economic challenges and those brought about by the global Covid-19 pandemic (Minerals Council South Africa, 2021). South Africa remains the global frontrunner in the production of many minerals, including platinum, chromium, manganese, vanadium, and vermiculite (Vegter, 2019). The South African mining industry paid

R27.2 billion in taxes in 2020 and employed around 451 427 citizens in the same year (Minerals Council South Africa, 2021), resulting in the fulfilment of over 1.3 million direct and indirect jobs. These employees supported approximately 4.5 million dependents in South Africa (Holman, 2019). The value of the mining industry in South Africa is significant, even today.

In the same breath, mine-related fatalities had increased significantly in 2020 by 18% relative to the prior year (Heiberg, 2021). Health challenges continue to affect mineworkers, from noise-induced hearing loss, occupational lung disease, pulmonary tuberculosis, and HIV/AIDS (Minerals Council South Africa, 2021). Furthermore, underground mining operations provide working environments with high temperatures, increased humidity levels, and uneven terrain. Continuous exposure to these hostile conditions has long-term health effects on mineworkers (Marwala, 2020).

Since its inception, the practices used in the South African mining industry has remained largely unchanged. As mining requirements increase, mineworkers' safety and overall mine production are negatively impacted, affecting the economics of mining in South Africa (Baxter, 2019). The radical innovation brought about by the fourth industrial revolution is critical in the transformation of the mining industry in South Africa (PWC & Minerals Council South Africa, 2021). Digital transformation is shifting the focus allowing mining organisations and the mining industry to improve on existing processes in creating new and enhanced products and services by generating new business models, enabling business responsibilities to be prioritised (Armstrong & Lee, 2021).

Recognising that the fourth industrial revolution is a fundamental enabler of safe and competitive mining, the relevance of its application to recover a stressed industry in South Africa is significant, realising how heavily the economy and citizens are dependent on the South African mining industry (Marwala, 2020).

1.3 Research problem

The mining industry has historically been one of the main driving forces behind the economy of South Africa, currently making up 8% to 15% of the country's total employment (Marwala, 2020). Furthermore, the improvement of the mine health and safety agenda has been slow, despite the "zero harm" aspirations set out by the Minerals Council South Africa in conjunction with mining companies, government, and trade unions (Minerals Council South Africa, 2021).

Despite being one of the most significant contributors to the South African economy, the mining industry's exposure to technological disruption is still relatively low compared to other sectors like media, ICT and financial services (Armstrong, 2019). This was also noted by the "digital vortex" construct, developed by the Global Centre for Digital Business Transformation, to conceptualise the impact of technological disruption on various industries. The vortex depicts all industries being drawn to the vortex eye at different rates, representing ultimate technological disruption (Bradley, 2015).

While there is strong evidence for the drivers of technological disruption in the South African mining industry, understanding the industry's ability to transform digitally, including the adoption levels of digital technologies, becomes key in understanding the industry's digital maturity. Digital maturity models define the

maturity stages and roadmap towards increased maturity using key factors, dimensions, and criteria (Berghaus & Back, 2016). Identification and application of a digital maturity model would assist in recognising key focus areas and factors to improve the overall digital maturity (Armstrong & Lee, 2021). The inhibitors of digital transformation in the South African mining industry must be further explored to understand the slow impact of technological disruption on an industry that demonstrates strong drivers for digital transformation.

1.4 Research objectives

This study aims to investigate the following research objectives (RO):

RO1. To contextualise digital transformation within the South African mining industry by identifying the perceived benchmark of what constitutes a high level of digital maturity,

RO2. To adopt a relevant digital maturity model in order to assess the current perceived status quo of the South African mining industry, and assess the gap compared to the established benchmark, and

RO3. To further explore the key areas for improvement, focusing on the inhibitors of digital transformation in the South African mining industry.

1.5 Significance of the study

The South African mining industry is amidst a challenging era has historically been one of the most significant driving forces behind South Africa's economy (Marwala, 2020). Matters of interest include increased costs, decreased mine productivity, health and safety concerns, and environmental and social issues.

Due to its extensive impact on mining operations, these challenges have been labelled the "perfect storm," describing the industry's resultant calamitous situation, which it finds itself in (Singh, 2017). Many of the challenges are non-exceptional to the South African mining industry and include the increased focus on mine health and safety and associated zero-harm initiatives, stricter regulatory requirements including efficient water consumption and renewable energy usage for reduced environmental impact, increased workforce skills gaps, obsolete culture and work methodologies, a decline in high-quality mineral reserves, social barriers including community and landowner issues, weak global demand, increased market volatility and weak pricing, increase in resource nationalism, and evolving client needs and requirements (Veritis, 2021). Furthermore, the mining industry in South Africa is not immune to technological disruption. Mine owners and operators are struggling with the more challenging areas of digital solution deployment, adoption, capability, and legacy migration concerns as they face the potential of digital transformation (Ramsay, 2018). The gap between the potential of digital transformation and its successful implementation in the South African mining industry is widening (Ernst & Young, 2018). *Section 2.6.2* explores the impact of technology on the mining industry further.

In 2013, the National Development Plan was executed with a primary aim to eliminate poverty and reduce inequality in South Africa by 2030. To realise these goals, the plan, which covers all industries, considers growing an inclusive economy, enhancing the capacity of its workforce, developing relevant capabilities, and promoting leadership and partnership (Government of South Africa, 2012). The South African Mining Extraction Research, Development, and Innovation (SAMERDI) Strategy is a collaborative development by the Council for

Scientific and Industrial Research (CSIR), Department of Mineral Resources, and Department of Science and Technology, that was later revitalised by the Mandela Mining Precinct and Mining Phakisa, in response and contribution by the South African mining industry to the country's National Development Plan (Macfarlane, 2018). The strategy looked to create shared value and prosperity through innovation by creating capability for mining-specific research, development and innovation, developing local manufacturing capability in hard-rock mining equipment, maximising local supply chains, and improving occupation health and safety and mine efficiencies for long-term economic sustainability through the modernisation of South African mining (Mandela Mining Precinct, 2019).

The South African mining industry, to which extent includes mine owners, government departments, trade unions, non-governmental organisations (NGOs), research institutions, policymakers/regulators and the mining workforce, realises the value and need to modernise the mining industry in South Africa. Digitally transforming the mining industry will establish the necessary process and methodological changes, technology adoption and upskilling required to increase social and environmental integrity within current mining operations (Singh, 2017). The South African Mining Extraction Research, Development, and Innovation Strategy's vision is thus "to maximise the returns of South Africa's mineral wealth through collaborative, sustainable research, development and innovation of mining technologies in a socially, environmentally and financially acceptable manner that is rooted in the wellbeing of local communities and the national economy".

Although the value of digitally transforming the South African mining industry is recognised and supported by the industry at large, the move to a modernised mining industry has been slow (Marwala, 2020). While not exceptional to the mining industry, South Africa has been classified as a laggard in its readiness for the future world of production and associated economic and social changes (4IRSA, 2021). The significance of this research study is to identify and explore the obstacles and complexities in formulating, implementing, and sustaining digital transformation programmes within the South African mining industry, and incidentally provide key insights on expediting the transformational process, thereby ensuring safe, sustainable, and competitive mining that will ultimately reposition South Africa as a world leader in mining once again.

1.6 Delimitations of the study

The research study has the following delimitations:

I. A qualitative research design is employed in this research in order to explore and provide a broader analysis of the phenomenon around the research topic,
II. The research study is limited to the South African mining industry. As such, the resources used for the research, including participants and organisations, are constrained to the South African mining industry,
III. The research study involves participants from strategic, tactical or operational organisational levels that are well-informed of the digital transformation and digital maturity in their respective organisations, and

IV. The research study, including the research instrument and other relevant material, is limited to the English language. Participants capable of engaging in the English language were appropriately employed.

1.7 Definition of terms

Council for Scientific and Industrial Research: More commonly known as the CSIR, the Council for Scientific and Industrial Research is a science and technology research institute aimed at harnessing technology to advance social and economic growth in South Africa. The institute supports both private and public sectors through research that is aligned with South Africa's socioeconomic strategy and objectives (Council for Scientific and Industrial Research, 2021)**.**

Covid-19: Developed in late 2019, the coronavirus disease 2019 (Covid-19) is a virus caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The Covid-19 outbreak was declared a global threat and a public health emergency of international concern by the World Health Organization due to its rapid outbreak and global spread (Li et al., 2020).

Digital: Basically, digital refers to technologies concerned with the creation, storage, and processing of data in two distinct states, positive and non-positive (TechTarget, 2021). In this study, the definition is extended to include additional capability and business applications such as artificial intelligence, additive manufacturing, the internet of things, drones, blockchain, robotics, big data, neuro- and bio-technology (Armstrong, 2021).

Digital Maturity: Maturity can be defined as a state of completeness or readiness of an entity. Digital maturity is, therefore, a concept that describes the measure

of an organisation's response to technological disruption in achieving its aspired strategic and operational goals (Aslanova & Kulichkina, 2020). Furthermore, it portrays the status quo of an organisation along its digital transformation journey (Armstrong, 2021).

Digital Maturity Model: A digital maturity model is considered a tool that primarily enables assessing an organisation's digital maturity. Such models provide a systematic approach to understanding the current state and capabilities in managing and guiding digital transformation within an organisation (Teichert, 2019).

Digital Roadmap: A digital roadmap serves as a blueprint for digital initiatives and associated actions to achieve the short-, medium- and long-term goals and objectives of an organisation. It ensures that the strategic vision is achieved through a practical plan and that the various digital initiatives and actions create value within the organisation (Weber, 2018).

Digital Strategy: A digital strategy includes the strategic intentions of the organisation to adopt and exploit digital technologies and digital solutions. It comprises a digital vision, transformational objectives, processes, technologies, guidelines, governance structures, and risk and compliance factors (Schallmo, Williams, & Lohse, 2018).

Digital Transformation: Digital transformation can be defined as an organisation's combined efforts in responding to technological disruption and changes brought upon by the fourth industrial revolution. This response can be

strategic, deliberate, or emergent, originating from other strategic priorities (Armstrong & Lee, 2021).

Disruption: Simply, disruption can be viewed as the radical change within an organisation, industry or market caused by innovation (Oxford University Press, 2021).

Eskom: A South African electricity public utility that was founded in 1923 as the Electricity Supply Commission by the South African government in accordance with the Electricity Act (1922). Eskom is organised into three divisions: generation, transmission, and distribution. Eskom generates around 95% of the power utilised in South Africa (Eskom, 2022).

Fourth Industrial Revolution: The term "Industrial Revolution" describes periods of significant industrialisation due to ground-breaking innovation that had a significant economic, political, and social impact globally (Chen, 2021). The "Fourth Industrial Revolution", abbreviated 4IR, describes the impact of disruptive technologies and digital innovation on all aspects of human development in the 21st century, changing the way people live, work and communicate (World Economic Forum, 2021).

Group of Twenty: More commonly referred to as G20, the Group of Twenty is a premier global initiative that was formed in 1999, comprising some of the world's largest economies. The participating nations meet annually to collaborate on

global policies regarding trade, finance, health, climate, and other pertinent issues (McBride & Chatzky, 2019).

IT/OT Convergence: IT/OT convergence is a concept that aims to move operational technologies (OT) or physical devices and equipment into the informational technology (IT) or digital sphere. This is achieved by using wireless connections to send pertinent data from each physical system to a central server for monitoring and analysis. The analysis' findings may then be sent back to the physical devices, allowing for more autonomous operation, improved precision, easier maintenance, and increased uptime (Bigelow & Lutkevich, 2021).

Laggard: Generally, laggards refer to organisations, industries or markets that develop, progress or respond slowly and lethargically to disruption and change (Dictionary.com, 2021). For the purposes of this research study, the nature of this disruption and change is digital.

Mandela Mining Precinct: A public-private initiative developed by South Africa's Department of Science and Innovation and the Minerals Council of South Africa, with an aim to revitalise mining research, development and innovation in pursuit of sustainability (Mandela Mining Precinct, 2021).

Mining Industry: The mining industry is concerned with the economic extraction of valuable minerals and geological materials as mineralised commodities from under the earth's surface (Corporate Finance Institute, 2021). The mining industry

is often considered a branch or part of the energy, manufacturing, or trade industries.

Mining Phakisa: A South African government initiative managed by the Presidency with an agile approach to research and innovation. The initiative was based on a "fail-fast" philosophy and employed a diverse selection of specialists and stakeholders within a laboratory environment to develop and test concepts and solutions promptly (Trade & Industrial Policy Strategies, 2015).

Non-Governmental Organisation: Abbreviated NGO and interchangeably referred to as a non-profit organisation (NPO), civil society organisation (CSO), membership organisation, charitable organisation, charity or the third sector, non-governmental organisations are citizen-based, non-profit entities that operate independently from government, representing a myriad of interests and activities (Europena Union, 2021)**.**

Sustainability: Derived from the word "sustain" that means to maintain or keep at a certain state or level, "sustainability" in the 21st century can be defined as the methodologies and actions that result in meeting current requirements without compromising the ability to meet future needs in the same way (White, 2013).

Trade Union: An organisation formed to protect and promote issues regarding wages and working conditions by engaging with respective employees. Trade unions aid in resolving labour disputes and make recommendations on labour policies and laws (Government of South Africa, 2021).

Zero Harm: A health and safety concept and culture that defines a work environment that does not expose any person to injury or harm. It ensures that

the work environment, through workplace design and safety awareness, poses little to no risk of fatality, injury or harm for all employees, contractors, and visitors (Kerema, 2019).

1.8 Assumptions

The research considers the following assumptions:

I. Participants are proficient in the English language; this research and the associated interviews were conducted in English,
II. Participants have current exposure to and experience in the South African mining industry,
III. Participants understand the concepts of digital transformation and digital maturity,
IV. Participants have provided honest, candid, and unbiased responses to the interview questions to the best of their knowledge and ability,
V. Where relevant, participants had provided documentation or other appropriate material to support their views,
VI. The inclusion criteria of the participants are appropriate for this research and assume all participants to have the same or similar exposure in the same or similar environment,
VII. Participants have appropriate motives for contributing to this research, aligned with generating new or enhanced knowledge and insights.

CHAPTER 2. LITERATURE REVIEW

The literature review initiates an analysis of concepts in the search for an empirical definition, purpose, and scope of digital transformation and digital maturity, followed by a critical review of digital maturity models. The human factors that advance or impede digital transformation are then investigated using theories of technology acceptance and adoption. The chapter concludes with an investigation of the South African mining industry, with an emphasis on the future and impact of technology on the industry and the resistance to adopting digital technology.

2.1 Introduction

Globally, there is a scope of organisations known as *digital masters*, who are digitally mature enough to shape organisational innovation and drive enterprise-wide transformation. These *digital masters'* financial performance and operational efficiency are much greater than their less digitally mature competitors (Westerman et al., 2012). It is evident that an intended equilibrium between these organisations' leadership capabilities and digital capabilities are significant differentiators for *digital masters* supported by a depth of standards, policies, and frameworks developed by both researchers and practitioners available to guide digital transformation. Yet, many industries, particularly the South African mining industry, still face a host of challenges that prove many digital maturity models ineffective.

While there is substantial support for the drivers of technological disruption in the South African mining industry, evaluating the industry's potential to transform and

adopt digital technology is critical in advancing the industry's digital maturity. Therefore, the literature review initiates an analysis of concepts in the search for an empirical definition, purpose, and scope of digital transformation and digital maturity. Using an approach by Armstrong & Lee (2021), a critical review of digital maturity models is conducted through the lens of global consultancy organisations, business models and frameworks, and academic literature and theories before evaluating a unified model of digital maturity. The analysis and adoption of a relevant digital maturity model would aid in identifying key focus areas and factors that would help to improve the overall digital maturity of the South African mining industry.

Although developing digitally advanced business and operational processes are one of the most critical requirements for overall digital transformation, having the skills, capabilities, and culture towards digital technology and innovation is another equally vital condition (Lööw et al., 2019). Therefore, it is necessary to reflect on the acceptance and adoption of technology and the human elements that either advance or hinder digital transformation. In doing so, the literature review considers organisational congruence models, the absorptive capacity of an organisation, the diffusions of innovation theory, modes of engagement and matching, and the technology acceptance model. While many of these models and frameworks are well defined, there is a consensus that many models expose a certain level of bias towards research or practice, migrating the literature review towards a unified theory of acceptance and use of technology.

The inhibitors of digital transformation in the South African mining industry needs to be explored to understand the slow impact of technological disruption on an

industry that demonstrates strong drivers for digital transformation. To this end, the literature review concludes with an inquiry into the South African mining industry, focusing on the future and impact of technology on the industry and the resistance to adopting digital technology. The myriad of economic, social, and environmental challenges that the industry faces suggest the need to move away from the extractive development model that dominates the South African mining industry towards a new approach that focuses beyond production and consumption, recognising that 'value' can be created in a multitude of ways other than through traditional industrial production (Mapungubwe Institute for Strategic Reflection, 2018).

2.2 The Fourth Industrial Revolution: Digital Transformation

Industrial revolutions signify global transformative events triggered by the complex system interaction between humans and technology that demonstrates a shift in how economic, social, and political value is generated, resulting in new ways of thinking, behaving, and existing. Throughout history, humans have invariably leveraged technology seeking improved and more efficient standards of living. To date, the industrial revolution narrative accounts for four major transformative events (Institute of Entrepreneurship Development, 2019). Figure 1 depicts these events through time in relation to the technologies that initiated the respective industrial revolutions. The fourth industrial revolution (4IR), used interchangeably with Industry 4.0, frames and analyses the impact of new technologies and their ensuing disruption and transformation on the extent of human development in the 21st century (Philbeck & Davis, 2019). Scwab (2016) emphasises the distinctiveness of the fourth industrial revolution in that

the velocity and exponential rate and depth of convergence has a profound impact on global industries, governments, businesses, and societies. Technology and digitalisation are key enablers of the fourth industrial revolution; therefore, exploring the concepts of digitalisation and technologies that underpin digitalisation is fundamental in the context of this research.

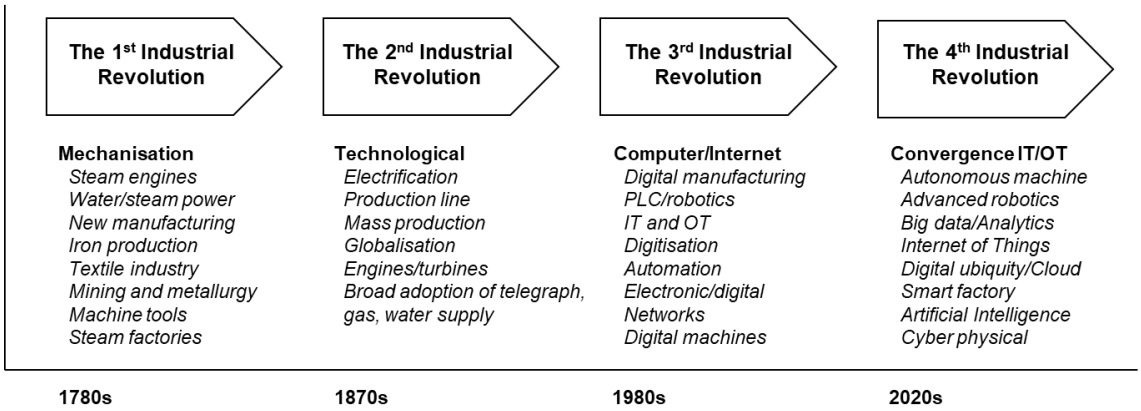

Figure 1: Progression of industrial revolutions and related technologies (Cunningham, World Economic Forum and the fourth industrial revolution in South Africa, 2018)

In a broad sense, technology can be viewed as the process of adapting nature, i.e., the physical material world, to meet a set of requirements or desired outcomes. Today, technology is frequently perceived as artefacts that include various hardware and software. However, technology extends to include the knowledge, information and processes required to operate the respective hardware and software (Pearson, Young, National Academy of Engineering, & National Research Council (U.S.), 2002). Technology in relation to the fourth industrial revolution concerns emergent technologies such as artificial intelligence, machine learning, the internet-of-things, additive manufacturing, cloud and edge computing, advanced robotics, and big data analytics, amongst

others, and is contextually referred to as d*igital technology* (Kretschmer & Khashabi, 2020).

Digital refers to using digits or numbers, i.e., binary code, to create a virtual, non-physical output. When digital or binary codes are used to build up logic, it forms the basis of programming code and information. Although digital has no physical form, it interacts within both the informational and physical domains (Armstrong & Lee, 2021). When physical processes or analogue information is encoded using binary or programming code to store, process, or transmit data, the practice is referred to as *digitisation*. Here, it is important to note that the information, not the process, is being digitised (Bloomberg, 2018). Digitisation can provide significant benefits in efficiency when the digitised information is used to automate processes and increase information availability; however, digitisation does not aim to improve the data or optimise processes (TruQC LLC, 2021). Subsequently, the process of reconceptualising and reconfiguring physical systems, in contrast to physical artefacts, into digital ones to elicit value and generate significant opportunities is referred to as *digitalisation* (Figure 2). With respect to businesses, digitalisation leverages digital technologies to transform business processes, resulting in opportunities for business efficiency and increased revenue. The extent to which businesses respond to digital technologies and the resultant disruption brings to light the concept of *digital transformation* (Armstrong & Lee, 2021).

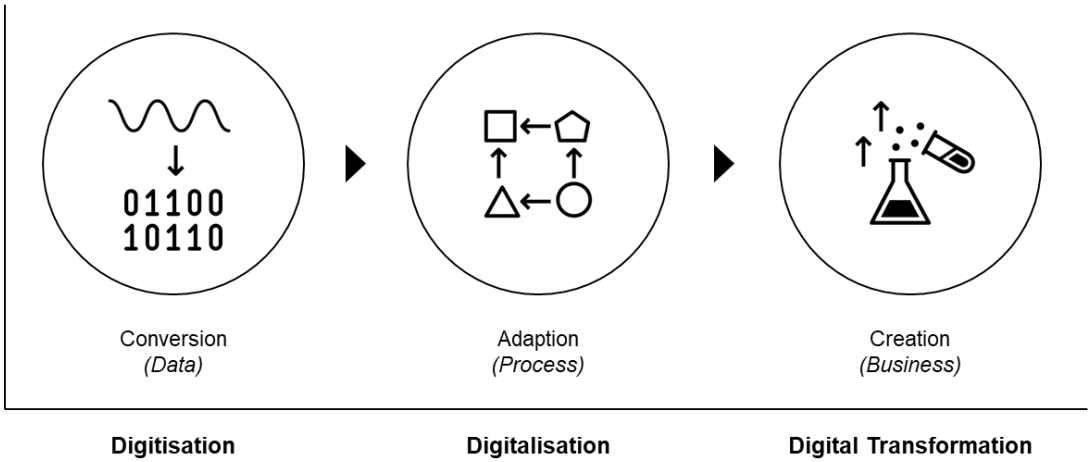

Figure 2: Distinguishing digitisation, digitalisation, and digital transformation (Bumann & Peter, 2019)

2.3 A Review of Concepts related to Digital Transformation

2.3.1 *Defining Digital Transformation*

Information, computing, communication, and connectivity technologies have improved significantly over the last decade, changing the way industries operate globally. The process of rapid and extensive adoption and application of digital technologies have impacted businesses immensely, effecting a radical shift in conventional business strategies, methodologies, capabilities, products, and services, setting the fourth industrial revolution into motion (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013). A review of 282 literature on *information systems* suggests that digital transformation is a multidimensional phenomenon that uses informational, computational, communication, and networking technologies to enhance an entity resulting in significant changes to its attributes (Vial, 2019).

The application and use of digital technologies in business processes to achieve strategic objectives and overall business efficiency epitomises the construct of

digital transformation (Aslanova & Kulichkina, 2020). Digital transformation includes both *digitalisation*, with a goal of organisational efficiency, and *digital innovation*, focusing on augmenting physical products with digital capabilities (Berghaus & Back, 2016). Sacolick (2017) highlights that digital transformation extends beyond the technology and its implementation and explores business strategy through technical capabilities, analysing business operating models and revenue-generating opportunities. To address the structural essence of the term digital transformation and the consideration of business strategy, value creation, and capability enhancement, Armstrong & Lee (2021) defines digital transformation as the aggregation of all change efforts within a business in response to technological disruption. This response can be “strategic”, “deliberate”, or “emergent”, stemming from other strategic processes. Berghaus & Back (2016) expresses that because digital transformation is an actively intended and performed change process, it is critical to contextually define the phenomenon and understand the mechanics of its construct.

2.3.2 *Purpose and Scope of Digital Transformation*

The purpose of digital transformation is to assist businesses in fulfilling their strategic goals and organisational mission in the face of technological disruption, which essentially relates to businesses being able to achieve their core purpose (Armstrong & Lee, 2021). To many, digital transformation aims to create new or enhanced business value, optimise business methodologies and processes, and develop capabilities to support the business into the future (Bumann & Peter, 2019). While most organisations associate digital transformation with operational efficiency and increased or alternate revenue generation, *digital masters*

understand that digital transformation and the technologies related to the fourth industrial revolution have the potential to assist all faculties of businesses. Organisations that gain absolute value from digital transformation recognise its impact on business strategy, change management and the workforce, talent strategies, organisational leadership, competition and coopetition, customer journeys, risk and compliance management, societal and environmental influence, and technological operations (Deloitte, 2020). Armstrong & Lee (2021) reiterates that the scope of digital transformation extends far beyond the technological benefits and, according to Aslanova & Kulichkina (2020), broadly features five main characteristics of strategy, organisational processes, people, technologies, and data.

2.3.3 *Digital Maturity and related Model Construct*

Assessing an organisation's current digital status quo is the first and arguably the most significant challenge that a business faces when undertaking digital transformation (Thordsen et al., 2020; Ochoa-Urrego & Peña, 2020). This requirement is defined by an organisation's digital maturity as the status of an organisation's digital transformation journey, portraying current transformational achievements including operational optimisation efforts, i.e., changes in products or processes, as well as capability development related to change processes (Chanias & Hess, 2016). An organisation's digital maturity is reflected in the suitability of its measuring and management processes in the context of its strategic objectives and reaction to environmental change, i.e., technological disruption (Thordsen, Murawski, & Bick, 2020). Further literature denotes digital maturity as a measure that helps businesses to assess their respective

capabilities (Poeppelbuss, Niehaves, Simons, & Becker, 2011), and the subsequent learned, rather than instinctive, response to an environment in a suitable manner (Kane, Phillips, Copulsky, & Andrus, 2019). Shahiduzzaman et al. (2017) emphasise that digital maturity is not a fixed concept due to the continual changes in the digital landscape. As a result, an organisation's digital maturity will need to be assessed over time. Still, digitally advanced organisations are referred to as "maturing" in recognition of the continuously evolving process (Kane, Phillips, Copulsky, & Andrus, 2019).

The concept of digital maturity is given particular focus by Westerman et al. (2014), providing evidence that organisations with a higher degree of digital maturity achieve better corporate success. Teichert (2019) suggests that when an organisation has established a solid digital foundation and thorough knowledge of exploiting that foundation for strategic business advantage, it reaches the pinnacle of its digital maturity. Several globally recognised consultancy organisations, including KPMG, McKinsey & Company, and Capgemini Consulting, have developed digital maturity frameworks and models to assess an organisation's level of digitalisation at a point in time. (Rossman, 2019). In fact, since the development of the Capability Maturity Model (CMM) by the Software Engineering Institute (SEI) in 1991 for its application in software systems (Paulk, 2009), maturity models and frameworks have emerged across various business domains such as Knowledge Management (KM), IT Management, Business Process Management (BPM), and Digital Government (Aguiar, Gomes, da Cunha, & da Silva, 2019). Ifenthaler & Egloffstein (2019) assert that maturity models are a well-established means of identifying the strengths and weaknesses of specific domains within an organisation and

inconsistencies between the current, i.e., as-is, and aspirational, i.e., to-be, organisational design. Hereto, maturity denotes an evolutionary progression towards the achievement of a desired state or condition.

Armstrong & Lee (2021) articulate the purpose of a digital maturity model in that it systematically identifies the underlying factors that either contribute to or obstruct digital transformation. Teichert (2019) adds that it is specifically the organisation's performance that is being measured against a digital maturity model, made up of pre-defined dimensions and criteria that relate to areas of actions that highlight the evolutionary path to digital maturity. Digital maturity models can be diagnostic in detecting an organisation's current digital state, normative in establishing or relating to a benchmark, or prescriptive in describing actions and measures for performance improvement (Armstrong & Lee, 2021). Deloitte (2018) critically suggests that digital maturity models do not aim to replace an organisation's overarching digital transformation framework but rather pose as a tool to guide the transformational journey.

Armstrong & Lee (2021) details the construct of digital maturity models further in Figure 3. Here, a *dimension* refers to a specific, quantifiable, and self-contained component that reflects an essential and distinct characteristic of digital maturity and denotes an action area. Dimensions typically comprise several *factors* which represent the influential characteristics for the performance of an organisation. Subsequently, *indicators* help assess how well or how poorly an organisation is performing according to each factor. Then, *measures* allow for a quantitative rating and assessment of each indicator.

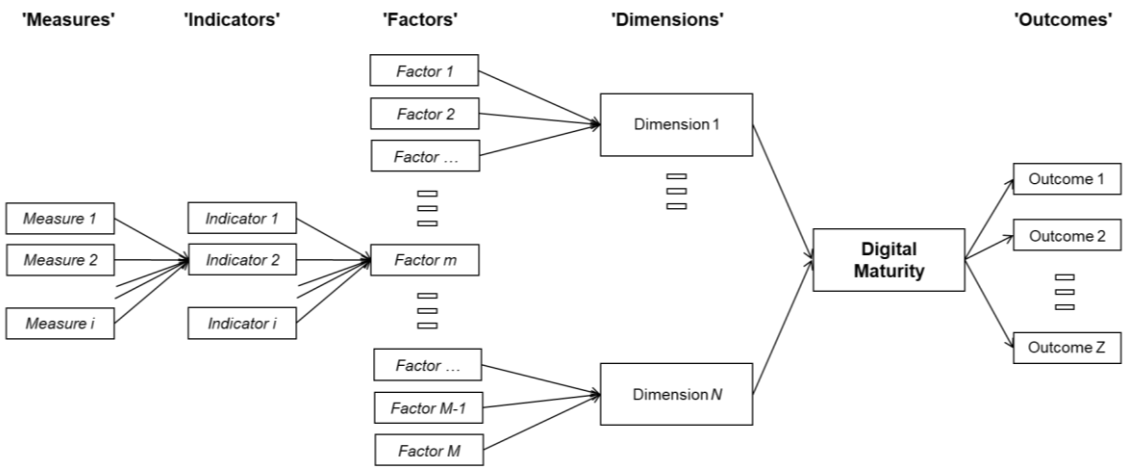

Figure 3: Factors, dimensions, and outcomes of digital maturity (Armstrong & Lee, 2021)

In assessing the construct of digital maturity models and evaluating relevant criteria, Westerman et al. (2014) advise that organisations who have mastered digital transformation have excelled in two dimensions: *digital capabilities*, which refers to the "what" of technology, and *leadership capabilities*, which signifies the "how" of change management.

To this end, the definition of digital maturity and the concept of digital maturity models have been reviewed. Several frameworks have risen over the last few decades, owing to the practical relevance of digital maturity models. Practitioners and researchers have recently aspired to assess digital maturity in the context of its application to business (Thordsen, Murawski, & Bick, 2020).

2.4 A Critical Review of Digital Maturity Models

Over time, digital maturity models have been criticised for generalising reality and displaying a lack of empirical support (De Bruin, Rosemann, Freeze, & Kaulkarni, 2005). In an analytical review of digital maturity models, Becker et al. (2009)

suggest that the methodologies and procedures related to relevant and popularised digital maturity models are abstractedly documented. Mettler & Rohner (2009) state that digital maturity models can be criticised for their lack of recommendations and activities for advancing organisations to higher maturity levels. While digital maturity models emphasise organisational processes, individual capacities and other human resource factors are frequently overlooked (Poeppelbuss, Niehaves, Simons, & Becker, 2011). Furthermore, Chanias & Hess (2016) highlight the heterogeneity present across the various digital maturity model dimensions. Teichert (2019) adds that while countless digital maturity models have been developed, there is still a misunderstanding of the shared dimensions across the various models. Another study supports that current digital maturity models have severe conceptual and methodological weaknesses in business application (Williams & Schallmo, 2020). Thordsen et al. (2020) most recently argued that the continual publishing of new digital maturity models for organisational application suggests a degree of arbitrariness in many models.

Researchers and practitioners alike are struggling to find a suitable and easily adoptable digital maturity model that has been peer-reviewed and validated (Lasrado, Vatrapu, & Normann, 2015). Armstrong & Lee (2021) suggests that a well-defined digital maturity model must consider the collective requirements typically addressed by global consulting organisations, business literature, and academic literature.

2.4.1 *Global Consultancy Organisations*

The lack of skills and awareness concerning the topic of digital maturity is increasingly acknowledged as a critical barrier to digital transformation within organisations, making it difficult to effectively analyse the existing and, more critically, future requirements for organisational transformation without such expertise (Williams, Schallmo, & Lang, 2019). Kuzin (2019) advises that the majority of challenges that organisations face, as they strive for greater digital maturity, are related to the roles of management and leadership, the formation of new competencies, the use of digital technology, and the formation of new proficiencies, concerning values, creativity, the art of management, complex human relationships, and emotional intelligence.

Based on global consultancy models and frameworks aimed at advancing organisations in their digital maturity, Williams et al. (2019) identified six essential focus areas: strategy, governance and leadership, people and culture, organisational processes, products and services, and digital technology. Voß et al. (2020) suggest that due to the complexities of how digital disruption might influence conventional businesses, digital maturity models should take a systemic approach rather than focusing on discrete change characteristics.

2.4.2 *Business Models and Frameworks*

Westerman (2014) states that digital transformation and the process of digitally maturing is not linear and recommends a compass to guide organisations through the transformational process. Here, the focus is on *framing the digital challenge*, *focusing the investment*, *mobilising the organisation*, and *sustaining the digital*

transition. In collaboration with Capgemini and the MIT Centre for Digital Business, Westerman et al. (2012) propose four types of digitally mature organisations; *beginners*, *conservatives*, *fashionistas*, and *digital masters* (synonymous with the term Digirati), based on an organisation's *leadership capabilities* and *digital capabilities* (Figure 4).

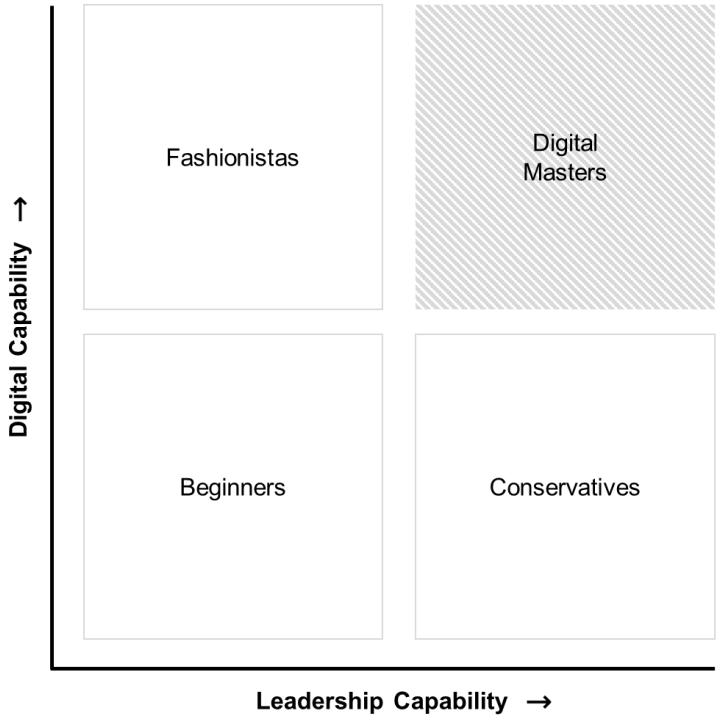

Figure 4: Four types of digital maturity (Westerman et al., 2012)

Several business literatures provide case studies and practical tools and strategies to improve an organisation's digital maturity using a pragmatic approach. Rogers (2016), for example, demonstrates how conventional businesses need to reconsider their underlying business assumptions in the view of competition, customers, data, value, and innovation. The publication relays leveraging and integrating networks, platforms, big data, disruptive business models, and rapid experimentation. There is a significant focus on rapid

experimentation, specifically regarding agile transformational processes in business literature, as Sacolick (2017) elaborated. Ismail et al. (2014) support this notion and explore additional organisational attributes like governance and leadership that allow for the attainment of an exponential organisation, being more dynamic and efficient than traditional businesses. Digital transformation looks at internal organisation mechanisms and often overlooks external stakeholders such as government, regulators, and, arguably the most important, customers and their journey. Accordingly, Evans (2017) explores the strategic levers for an optimal digital customer experience. Business literature, as in the work of Iansiti & Lakhani (2020), also addresses the emerging risks associated with digital maturity that includes and is not limited to: compliance risk, cybersecurity risk, workforce risk, third-party risk, automation risk, resiliency risk, and data privacy risk (De Oliveira, 2021).

Thordsen et al. (2020) appropriately suggest that the consistency and universality of digital maturity models presented by business literature remain unclear, principally due to their empirical nature and lack of peer-based quality reviews.

2.4.3 *Academic Literature and Theories*

Researchers in academic literature have realised that the evolution of digital maturity models needs to consider multidimensional design frameworks that shift away from a solely technological focus through time (Ochoa-Urrego & Peña, 2020). In examining over 150 academic-based digital maturity literature and models, Lasrado et al. (2015) conclude that there is an apparent lack of theoretical foundation for models that are based upon the Capability Maturity

Model or similar, a lack of robust empirical validation in the range of dimensions and factors, and a lack of operationalising maturity measurements.

Over the last decade, there has been an explosion of scholarly research on digital transformation and digital maturity. Several academic literatures examine digital maturity models and discuss the gaps and opportunities (Armstrong & Lee, 2021). However, only a few frameworks have appropriately recognised and addressed the issues resulting from research-driven digital maturity models (Lasrado, Vatrapu, & Normann, 2015). Consequently, Teichert (2019) asks the precarious question of "who is driving the development of digital maturity models – practitioner or academic?" To this end, researchers immediately recognise the need to collaborate with practitioners to develop relevant digital maturity models.

2.4.4 *A Unified Model of Digital Maturity*

Digital maturity models that are "theoretically sound, methodologically rigorous, and empirically validated" are hard to come by, even today (Lasrado et al., 2015; Armstrong & Lee, 2021). Armstrong & Lee (2021) assent the notion that none of the existing models adequately address all aspects of digital maturity, leaving out critical elements such as "resource allocation, organisational leadership, leadership transformation, new value streams and business models, and others." In response to the concerns and requirements outlined above and in order to provide necessary insights to researchers and guidelines to practitioners, Armstrong & Lee (2021) took a revised, contemporary approach in reviewing relevant and publicised digital maturity models. In pursuit of an empirical and well-defined digital maturity model, theories and models posed by global consulting organisations, business literature, and academic literature were assessed, and

conclusively a unified model of digital maturity was formulated (Armstrong & Lee, 2021).

The unified model of digital maturity assesses models and frameworks from global consulting organisations including Accenture, Bain and Company, Deloitte, Ernst and Young, Forrester, Gartner, IDC, KPMG, McKinsey & Company, PricewaterhouseCoopers (PWC), and the World Economic Forum. The analyses then considers business literature, including Leading Digital: Turning Technology into Business Transformation (Westerman et al., 2014), The Digital Transformation Playbook (Rogers, 2016), Mastering Digital Business (Evans, 2017), Exponential Organisations: Why New Organizations are Ten Times Better, Faster, and Cheaper Than Yours (and What to do About it) (Ismail et al., 2014), and The Technology Fallacy: How People Are the Real Key to Digital Transformation (Kane et al., 2019). Finally, relevant reviews of academic literature were examined and includes digital maturity model reviews by Bumann & Peter (2019), Teichert (2019), and Berghaus & Back (2016).

The unified model of digital maturity proposes two dimensions, *leadership and strategy*, and *digital application and impact*, based upon Westerman et al. (2012)'s digital mastery framework. The model details 12 key factors, depicted in Figure 5, making provision for both empirical and theoretical influences, and encompassing the key organisational areas of strategy, governance and leadership, people and culture, organisational processes, products and services, and digital technology as relayed by Williams et al. (2019).

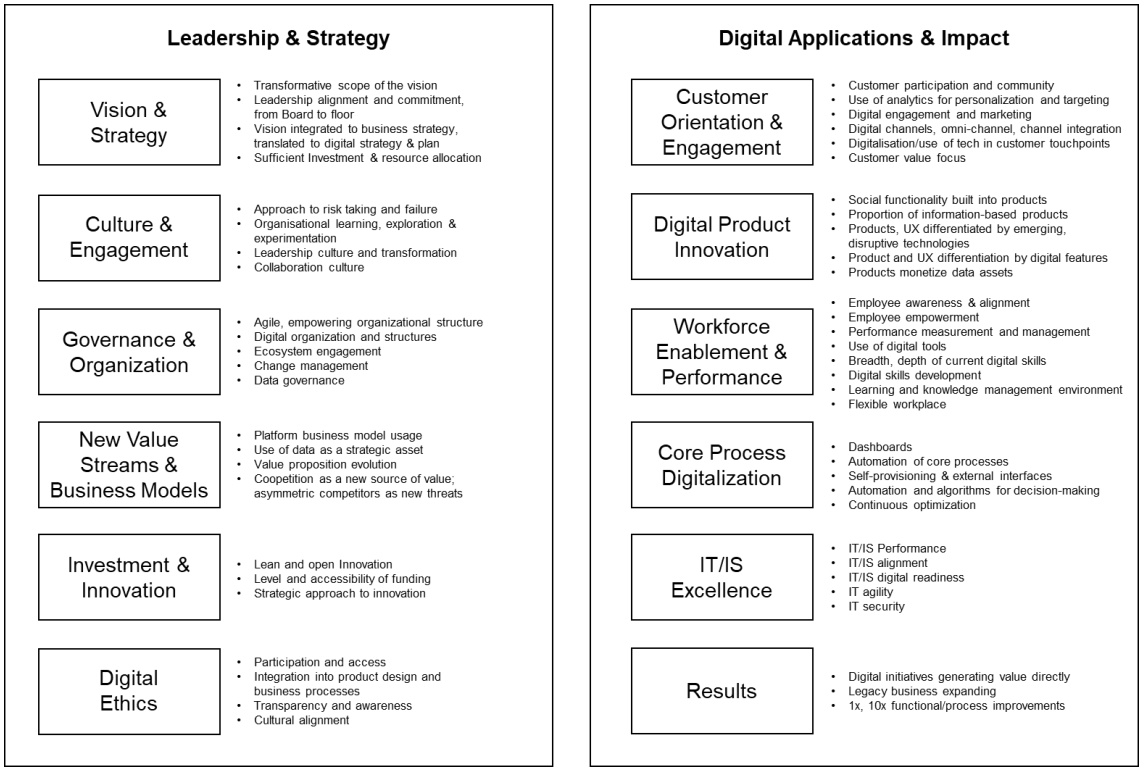

Figure 5: Dimensions and factors of a unified model of digital maturity (Armstrong & Lee, 2021)

The unified model of digital maturity inherently possesses limitations and risks, including the lack of empirical data required to assess the priority and subsequent weighting of each factor and the natural statistical dependency of each factor on one another. However, the model is current, non-selective, operationalisable, universally applicable, and integrates requirements from researchers and practitioners, organisations and academia and proposes arguably the most cohesive and empirical digital maturity model thus far.

2.5 Theories of Acceptance and Adoption of Technology

Developing digitally advanced business and operational processes are critical requirements for digital transformation, however, having the skills, capabilities, and culture to embrace digital technology and innovation is another equally

important condition (Lööw et al., 2019). As a result, it's important to reflect upon how people embrace and adapt technology, as well as the human factors that advance or impede digital transformation. To this end, leading theories and models of acceptance and adoption of technology are discussed in *section 2.5* and considered in the research study. While many of these models and frameworks are well defined, there is agreement that many of them reveal a level of bias toward research or practice, which suggests a review of a unified theory of acceptance and use of technology.

2.5.1 *Organisational Congruence Models*

The concept of digital maturity is based on well-established organisational models, frameworks, and theories. Working towards digital maturity necessitates an interaction of various key organisational components (Armstrong, 2021). Furthermore, understanding the dynamics and performance of an organisation is a vital step in developing and directing effective large-scale digital transformation. Singh (2013) agrees that organisational leadership styles must be carefully coordinated to align with the existing business culture.

The Nadler-Tushman Congruence Model is a systems thinking framework developed by Nadler & Tushman (1980) and provides an integrated approach to exploiting organisational artefacts that could influence transformation. The model, illustrated in Figure 6, enables organisations to consider change holistically rather than simply input and output dimensions. The Nadler-Tushman Congruence Model necessitates an outlook of an organisation's current inputs and outputs and a plan or roadmap for achieving its strategic objectives. The formal and

informal processes of tasks, culture, people, and structure that enable the transformational process are at the centre of the model.

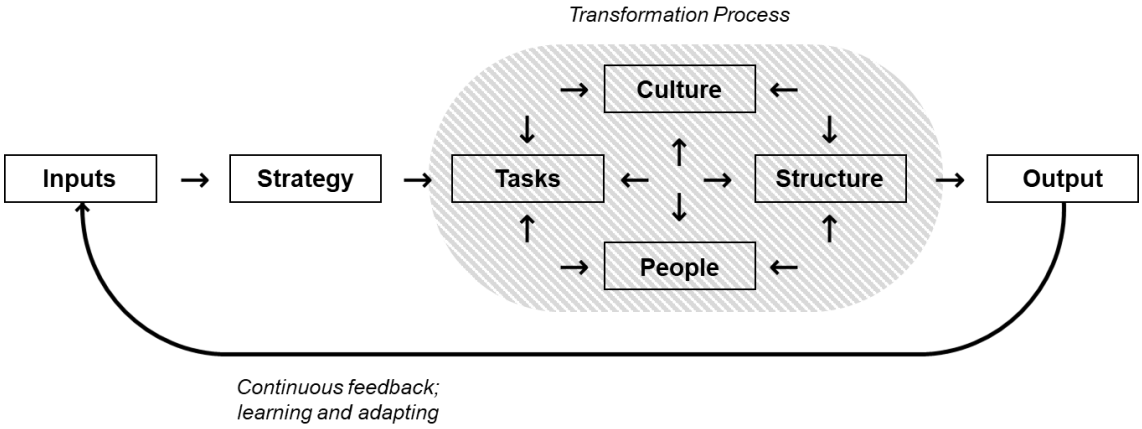

Figure 6: Nadler-Tushman congruence model
(Nadler & Tushman, 1980, p.13)

Similarly, the McKinsey 7S framework depicts a network of interconnected dimensions that influence an organisation's ability to change. This framework is used as a design tool to facilitate organisational change, implement relevant strategies, predict future areas of change, and facilitate merger strategies between organisations (Caredda, 2020). The McKinsey 7S Framework examines the seven essential components that contribute to organisational transformation success, including strategy, structure, staff, skills, systems, style, and shared values (Singh, 2013).

Caredda (2020) critically suggests that although congruence models serve as excellent diagnostic tools, they do not provide complete direction on how to perform a change process, placing reliance on other frameworks and models. Additionally, the focus of these congruence models is generally on the formal parts of each component compared to the soft elements, which are the ones that typically have the greatest impact on change.

2.5.2 *The Absorptive Capacity of an Organisation*

The capability of individuals, businesses, and public policies to keep up with the rate of technological change is critical to the success of digital transformation and the pursuit of digital maturity. In Figure 7, Kane et al. (2019) relay that there exists a delay in the ability for individuals within an organisation to keep up with the rate of technological change, i.e., *adoption*, a delay in the ability for organisations to meet individual's requirements to engage with the respective digital technologies, i.e., *adaptation*, and a delay in the ability for regulators and public policy to keep up with an organisation's need to use digital technologies, i.e., *assimilation*.

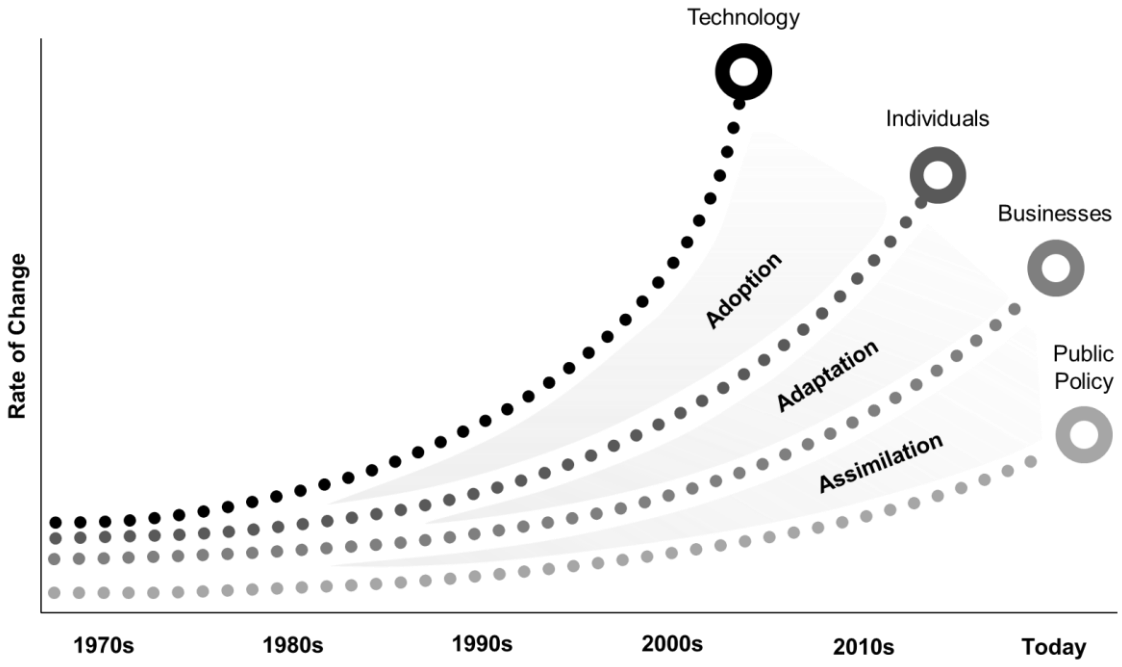

Figure 7: Adoption, adaptation, and assimilation of digital technologies (Kane et al., 2019, p.30)

Armstrong & Lee (2021) explains that the notion of an organisation's absorptive capacity aims to illustrate that to integrate and utilise new knowledge, businesses require relevant information, whether scientific, technological or otherwise. The

resultant adoption, adaptation, and assimilation gaps can be reduced significantly by supplementing, augmenting, and upskilling individuals, organisation's and regulators, thereby increasing the knowledge-base and absorptive capacity of these respective entities. Cunningham (2018) suggests that the approach requires learning from leaders and altering and integrating knowledge, specifically to meet the needs of local contexts better and, in many instances, developing countries. Cohen & Levinthal (1990) affirms that the more information an organisation has access to, the more it learns and develops.

2.5.3 *The Diffusion of Innovation Theory*

Armstrong (2021) highlights that while it is evident that individuals adopt new technology faster than businesses, individual employees differ in their rate of adoption. The practice by which individuals accept a new concept, product, practice, or philosophy is described in the diffusion of innovation theory, popularised by Rogers (1962). The theory explains that a small number of individuals are initially receptive to a new concept and adopt it. As these 'early innovators' publicise information about the new concept, more individuals become interested, resulting in mass appeal and subsequent adoption. Over time, the new concept spreads until it reaches saturation. Rogers et al. (2008) identify five distinct categories of adopters, including innovators, early adopters, early majority, late majority, and laggards, as seen in Figure 8.

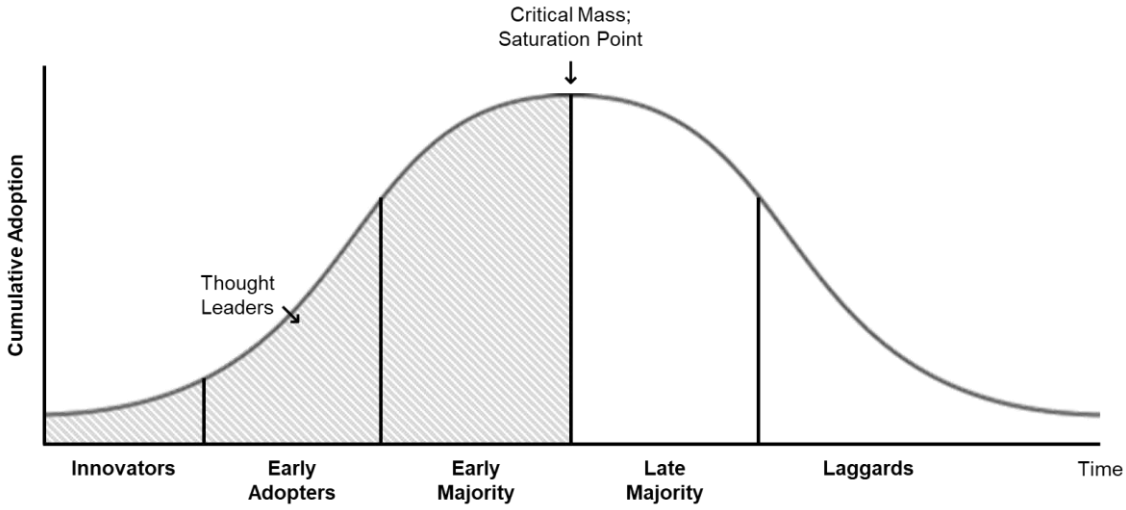

Figure 8: Diffusion of innovation adopter categories
(Rogers et al., 2008, p.418)

Kaminski (2011) explains that the goal, according to this theory, is not to move individuals from one of the five adopter groups to another but to simplify innovation to fulfil the demands of all five, guided by peer networks, adoption frameworks, innovation characteristics, re-invention strategies, and communication channels.

2.5.4 *Modes of Engagement and Matching*

Scholkmann (2021) discusses that the discrepancy between an intended and implemented learning activity within an organisation with respect to digital adoption can be regarded as the perceived resistance to change. Individuals within an organisation engage with digital technology in four respects; *cumulative* involves learning about technology by acquiring fundamental knowledge about its functionality; *assimilative* enables individuals to use standards and best practices to learn how to use the technology; *accumulative* allows learning and implementing new processes based on digital technology opportunities, and

transformative-expansive involves individuals generating new ideas in respect to digital technologies in order to recognise, structure, and set the pace of digital adoption.

Boateng (2011) refers to the concept of "matching" that portrays a consulted and communicated shared understanding of which modes of engagement, outlined above, might match the organisational learning and change requirements. An individual’s acceptance of digital technologies or perceived resistance to change "is an interplay between individual and organisational forces and barriers".

2.5.5 *The Technology Acceptance Model*

In exploring an individual's acceptance of digital technologies, Lee et al. (2003) affirm that the Technology Acceptance Model (TAM) is the most influential and widely used theory. Alsharida & Hammood (2021) add that its common usage for predicting the adoption of numerous technologies is due to the model's simplicity, versatility, and soundness. Built upon the foundations of the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 2010), the Technology Acceptance Model was developed by Davis (1986) and suggests that two primary variables determine an individual's acceptance of information systems which include the *perceived usefulness* and the *perceived ease of use* of the technology or system. Due to realised inadequacies in this Technology Acceptance Model, a revision of the model was done and considers the relationships between the *perceived ease of use* and the *perceived usefulness* of technology, *computer anxiety* and the *perceived ease of use*, and the *perceived ease of use* and *behavioural intentions* (Venkatesh & Bala, 2008).

According to Ajibade (2018), the Technology Acceptance Model is better suited to individual technology use and acceptance than to organisational applications that require the integration of business information technology. The premise is that within an organisation, an individual's IT knowledge and expertise facilitate technology use, while the organisation's regulations, policies, and IT guidelines regulate technology acceptance and intentions.

2.5.6 *A Unified Theory of Acceptance and Use of Technology*

Up to this point, there are shared views that factors such as environment, social, culture, strategy, skills, values, and structure must be considered when examining the acceptance and adoption of technology to advance digital maturity within an organisation. Researchers and practitioners are frequently obligated to pick and select traits from a wide range of often contradictory models and ideas (Venkatesh, Morris, Davis, & Davis, 2003). In response to the requirement for an integrated, unified view between relevant models, frameworks and theories, Venkatesh et al. (2003) proposed the Unified Theory of Acceptance and Use of Technology model (UTAUT). Momani (2020) suggests that by incorporating the most advantageous constructs from various previous theories and models, the Unified Theory of Acceptance and Use of Technology model emerges as one of the most cohesive and established technology acceptance theories. While the model takes into consideration a myriad of previous literature, models, frameworks, and theories, Negahban & Chung (2014) points out that key concepts were derived from the Innovation Diffusion Theory, Theory of Planned Behaviour, Technology Acceptance Model, Motivation Model, and the Social Cognitive Theory.

In a more recent study, Venkatesh et al. (2016) suggest that the construct of the Unified Theory of Acceptance and Use of Technology model identifies four factors, i.e., performance expectancy, effort expectancy, facilitating conditions, and social influence, and four moderators, i.e., age, gender, voluntariness, and experience, as seen in Figure 9. The factors of performance expectancy, effort expectancy, and social influence were understood to affect behavioural intentions to use technology, while these behavioural intentions, together with the factor of *facilitating conditions,* govern the technology use. Furthermore, numerous model relationships are regulated by the four moderators.

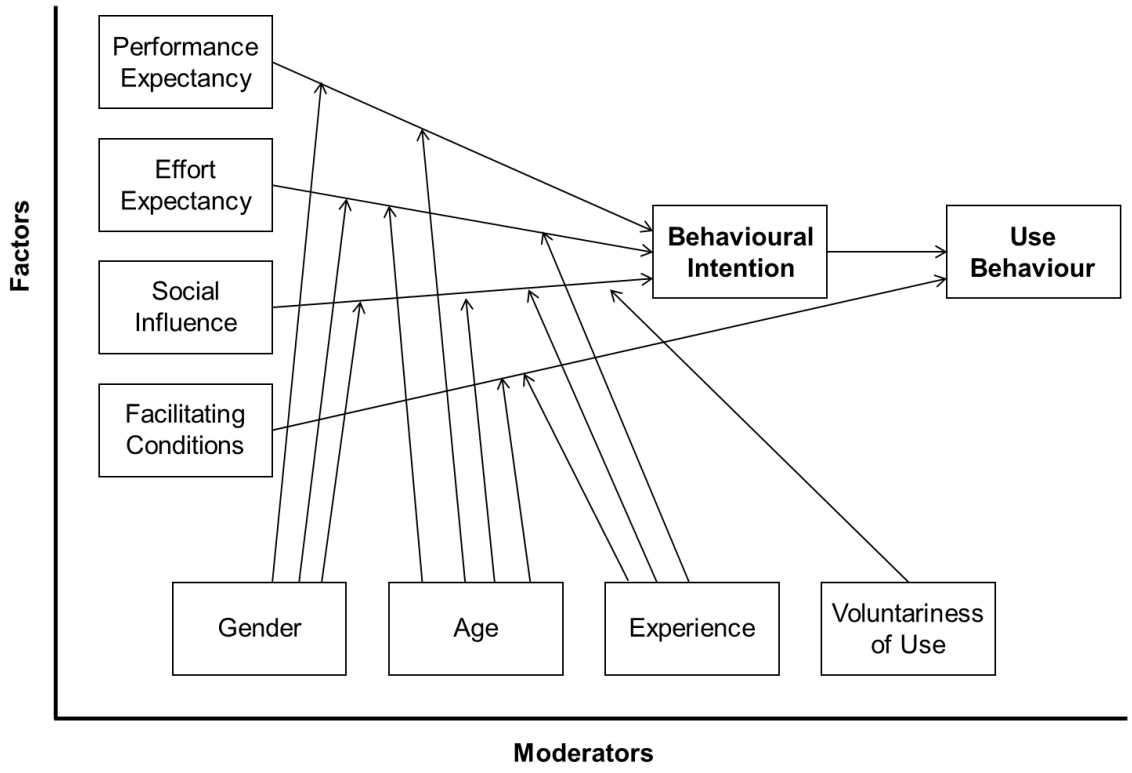

Figure 9: Factors and moderators of the unified theory of acceptance and use of technology model (Venkatesh et al., 2003, p.280)

The Unified Theory of Acceptance and Use of Technology model remains relevant and valuable in highlighting the considerations and variances in

behavioural intention, acceptance, and adoption of digital technology. While it provides an understanding of factors that might inhibit digital adoption, it is crucial to consider these factors within the context of the research environment.

2.6 An Inquiry into the South African Mining Industry

2.6.1 *The Future of the Mining Industry*

Global investors and the South African government, through a resource nationalism agenda, both express a level of aversion towards the South African mining industry. Community pressures for increased corporate social responsibility, commodity price instability, cost pressures, and demands from trade unions and environmental groups all add to the myriad of challenges faced by the South African mining industry (Burger et al., 2019). Leon (2012) emphasises that investor confidence is vital in a capital-intensive and high-risk industry, especially when considering the importance of mining to the South African economy. However, there is a growing gap between the South African mining industry's current 'state of affairs and the aspirations of long-term growth, employment, and development. Lööw et al. (2019) explain that while having a cutting-edge, digitally advanced production process is one of the most critical requirements for the future of mining, having a skilled workforce capable of handling digital technologies is another, equally vital condition, and where generational concerns is a significant challenge to overcome. Burger et al. (2019) highlight that the mining industry assigns substantial resources to manage and mitigate risks and social pressures and realise opportunities; however, it is still

unclear how organisations within the mining industry should achieve a return on investment sustainably and responsibly.

From climate change to rising inequality, today's industry’s concerns highlight the need to shift away from the extractive development model that dominates the South African mining industry towards a new approach that looks beyond production and consumption. The Mapungubwe Institute for Strategic Reflection (2018) describes the concept of a *well-being economy*, such that an economy that prioritises wellness, unlike traditional growth-based industrialisation, and understands that 'value' can be created in various ways, not just through standard industrial output.

2.6.2 *The Impact of Technology on the Mining Industry*

The aim of mining and mine operations has remained the same since its inception; to extract valuable metals and minerals from the ground and to separate this valuable material from waste material. Over the years, the scale of mining operations and technologies used in the mining and extraction processes have evolved substantially (OECD, 2019). Swart (2018) points out that one of the most challenging principles in the mining industry has been the ability to make key, real-time decisions based on data from several systems, processes, and devices. Faced with the prospect of digital transformation, mine owners and operators are grappling with the more complex areas of digital solution deployment, generational workforce development, and legacy transition concerns (Ramsay, 2018). In a recent report, Ernst & Young (2018) highlights the rising gap between the potential of digital transformation and its successful implementation within the South African mining industry.

The realised value and impact of digital technology has demonstrated unprecedented benefits within the mining industry in removing employees from hazardous work environments and improving operational efficiency and productivity, especially towards remote operations, which are distinctive of the mining industry. Bliss (2018) asserts that as these technologies become more commercially feasible, the risks associated with their adoption diminishes.

The quality and quantity of unparalleled data available to mining organisations have changed radically due to networked sensors, machinery, devices, and visual data from satellites and other digital technologies. As a result, the capabilities offered by automation for mine operations' productivity, health, and safety are critical to the mining industry. Charou et al. (2010) explains the use cases of remote sensing techniques such as unmanned aerial vehicles and satellites assisting mining organisations in significantly reducing their ecological footprint. The widespread use of sensor technology to monitor emissions, water, and air quality, reduce energy consumption, and post-closure emission observations guarantee that mining operations will better understand any potential issues in near real-time.

Romero et al. (2016) devised a series of typologies for the fourth industrial revolution's impact on the mining industry, based on eight archetypes and respective digital technologies. Here, the benefits and enablement of digital technology and capabilities to critical applications within the mining industry are provided in Table 1.

Table 1: Typology of archetypes for the mining industry (Romero et al., 2016)

Archetype	Technological Characteristics
The Super-Strength Miner	For enhanced limb movement, strength, and endurance, biomechanical support is used.
Archetype	**Technological Characteristics**
The Augmented Miner	For merging information from the internet to the physical world, augmented reality (AR) is used.
The Virtual Miner	Virtual reality (VR) is used to simulate and train dangerous real-life scenarios.
The Healthy Miner	Wearable sensors are used to track health parameters as well as GPS location.
The Smarter Miner	Interacts with information systems using intelligent personal assistants.
The Collaborative Miner	Collaborative robots are used to complete repetitive and difficult jobs.
The Social Miner	For interaction between operator-and-operator and between operator-and-IoT, enterprise social networking platforms are used.
The Analytical Miner	Big data and analytics is used to find helpful statistics and predict significant occurrences.

Mining is an essential aspect of how humans can create a more socially just society while remaining within ecological boundaries in collaboration with digital technologies. In a recent analysis of the state of digital transformation in the South African mining industry, PWC & the Minerals Council South Africa (2021) reassures that the industry will become more globally competitive, attract great skills, and contribute to renewable resource generation, as the economy and

society can be re-imagined by utilising digital technology and transformation to enable a more advanced mining industry.

2.6.3 *Candidate Inhibitors to Digital Transformation*

In exploring the barriers to digital transformation in the South African mining industry, it is essential to consider candidate inhibitors to understand the existing perceptions and experiences that surround this research inquiry. A consolidation of candidate inhibitors and associated dimensions, factors, and indicators in relation to the unified model of digital maturity is provided in Table 2 and is discussed below.

Marwala (2020) motivates four reasons why the mining environment is unfavourable for the implementation of technologies offered by the Fourth Industrial Revolution, related to the physical capacity of the hardware to meet the demands of a mining environment.

I. Temperature regulation is an essential factor in the successful operation of semiconductor-based technologies. In the case of underground mining operations, computers must be constantly cooled by internal fans within high-temperature environments to avoid overheating.
II. The presence of moisture in the air prompts rust to form on metals. Humidity also affects the performance of computers, making them unpredictable and unreliable.
III. Because mining operations have uneven surfaces, robots and other comparable technologies designed for factory floors perform poorly in mining environments.

IV. Sensors required to power robots are not primarily built for use in subsurface environments, such as underground operations.

In addition to the hostile and ever-changing environment, mining operations are geographically isolated, contributing to a host of software challenges, like wireless connectivity (Young & Rogers, 2019). Young & Rogers (2019) makes mention of the connectivity challenges of large mobile equipment at mining sites, emphasising that these mobile assets are utilised for decades, but network vendors only maintain their products for a few years before becoming obsolete. According to Equinix (2021), network delays caused by geographical distance impede real-time analytics and integration. The lack of real-time data and device integration inhibits the adoption of technologies such as augmented reality, virtual reality, internet-of-things, and drones. The value of these technologies can only be realised if seamlessly integrated for accessibility, secure storage, and constructive processing. Furthermore, big data generated by mining operations cause network capacity constraints, unpleasant user experiences, cost inefficiencies on legacy network infrastructure (Equinix, 2021), and increased cybersecurity threats. Mining operations maintain hundreds, even thousands, of data-generating applications simultaneously. Cybersecurity threats increase when data is shared among partners and other stakeholders (Young & Rogers, 2019). Mining operations require network solutions that can scale over time to meet the dynamic and strong demands of the South African mining industry

Greane (2021) highlights key issues and barriers to digital adoption and digital transformation, including internal factors such as legacy systems, traditional and complacent culture, the existence of silos, risk-averse organisations, cyber

threats, lack of skill and talent, as well as external factors such as labour laws and unions, environmental demands, social licence to operate, government and regulatory policies, competition, global pandemic outbreaks, climate change, and commodity supply and demands, which contribute towards the depleted realised value of digital investment and adoption in the South African mining industry. Due to the labour burdens associated with automation within the South African mining industry, there are fears that the underlying factors supporting mining operations' social license to operate may become increasingly stressed, explains Bliss (2012). Governments and organisations must ensure that artificial intelligence and automation technologies do not jeopardise efforts to create shared value, such as job creation and investment in local communities, or divide the mining industry into low-skilled, low-paying jobs and sophisticated, high-paying jobs for those who can benefit from the migration to digital technologies.

In their recent review of the South African mining industry, PWC & the Minerals Council South Africa (2021) emphasise that digital technologies deployed in a people-centric manner have the advantage of creating new, better-paying, safer, healthier, and more rewarding jobs. Instead of being viewed as a threat to an individual's livelihood, this highlights the benefits of digital technology and digital transformation in becoming an ally to assist the mining workforce. Cunningham (2018) argues that improved education, infrastructure, and legal frameworks that ensure increased data protection and privacy and monitor competitive and anti-competitive behaviour will require a more technology-intensive and digital future for the South African mining industry.

Table 2: Candidate Inhibitors to Digital Transformation in the South African Mining Industry

No.	Candidate Inhibitor	Description	Source	Indicator	Factor	Dimension
1	Risk-averse Organisations	Reluctance to propose and advocate risky projects, where innovation and concepts are to be proven, and results are not guaranteed	(Greane, 2021)	Approach to Risk Takings; Organisational Learning, Exploration and Experimentation	Culture and Engagement	Leadership and Strategy
2	Traditional and Complacent Culture	Employees are paralysed by fear and uncertainty; the existence of silos, teams and projects are not agile and innovative	(Greane, 2021; PWC & the Minerals Council South Africa, 2021)	Leadership Culture and Transformation; Collaboration Culture	Culture and Engagement	
3	Government and Regulatory Policies	Regulatory frameworks are too rigid to handle the speed of technological advancements, and the unexpected negative consequences on society	(Greane, 2021; Cunningham; 2018)	Participation and Access	Digital Ethics	
4	Environmental Demands	With the world's resources under increasing strain and an urgent need to decrease emissions and prevent climate change	(Greane, 2021)	Integration into Product Design and Business Processes	Digital Ethics	
5	Labour Laws and Unions	Labour burdens associated with automation suggests that underlying factors supporting social license to operate may become stressed	(Greane, 2021)	Employee Empowerment; Digital Skills Development	Workforce Enablement and Performance	Digital Application and Impact
6	Social Licence to Operate		(Greane, 2021; Bliss, 2012)			

No.	Candidate Inhibitor	Description	Source	Indicator	Factor	Dimension
7	Lack of Skill and Talent	Understanding and implementing new technologies necessitates a unique set of abilities to capitalise on value from modern technologies	(Greane, 2021; Cunningham, 2018)	Digital Skills Development	Workforce Enablement and Performance	Digital Application and Impact
8	Legacy Systems	The complexity and integration cause difficulty in upgrading only part of the system. Complete upgrades of such systems pose risks and are costly.	(Young & Rogers, 2019; Greane, 2021; Cunningham, 2018)	IT/IS Performance	IT/IS Excellence	
9	Network Delays	Network delays effects real-time data and analytical requirements	(Equinix, 2021)	Technological Readiness/ Capability		
10	Network Capacity Constraints	Big data generated by mining operations cause network capacity constraints	(Equinix, 2021)			
11	High Temperatures	Internal fans must constantly cool computers to avoid overheating	(Marwala, 2020)			
12	Humidity	Prompts rust to form on metals; also affects the performance of computers	(Marwala, 2020)			
13	Uneven Surfaces	Robots designed for factory floors perform poorly in mining environments	(Marwala, 2020)			
14	Unsuitable Sensors	Sensors that are required to power robots are not primarily built for use in subsurface environments	(Marwala, 2020)			
15	Cybersecurity Threats	Data shared from the hundreds of mining applications among stakeholders increases cybersecurity threats	(Young & Rogers, 2019; Greane, 2021)	IT Security		

2.7 Conclusion of Literature Review

Because technology and digitalisation are significant enablers of the fourth industrial revolution, understanding the concepts associated with digitalisation is critical to this research study. The status of an organisation's digital transformation journey realised through digital maturity is depicted by current transformational achievements such as operational optimisation efforts and capability development related to change processes within an organisation.

Digital maturity models have been critiqued for oversimplifying reality and missing empirical evidence. A well-defined digital maturity model must consider the collective criteria that global consulting organisations, business literature, and academic theories address. The unified model of digital maturity proposes arguably the most integrated and empirical digital maturity model to date.

Working towards digital maturation demands the collaboration of several critical organisational elements. Understanding an organisation's dynamics and performance is significant in planning and directing effective large-scale digital transformation. Subsequently, there are common perspectives that variables including environment, social, culture, strategy, skills, values, and structure must be considered when analysing technology acceptance and adoption, aiming to achieve digital maturity within an organisation. The Unified Theory of Acceptance and Use of Technology model presents a well-defined, integrated perspective of the factors influencing behavioural intention, acceptance, and adoption of digital technology.

Key challenges and impediments to digital adoption and digital transformation, such as mine site conditions, legacy systems, lack of connectivity, complacent culture, cyber risks, lack of capabilities, environmental demands, social licence to operate, government and regulatory policies, trade union mandates, competition, and commodity supply and demand amongst others, contribute towards the depleted realised value of digital investment and adoption in the South African mining industry. However, in a recent study on the state of digital transformation, it is highlighted that digital technologies implemented in a people-centred manner can create new, higher-paying, safer, healthier, and more fulfilling jobs.

The challenges facing the South African mining industry centre on the need to shift away from the extractive development model that currently dominates the industry and toward a new approach that recognises that business value can be realised in a variety of ways. It is thus vital to investigate the inhibitors to digital transformation in the South African mining industry by gaining a better understanding of the context of the transformational journey, applying a unified and integrated model of digital maturity, and identifying critical areas for improvement.

2.7.1 *Proposition 1*

While organisations and individuals realise the value and need to modernise the South African mining industry, there is a rising gap between the level of digital maturity that could have been achieved and that which most organisations within the South African mining industry have achieved. In exploring this proposition, the research study will:

I. Identify the perceived benchmark of what constitutes a high level of digital maturity in the South African mining industry, as per RO1, and

2.7.2 *Proposition 2*

The unified model of digital maturity considers the needs of researchers and practitioners, as well as organisations and academics, and provides the most coherent and empirical digital maturity model to date. The research study will thus adopt the unified model of digital maturity in order to:

II. Assess the current perceived status quo of the South African mining industry, and assess the gap compared to the established benchmark, as per RO2.

2.7.3 *Proposition 3*

The South African mining industry's risk appetite, culture, digital ethics, legislation and compliance, skill development, employee empowerment, infrastructure, IT readiness, system performance, and security have been highlighted as potential barriers to digital transformation. This research study will investigate this proposition by:

III. Exploring the key areas for improvement, focusing on the candidate inhibitors of digital transformation in the South African mining industry, as per RO3.

CHAPTER 3. RESEARCH METHODOLOGY

In pursuit of the research objectives portrayed in section 1.4, this research study aims to understand the slow impact of technological disruption on an industry with significant drivers for digital transformation. Chapter 3 exposes the research framework used for exploring the inhibitors to digital transformation within the South African mining industry. This strategy is predicated on effecting a worldview about the research study and a specific research approach, design, and methodology. The research instrument, data collection, and sampling techniques of the study are all impacted by the selection of the research methodology. To ensure reliability and dependability, it is critical to identify the research study's limitations and those features of the research design and methodology that influence the interpretation of the study results and outcomes.

3.1 Research approach

The nature of the research topic and objectives leans towards an exploratory investigation of theories and concepts that inhibit digital transformation within the South African mining industry. To this end, a qualitative research methodology is employed that, according to Schindler (2019), includes an "array of interpretive techniques which seek to describe, decode, translate, and otherwise come to terms with the meaning, not frequency, of certain more or less naturally occurring phenomena in the social world”. Creswell & Creswell (2018) add that this type of inquiry promotes an inductive approach to the research, with an emphasis on individual meaning and reporting of complexities of the research problem.

Rahman (2017) highlights the benefits of a qualitative research approach such that it has the ability to comprehend diverse individuals' thoughts, opinions, and experiences, as well as evaluate the significance of their decisions and actions in the real world, providing a holistic understanding of the human experience within the context and environment of concern. In exploring the critical impediments of digital transformation in an industry that is considered a laggard in its digital maturity, qualitative research will allow for the study of a myriad of views and inner experiences to extricate valuable information. The framework of a qualitative research approach is flexible since it can be built and reconstructed to a large extent providing a suitable and detailed evaluation of the research problem. This offers the opportunity to do an in-depth analysis of the complexities of the research problem, ensuring an interpretive and appropriate outcome.

An essential and often hidden attribute to the research approach is the philosophical worldview or paradigm, which refers to the basic set of beliefs that guide the research methodology (Creswell & Creswell, 2018). The philosophical worldview of interpretivism aims at understanding the many ways of viewing and experiencing the world through various contexts and cultures. Interpretivists not only describe objects, people, or events, but also analyse them in social contexts, due to the diverse perspectives on phenomena (Pham, 2018). Given the requirements from both researchers and practitioners for a unified, theoretically sound, and empirically validated perspective on digital transformation and digital maturity, the interpretivist worldview is ideal for exploring the inhibitors to digital transformation in the South African mining industry. The research study relies on an interpretative knowledge of the human experience.

3.2 Research design

The research objectives of this study favour a phenomenological inquiry, via a qualitative research design, focused on gathering data from individuals' knowledge, interactions, and environments to offer a contextual view of the barriers of digital transformation in the South African mining industry, and exposes the participants' experiences, the meaning assigned to those experiences, and the experienced processes (Worthington, 2013). As portrayed by Van Manen (1997), conducting a phenomenological investigation entails examining "the way a person experiences or understands his or her world as real or meaningful." The foundation of a phenomenological research inquiry is to determine whether a shared experience has an essence or essences as a result of a common occurrence or phenomenon. Different individuals' experiences are grouped, examined, and compared to the identification of the common phenomenon. This research design is based on philosophically solid principles (Creswell & Creswell, 2018) and will rely on conducting interviews as the primary data collection methodology. In applying this form of research design, it is essential to understand the advantages and disadvantages of the research being conducted, as portrayed in Table 3.

Table 3: The advantages and disadvantages associated with a phenomenological research design (Easterby-Smith et al., 2008)

Advantages	Disadvantages
Ability to evaluate change processes over a series of time	Data collection might take a long time and may require a lot of resources

Advantages	Disadvantages
It supports the understanding of the meanings of individuals	Data processing and interpretation can be challenging
As new issues and ideas arise, it aids in the adjustment process	Controlling pace, progress, and end goals may be more difficult than using comparative design approaches
Makes a contribution to the creation of new theories	A phenomenological investigation may be viewed with scepticism by policymakers
Collects data that appears to be natural compared to artificial	

3.3 Data collection methods

Qualitative research is a type of inquiry that aims to express and clarify human experience as it manifests in people's lives. Data, in qualitative research, is primarily obtained through the use of spoken or written words, through interviews, documents, observations, and artefacts, rather than numbers (Polkinghorne, 2005). According to Silverman (2005), interviews and other qualitative data collection methods are thought to provide a "deeper" understanding of social matters compared to quantitative inquiries like questionnaires. Interviews are fitting where little is known about the research topic, or detailed insights from individual participants are required. A research interview ultimately aims to understand individuals' perspectives, experiences, sentiments, and motives on the research topic.

The research methodology in this study uses semi-structured interviews that feature a series of questions that help define interest areas and allow the researcher or participants to deviate from exploring an idea or response further.

This interview approach provides participants with some direction on areas of the study as well as a level of organisation. Gill et al. (2008) explains that the agility of this technique allows for the finding or development of knowledge that is valuable to participants that the researcher may not have considered. Therefore, purposive and iterative strategies are employed to select interview participants (Polkinghorne, 2005), which will be discussed further on.

3.4 Population and sample

3.4.1 *Population*

The research study population focuses on the South African mining industry, which includes various stakeholders, as shown in Figure 10, focusing on the industry's economics, environmental and social impacts, or governance, risk, and compliance effects.

The mining industry is an essential part of the South African economy and has contributed approximately 9% towards the country's Gross Domestic Product in 2020 and has employed around 451 427 citizens in the same year (Minerals Council South Africa, 2021), resulting in the fulfilment of over 1.3 million direct and indirect jobs (Holman, 2019).

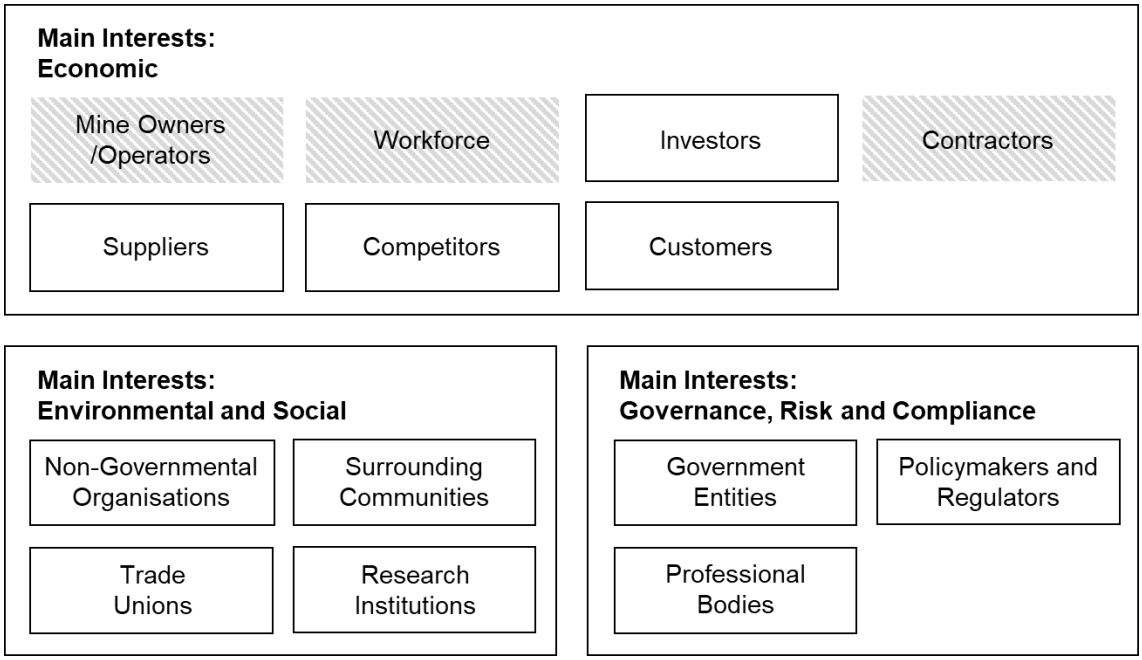

Figure 10: Stakeholders of the South African mining industry (Centre for Energy, Petroleum and Mineral Law and Policy, 2021)

3.4.2 *Sample and sampling method*

While there are many stakeholders involved in the South African mining industry, the sampling frame of this research study focuses on three key stakeholder groups: mine owners/operators, the mining workforce, and mining contractors, all of whom have a critical influence and impact on the digital maturity and transformation of the respective organisations or within the South African mining industry at large.

The research study's unit of analysis encompasses the South African mining industry in its entirety. Participants from the stakeholder groups of mine owners/operators and the mining workforce share perspectives from their respective organisations. In contrast, participants from the stakeholder groups of mining contractors have a broader picture of the South African mining industry.

This provides a comprehensive view of the South African mining industry from a diversity of perspectives.

Purposive sampling, specifically judgmental sampling, is employed for this research inquiry. Purposive sampling refers to a series of non-probability sampling methodologies or strategies that lean towards the researcher's discretion in selecting the individuals to participate in a study (Sharma, 2017). Judgmental sampling is particularly beneficial in this regard since the researcher's expertise is required to select a more representative sample due to the small number of individuals available within the research population that possess the attributes that the research is concerned with, which can lead to more accurate results (Alchemer, 2018). The researcher is able to apply appropriate discretion and expertise through his comprehensive understanding of the mining landscape and stakeholders within it, with significant exposure to mining and exploration operations, both locally and internationally. In exploring the inhibitors of digital transformation within the South African mining industry, selected stakeholder groups within the research population and specific individuals within these stakeholder groups possess the required experience and exposure to provide necessary insights and information in pursuit of the research objectives.

Table 4 provides the summary profile data of the research sample, revealing the representation of each key stakeholder group. The participants equally represent the 'mining workforce' and 'mining contractor' stakeholder groups, with a relatively modest representation of the 'mine owner/operator' stakeholder group. The participants are from diverse levels within the mining industry, ranging from

top to middle management, or have professional IT and digital roles. A further breakdown of the abstraction level of the research participants is presented, providing insight into their strategic, tactical, or operational functions.

Table 4: Summary profile data of the research sample

Stakeholder Group	Participant		Abstraction Level	Participant	
	Count	%		Count	%
Contractor	6	40%	Strategic	3	20%
			Tactical	2	13%
			Operational	1	7%
Mine Owner	3	20%	Strategic	0	0%
			Tactical	3	20%
			Operational	0	0%
Workforce	6	40%	Strategic	0	0%
			Tactical	2	13%
			Operational	4	27%

3.5 The research instrument

An interview guide was commissioned to conduct the semi-structured interviews for this research study. The interview guide document establishes a standardised framework for conducting semi-structured interviews, ensuring that all participants have the same experience making it easier to evaluate all participants in the same manner, and eliminating the possibility of bias during the interview process (Verlinden, 2021).

Figure 11 portrays the phased approach used to create the interview guide for this research study. Phases 1 and 2 involve understanding the research topic and

objectives and evaluating the suitability of the selected data collection method. Phases 3, 4, and 5 involves formulating the interview guide in a structured and cohesive manner with subsequent reviews and reformulation where required.

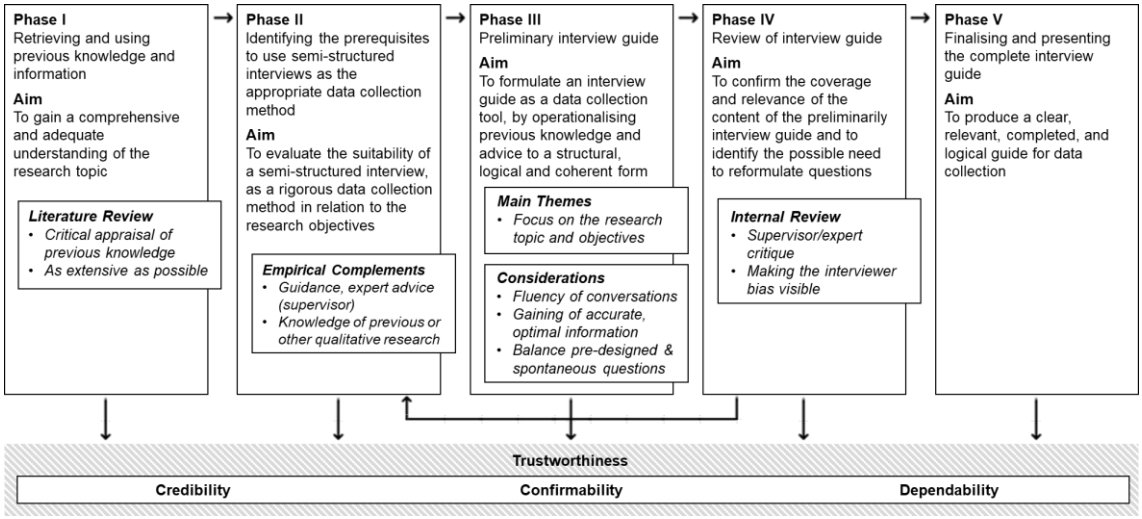

Figure 11: The framework used for the development of a qualitative semi-structured interview guide (adapted from Kallio et al., 2016)

The interview guide, featured in APPENDIX D: INTERVIEW GUIDE, consists of six sections that govern and guide the interview process, as summarised in Figure 12. The focus of the interview guide concerns the *primary enquiries* and *guiding topics* sections that is centred around the Unified Model of Digital Maturity by Armstrong & Lee (2021) and the Unified Theory of Acceptance and Use of Technology by Venkatesh et al. (2003) that both serve as "theoretically sound, methodologically rigorous, and empirically validated" (Lasrado et al., 2015) frameworks to undertake this research inquiry.

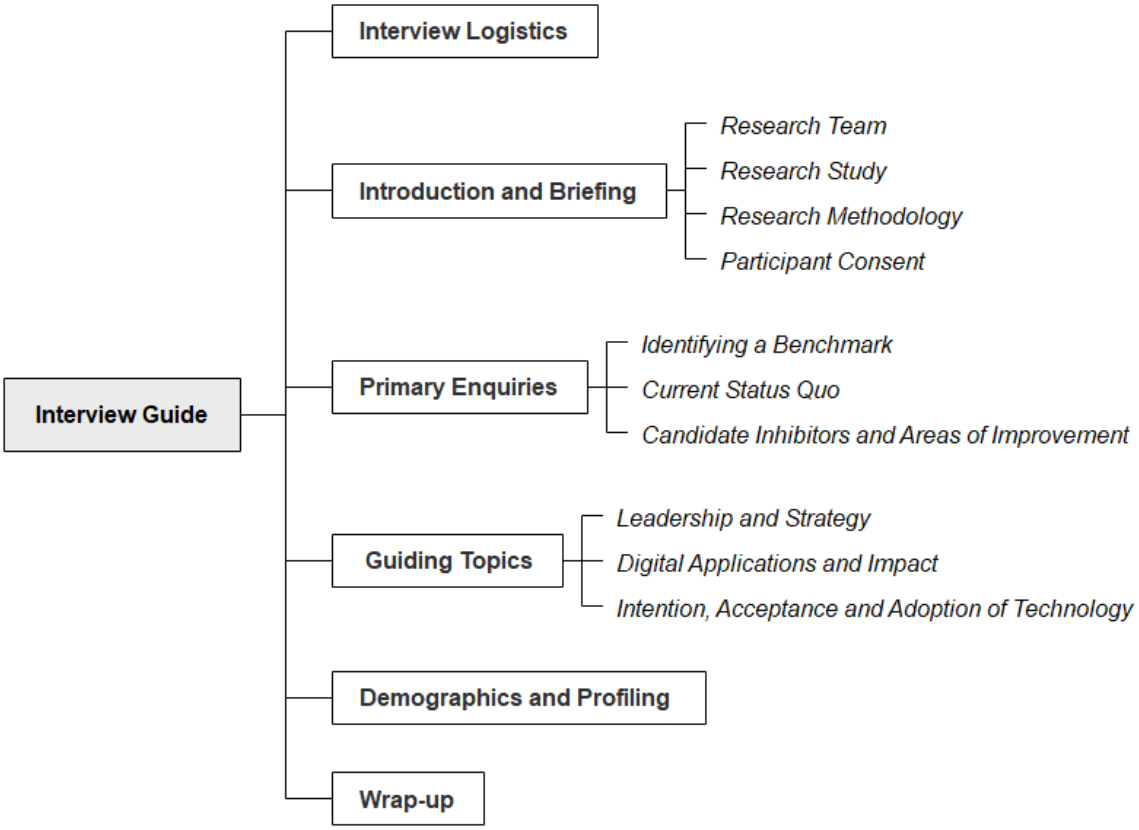

Figure 12: A summary of the research interview guide
(APPENDIX D: INTERVIEW GUIDE)

The design of the *primary enquiries* and *guiding topics* aims to address the research objectives of (I) contextualising digital transformation within the South African mining industry by identifying the perceived benchmark of what constitutes a high level of digital maturity, (II) adopting a relevant digital maturity model in order to assess the current perceived status quo of the South African mining industry, and assess the gap compared to the established benchmark, and (III) exploring the key areas for improvement, focusing on the inhibitors of digital transformation in the South African mining industry.

3.6 Procedure for data collection

Semi-structured one-on-one interviews, using a pre-defined interview guide, was used for data collection due to their flexibility in allowing in-depth analysis with a relatively small sample size, focusing the research on the participants' perspectives. A total of 15 participants were interviewed based on their skills, experience, knowledge, and exposure to digital transformation within the South African mining industry. The selected participants represent various stakeholders within the mining industry within the top to middle management levels and have specialist IT and digital roles that are exposed to project exploration, evaluation, execution, and realised benefits in the South African mining industry. These participants fulfil various roles on a strategic, tactical, or operational level.

3.7 Data analysis and interpretation

3.7.1 *Data Analysis*

Upon eliciting data from the various interviews, Figure 13 portrays the data analysis procedure used in this qualitative research study. The initial step of this process brings to light the concept of "winnowing", wherein only relevant information was prepared and analysed, disregarding unnecessary and non-applicable data. Creswell & Creswell (2018) highlight the impact of "winnowing" as aggregating information into a small number of focused themes instead of preserving the entire depth of extracted data.

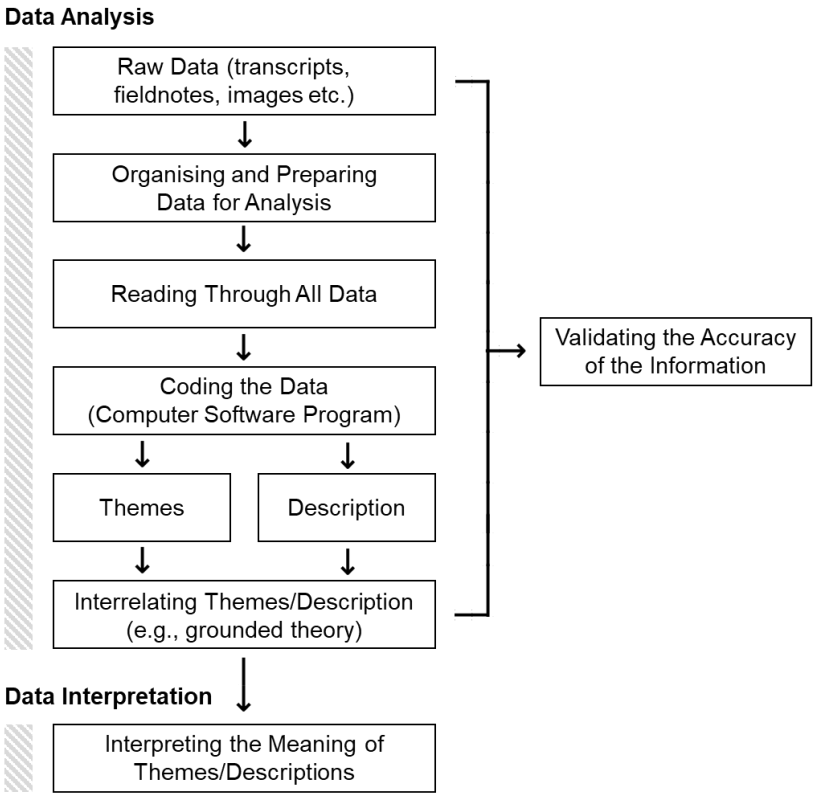

Figure 13: Data analysis procedure for the research study (adapted from Creswell & Creswell, 2018)

Furthermore, this research study used an appropriate computer software program, Atlas.ti, to analyse the data obtained during the research interviews. While many researchers prefer using traditional, manual methods for preparing and analysing qualitative data, the use of computer software programs provides a reliable data analysis methodology, with features that include annotation coding and query, data visualisation linking, media analytics for mapping/networking, multi-language processing, qualitative comparative and content analyses, sentiment analysis, and statistical and text analysis if required (Predictive Analytics Today, 2021). Alhojailan (2012) explains that computer software programs are more efficient at organising and categorising collected data into themes, concepts, and ideas, providing more detail in the data analysis. More

notably, the computer software program increases the rigour of the analytical processes, removing impressions and influences of the participant onto the researcher.

3.7.2 *Data Interpretation*

In qualitative research, interpretation entails several steps, including aggregating the general findings, comparing the findings to the literature, and discussing a personal perspective on the findings (Creswell & Creswell, 2018). Because qualitative research is so complex, varied, and nuanced, it is necessary to deduce themes and patterns in order to develop meanings and interpretations about the research topic. Thematic analysis is one of a group of qualitative data analysis approaches that focuses on discovering themes and patterns of meaning in the data gathered (The University of Auckland, 2021), and as such, will be used in this research study.

A thematic analysis enables the research themes' recurrence in data analysis to be linked to the entire context of the research inquiry. This type of analysis connects the numerous impressions and opinions of the participants and compares them to the data that was obtained in the literature review. This will improve the research's overall meaning by adding empirical validation, accuracy, and value (Alhojailan, 2012).

3.8 Limitations of the study

The research study has the following limitations:

I. The lack of prior research and subsequent literature in the context and environment of this research inquiry,
II. Introduction of a representation bias due to sample size and focused sampling,
III. Inability to verify participant's information and views objectively against the research scenarios and objectives in a qualitative inquiry,
IV. Difficult to investigate causality since a qualitative inquiry is based upon participant experience, exposure, opinion, and judgment and is somewhat difficult to replicate,
V. Purposive or judgemental sampling is susceptible to selection bias and error due to a lack of random sampling,
VI. The flexibility of thematic analysis can lead to inconsistencies and a lack of cohesion when deriving themes based on the collected data,
VII. Cultural and linguistic researcher bias has the potential to influence methodological selection and interpretation of the data.

3.9 Transferability and dependability

A qualitative research study is dependent on the *trustworthiness* of the data elicited during the semi-structured interviews (Devault, 2019). The purpose of evaluating data trustworthiness is to support findings that are fact-like in a qualitative inquiry. Elo et al. (2014) explains how the trustworthiness of information is highly dependent on the availability of complete, suitable, and well-saturated information. Furthermore, increasing the trustworthiness of information includes sophisticated methodologies in data collection, content scrutiny, trustworthiness debates, and interpretation of the results. Arguably, the most

prevalent framework for evaluating qualitative information was developed by Lincoln & Guba (1986), who proposed four main components of data trustworthiness: transferability, credibility, dependability, and confirmability.

3.9.1 *Transferability*

Trochim (2021) recommends that a research study can improve transferability, to different contexts or settings, by thoroughly articulating the research context, key assumptions, data collection processes, and experiences that guide the study through thick descriptions. Lincoln & Guba (1986) assert that thick descriptive data allows readers to apply all or part of this research findings to another context and make judgments about the degree of fit or similarity.

This research study is focused on the context of the greater mining industry within South Africa. The research study aims to investigate the challenges and difficulties involved in developing, implementing, and maintaining digital transformation programs in the South African mining industry, as well as to provide insights on how to speed up the transformative process, which can be generalised to any organisation within the South African mining industry. Furthermore, the frameworks, theories, and models used will allow the collected data and resultant insights to be applied to the global mining industry. The data collection methodology and experience is documented in detail to contribute to a better and more comprehensive understanding of the research context, effecting increased transferability.

3.9.2 *Credibility*

According to Devault (2019), triangulation and member checks assist in the establishment of credibility and contribute to the trustworthiness of the research study. Extended engagements with and observations of research participants are essential in increasing the study's credibility.

This research study employs triangulation by combining different methodologies, data sources, participants, frameworks, and theories to fully understand the research topic. The interviews in this research study ask the same research questions to the range of participants, although employing a variation in the methodology where necessary to derive answers and descriptors to the same research questions. The information received from the interviews was compared and evaluated for consistency. Additional credibility is supported by selecting participants based on their skills, experience, knowledge, and exposure to digital transformation in the South African mining industry.

3.9.3 *Dependability*

Dependability, closely linked to reliability, is critical to trustworthiness since it demonstrates that the research study's conclusions are consistent and reproducible (Devault, 2019). Impartially, the concept of dependability highlights the need for the research study to account for the ever-evolving context in which the research phenomenon takes place (Trochim, 2021).

In this research study, the interview results, sanitised of personal identifiable information and any other raw information pertaining to this research, is presented. This allows for an inquiry audit to be conducted to evaluate the data

collection, data analysis, and research finding methodologies. Furthermore, this research study is supervised, ensuring a degree of review and inspection throughout the research process, further validating the study's dependability.

3.10 Demographic profile of respondents

The participants in this study were selected based on their abilities, experience, knowledge, and exposure to digital transformation in the South African mining industry. The selected participants represent diverse mining industry stakeholders. Furthermore, participants are positioned between the top to middle management levels or within expert IT, and digital roles exposed to project exploration, appraisal, execution and realised benefits of digital transformation.

Further demographic factors and information, including gender, age, and location that have been collected, would not influence the outcome and interpretation of this research study. The demographic analysis of the research sample is presented in section 4.2.

3.11 Ethical considerations

Smith & Quelch (1992) discloses the concept of *human intervention* in research, referring to various activities that provide a researcher with access to information that is unavailable to the public. Of these activities, interviews are most noteworthy in the context of this research study. The likelihood that engagement with participants may inadvertently harm them in an unintended way is significantly increased during human intervention (Business Research Methodology, 2021). To this end, ethical considerations are key in avoiding unjust

implications of the research study towards the selected participants, including the right to privacy, the right to safety, the right to choose, the right to be informed, and the right to respect (Smith & Quelch, 1992).

The research study had the following ethical considerations:

I. Participation was entirely voluntary in this research study, with no coercion or deception imparted to the participant,
II. The participant's confidentiality and anonymity were preserved during the duration of this research study,
III. The protection of personal information and other privacy elements were ensured throughout this research study,
IV. The respect and dignity of participants were prioritised throughout this research study,
V. Participants were not exposed to any harm, including physical harm, psychological harm, emotional harm, or social harm (i.e., embarrassment),
VI. The analysis, interpretation, and results of this research study did not misrepresent someone else's work as the researcher's (plagiarism), fabricate information or results (academic fraud), or misreport data for the researcher's advantage (misrepresenting results).
VII. The research exposes any conflicts of interest between the research team (including the researcher, the facilitating institute, relevant affiliations, the research sponsor, and the research supervisor) and the participants,
VIII. Participants were informed of the context, purpose, and process of the research study through a participant information sheet (APPENDIX A: PARTICIPANT INFORMATION SHEET),

IX. Participants were informed of their rights, and the research inquiry had sought consent to conduct the interview (APPENDIX B: CONSENT TO PARTICIPATE),

X. Participants were informed of their rights, and the research inquiry had sought consent to audio/video recording of the interview (APPENDIX C: CONSENT TO AUDIO/VIDEO RECORD),

XI. All communication related to this research study was done in an honest and transparent manner,

XII. All participants were given an alias where an individual participant's perspective was mentioned within the research report.

CHAPTER 4. PRESENTATION OF FINDINGS

4.1 Introduction

A total of 15 participants were interviewed based on their skills, experience, knowledge, and exposure to digital transformation within the South African mining industry. The interviews were conducted between 4 November 2021 and 24 November 2021 and proceeded for an average duration of 1 hour and 10 minutes per interview. The interviews were recorded using Microsoft Teams and transcribed using Microsoft Stream. The findings were extracted from the interview transcripts, demonstrating emerging themes, and expressed views by the respective participants pertaining to the research study. This thematic approach allows the research to connect the recurrence of study themes in the data analysis to the overall context of the research inquiry.

In order to explore the research inquiry, the interviews were guided by the three research objectives:

RO1. To contextualise digital transformation within the South African mining industry by identifying the perceived benchmark of what constitutes a high level of digital maturity,

RO2. To adopt a relevant digital maturity model in order to assess the current perceived status quo of the South African mining industry, and assess the gap compared to the established benchmark, and

RO3. To further explore the key areas for improvement, focusing on the inhibitors of digital transformation in the South African mining industry.

4.2 Presentation of demographic data

Demographic data was collected during the interview process and summarised in Table 5, providing context on the research participants and validating stakeholder representation. In order to uphold confidentiality, the identities of the participants were redacted and coded with PTP001, PTP002, and so on.

The average tenure of the research participants is 15 years which indicates strong business acumen and experience. The participants provide an equal representation of the mining workforce and mining contractor stakeholder groups, with a marginal representation of the mine owner/operator stakeholder group, as observed in Figure 14. It is observed in Figure 15 that participants work within executive (3), senior management (7) or middle management (5) levels and operate within specialist IT and digital roles that are exposed to project exploration, evaluation, execution, and transformational business processes within the South African mining industry.

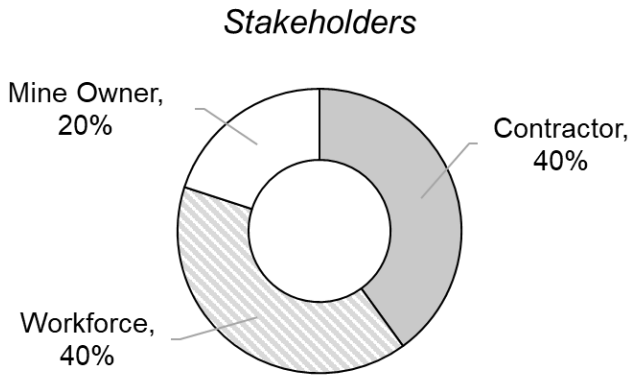

Figure 14: Stakeholder representation of participants

Table 5: Summary demographic data of the research participants

Participant	Stakeholder	Gender	Race	Age Range	Job Level	Tenure
PTP001	Contractor	Male	Asian	40-49	Executive	26
PTP002	Contractor	Female	Black	30-39	Executive	10
PTP003	Workforce	Female	White	30-39	Senior Management	15
PTP004	Workforce	Male	Asian	30-39	Middle Management	15
PTP005	Contractor	Female	White	40-49	Senior Management	20
PTP006	Workforce	Male	Black	30-39	Middle Management	7
PTP007	Contractor	Male	White	40-49	Executive	20
PTP008	Mine Owner	Male	Black	40-49	Senior Management	15
PTP009	Mine Owner	Female	Asian	30-39	Senior Management	15
PTP010	Workforce	Male	Black	30-39	Middle Management	10
PTP011	Contractor	Female	White	40-49	Middle Management	20
PTP012	Contractor	Male	Black	30-39	Senior Management	17
PTP013	Mine Owner	Female	Asian	30-39	Senior Management	12
PTP014	Workforce	Female	Black	30-39	Middle Management	9
PTP015	Workforce	Female	Black	30-39	Senior Management	15

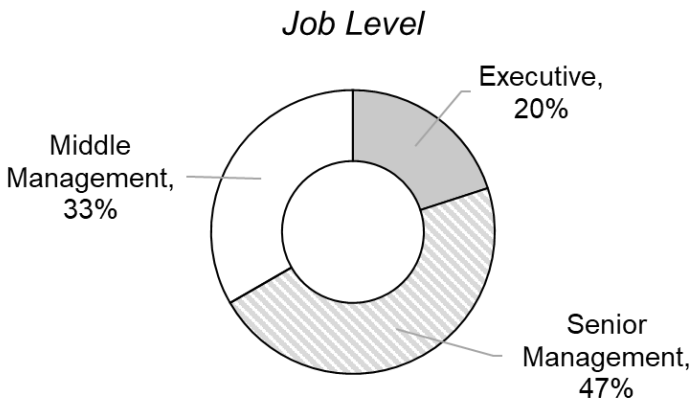

Figure 15: Job level representation of participants

The demographic data reveals a relatively equal representation of males and females within the research participant group. Participants are spread between race categories of Black (47%), White (27%) and Asian (27%). Participants fall predominantly within two age groups: 30-39 years (67%) and 40-49 years (33%). Furthermore, participants are disproportionately located within 4 of the 9 official provinces of South Africa. The participants' location information has not been reported in order to maintain the desensitisation of the data contained in Table 5.

4.3 Thematic analysis of data

4.3.1 *Generation of codes*

The initial data analysis phase entailed generating a series of primary codes guided by the research questions. An open coding methodology was used that involved segmenting the transcribed data and assigning codes (or labels) to each segment without the use of predefined codes. Table 6 showcases a total of 227 primary codes that were generated and grouped by research objective ahead of categorising the codes and deriving applicable themes.

Table 6: Primary codes generated and grouped by research objective

Understanding Digital Tranformation
Safe working environment
Operational efficiencies/optimisation
Digitisation and automation
Data management/recording/accuracy
Improved decision making
Cut/reduced costs
Risk management
Increased revenue
Change management
Changing the mining landscape/legacy ways
Regulatory compliance/assurance
Governance, transparency, sustainability
Customer engagement
Shared value/information
Business transformation/Innovation
Communication and engagement
Competitive advantage

Risks to Digital Trasnformation
Nomenclature/Language
Physical Security/Business Continuity

Status Quo of Digital Transformation
Experimental/trial-and-error phase
Little value created, no major shifts and/or changes
Lots of investment, little return
Linear value creation through digital adoption, not exponential
Cost reduction being a major driver for digital transformation
Significant movement in operational transparency
Improvement in operational efficiency and production
Laggard, relatively immature to other industries, infancy
Identified requirements, but little progress to close the gaps
Stronger leadership required around digital
Digital transformaiton is incredibly slow paced, no urgency
Impact no realised, since the core focus in getting ore out of the ground
Hesitation caused by impact to the workforce
Great affinity to transform digitally due to external pressure
Complancent culture, reluctant/resistent to change ways, ageing workforce
Covid-19 excellerated digital process transformation, and digitisation
Low level and younger employees not consulted or involved in the process
Focus on the "pretty picture" instead of reliasing the true value
Many employees are underqualified/low skilled, basic matric
Greater expectations from the new generation of workforce
Mismatch btewwen the digital teams and the general workforce
Immature capability, immature culture
Value in instances still only seen in revenue increase
Majors and juniors are significantly different in their maturity
Progress on strategy and digitisation, but not overall implementation
Ability/budget to transform is imapcted by the depleting resources
Labour laws and trade unions protecting job security
Vendors, suppliers, contractors also impact the slow transformation
Majors are backed by international support and can invest aggresively
Return on onvestment not thoroughly realised
South African mining is playing ctach-up to other geographies
No urgency to transform, mining/business is not threathened by old methods

Inhibitors to Digital Transformation
Application in Mine Environments
Awareness
Collaboration
Communication
Competitive Advantage
Core Process Digitisation
Culture/Adoption/Change Management
Cybersecurity Threats
Data Management
Economic Impact
Ecosystem Engagement
Footprint
Government/Regulation
Innovation/R&D
IT Infrastucture/Network/Connectivity
Legacy Systems
People/Human Error
People/Jobs Loss
People/Skills/Application
Risk Aversion
Social Licence to Operate
Theft
Unions/Labour Laws
Vision/Strategy/Leadership

Factors of Digital Transformation
Unified vision/understanding/definition/strategy/intention
Digital readiness
Change management
People, inclusivity, culture, values
Skills, education, capability, and confidence
Data
Organisational process and methodologies
Ecosystem view, alignment, engagement
Control and governance
Investment and funds
Measuring success, results
Leadership
New revenue streams, competitiveness
Client solutions/needs/experience, customer engagement
Innovation
Security, business continuity, cyber security
Operational safety
Partnerships, co-creation
Governance, project management
Research and Development
IT infrastructure, systems and applications
Operating model
Core Process Digitisation
Digital Ethics
Governance/Organisation
New Value/Business Models
Sustainability
Workforce Enablement

High level of Digital Maturity
Culture shift amongst all stakeholders; agile mindset
Change business and operational processes
Knowlegdable consumer and operator
Reduced people dependency, fully digitised organisation
New solutions to market
Innovative people and business environment
No connectivity/infrastructure constraints
Removal of manual and repetitive tasks, automated environment
Availability of a digital strategy
Transparency throughout organisational layers
Clear and fluent data flow from operations to boardroom
Real-time decision making by leadership
Accurate and high quality data
Real-time safety and monitoring mechanisms and devices
Remotely operated operational mining solutions
GPS monitoring and trcking of people and equipment
High level of machine-to-machine communication
Creating shared value between all stakeholders
Doing business sustainably with ESG in mind
Infrastucture to support business and operations
Full network and communication covergae
Appropriate data architecture
Cloud hosted storage and work environment
High level of security and access control

Gaps to achieving Digital Maturity
Awareness and education of emplyess and unions
Priority of budgets, lack of available funds
Older generation, complacent mindsets, not willing to change
Lack of experimentation, current methods work well
Cost vs. benefit or value
Culture, maturity of the workforce, inability to "bend" the rules
Location of mine sites, and the mining environment
Government regulatory compliance
Capacity and capability to mature digitally
Customers are few, and customer requirement/needs are low
Availability of suitable operational technology
Lack of focus on basic digitisation
Not understanding the different types of value
Lack of information sharing, and transparency
Lack of collaboration and shared value, "value beyond compliance"
The approach of "reinventing the wheel"
Infrastructure (network) and instrumentation
Lack of network (and other) service provision
Job security, fear, and unemployment

Improvement Suggestions
Awareness/Education
Communication
Culture/Diversity
Financial Incentive/Tax Break
Government/Regulation/Compliance
Integration
Operational Technology/Safety
People/Skills/Jobs/Fears
Shared Value

Key
RO1
RO2
RO3

4.4 Theory pertaining the Propositions 1, 2 and 3

In exploring Propositions 1, 2 and 3, the research instrument collected participants' understanding of digital transformation, the elements that lead to digital transformation, factors that constitute a high level of maturity, the current perceived status quo of digital transformation, as well as the gaps and inhibitors that exist in exploring key areas of improvement in digital maturity in the South African mining industry. The research instrument adopted the unified model of digital maturity, being current, non-selective, operationalisable, universally applicable, and considerate of the requirements of researchers and practitioners, organisations and academia, proposing arguably the most cohesive and empirical digital maturity model to date. Based on Westerman et al. (2012)'s digital mastery framework, the unified model of digital maturity provides two dimensions: leadership and strategy, and digital application and impact. The model outlines 12 key factors, including both empirical and theoretical influences, as well as the key organisational areas of strategy, governance and leadership, people and culture, organizational processes, products and services, and digital technology as ascribed by Williams et al. (2019).

4.5 Findings pertaining to Proposition 1

4.5.1 *Identification of themes for Proposition 1*

The open coding process identified 113 primary codes pertaining to Proposition 1, which included numerous similarities and duplications between the 3 inquiries within the research instrument related to RO1. The thematic analysis advanced

by grouping similar codes and eliminating duplicate codes prior to organising the primary codes into 41 categories, as represented in Table 7. Subsequently, emerging themes were observed between the primary codes and derived categories. The emerging themes presented in Table 7 aligns with the unified model of digital maturity (i.e., the adopted digital maturity reference model) and were reviewed in line with RO1.

Table 7: Codes, categories, and emerging themes for Proposition 1

Coding		
Factors of Digital Transformation	**Understanding Digital Tranformation**	**High level of Digital Maturity**
Unified vision/understanding/definition/strategy /intention		Availability of a digital strategy
Leadership; Research and Development		Real-time decision making by leadership; Knowlegdable consumer and operator
Governance, project management; Control and governance; Governance/Organisation; Data; Change management; Organisational process and methodologies; Ecosystem view, alignment, engagement; Partnerships, co-creation; Sustainability	Governance, transparency, sustainability; Regulatory compliance/assurance; Improved decision making; Data management/recording/accuracy; Change management; Changing the mining landscape/legacy ways; Operational efficiencies/optimisation	Transparency (organisational layers); Clear and fluent data flow; Accurate and high quality data; Appropriate data architecture; Culture shift amongst all stakeholders; agile mindset; Change business and operational processes; Sustainability with ESG
New revenue streams, competitiveness; New Value/Business Models; Operating model	Increased revenue; Competitive advantage	New solutions to market
Investment and funds; Innovation	Business transformation/Innovation	Innovative people and business environment
Digital Ethics		
Client solutions/needs/experience, customer engagement	Customer engagement	
Operational safety	Safe working environment	Real-time safety and monitoring mechanisms and devices; Remotely operated operational mining solutions; GPS monitoring and tracking of people and equipment; High level of machine-to-machine communication
Workforce Enablement	Communication and engagement; Shared value/information	Creating shared value between all stakeholders
Core Process Digitisation	Digitisation and automation	Removal of manual and repetitive tasks, automated environment; Reduced people dependency, fully digitised organisation
IT infrastructure, systems and applications; Digital readiness; Security, business continuity, cyber security	Risk management	Cloud hosted storage and work environment; Infrastucture to support business and operations; Full network and communication covergae; No connectivity/infrastructure constraints; High level of security and access control
Measuring success, results	Cut/reduced costs	

Categories
Framing the Strategy
Board to floor
Driven by leadership
Alignement to business strategy
All-inclusive process
Culture/Agile
Risk
Fail fast/Experimentation
Collaboration
Diversity
Digital governance
Ecosystem
Change management
Data
Data Asset
Value Prop
Funding
Innovation (Strategic, Open, Lean)
Ethics
Transparency
Customer needs
Analytics
Dashboards
User Experience
Culture
Safety
Sharing
Environment
KPI
Skill/Educate
Decision-making
Automation/Processes
Infrastructure/Network
Access
Excellence
Security
Measure
Value

Themes
Vision and Strategy
Culture and Engagement
Governance and Organisation
New Value Streams and Business Models
Investment and Innovation
Digital Ethics
Customer Orientation and Engagement
Digital Product Innovation
Workforce Enablement and Performance
Core Process Digitalisation
IT/IS Excellence
Results

4.5.2 *Participant views for Proposition 1*

The following section focuses on the factors and perspectives indicated by participants as constituents of a high level of digital maturity in the South African mining industry to determine an appropriate benchmark for exploring the larger research inquiry.

4.4.3.1 Vision and strategy

13 of the 15 participants stated that formulating an appropriate digital strategy is one of the primary factors inherent within digitally mature organisations. This includes a clear understanding of why mining organisations need to transform digitally as well as a strong vision and plan for how digital transformation can deliver new or increased value.

“I think in the first instance it's a strategy and being intentional about it. The organisation needs to understand what their strategy is and how they are going to go about achieving it.” – PTP013

A few participants emphasised the importance of integrating the vision and digital strategy into the business or corporate strategy. The discussion must focus on how organisations may do things differently, rather than just better, as implied by the term ‘transformation’.

“There needs to be a willingness from a corporate strategy level to include digital optimisation in the organisation or at the operations.” – PTP009

“It really should start being a conversation about the businesses itself. Just using that word transformation. It's not about doing things better; it's about doing things differently.” – PTP001

Leadership must articulate, support, and promote the digital agenda and strategy. To guarantee successful uptake and execution, getting the right individuals on board is critical to ensuring a well-communicated vision.

“I think it is important for the leadership of the company to communicate their strategy and vision effectively to the employees.” – PTP004

“Firstly, you need the right people to be driving that. Once you've got the right, people, the vision becomes clearer.” – PTP003

Participants believe that leadership alone is insufficient to ensure total buy-in. The strategy development process in digitally mature organisations must be all-inclusive, engaging the workforce – the end-users of digital solutions in mining operations – amongst other stakeholders.

“I think the strategy is supposed to be set at a certain level with broad stakeholder engagement, which includes people on the ground, communities, employees, etc.” – PTP009

“It's not your leadership that's going to use the technology as much as the semi-skilled and unskilled workers. I think it's so important to get everybody on board.” – PTP005

4.4.3.2 Culture and engagement

According to participants, culture and engagement are the most important enablers of a digital strategy. While there is some subjectivity on the indicators of culture, there is general agreement that culture and engagement are critical to digital maturation. There is a clear correlation between a desired culture and innovation, which creates an atmosphere in which everyone inside the organisation may contribute ideas and thoughts towards creating value.

“Driving a culture where people can feel they can come up with ideas of transforming the organisation.” – PTP015

Creating a learning organisation begins with providing employees with an exploratory and experimental environment. Digitally mature mining organisations are knowledgeable consumers and adopters through exploration, observation, and experimentation.

“The benefit is to take the learnings from other industries in and draw it into this.” – PTP007

“Keeping an ear on the ground and being a knowledgeable buyer is a critical component of this.” – PTP001

An ideal culture is portrayed as “fail fast”, with a strong risk appetite. In an industry where one size does not fit all, the ability to fail and not be disoriented by that failure is essential. It is also stated that the scope of a "fail fast" approach would be managed by Centres of Excellence for digital transformation within digitally mature organisations.

“You need to be able to have the kind of culture that is “fail fast” and learns from their failures, and it's okay to continue trying.” – PTP009

Despite this perspective, some participants believe that risk can be managed, and achieving a higher digital maturity need not be high risk for mining organisations.

“There are approaches to digital transformation that we can take which is risk-averse such as demonstrating the value via proof of concepts. Once that proof of concept has been successful, rolling it out in a risk-averse manner can be achieved.” – PTP004

A key factor in digitally mature organisations is collaboration. Many of the mining industry's triumphs may be accredited to collaboration, such as tackling operational safety and, more recently, the mining industry's agenda in creating a safe working environment amidst the COVID-19 epidemic.

“The integration is very, very important, and integration is not possible in a siloed involvement.” – PTP008

“That's exactly how we are winning when it comes to safety and COVID because we had to collaborate, we didn't have a choice, and that collaboration means we can learn from each other one.” – PTP014

Another viewpoint highlights the concept of diversity, stating that collaboration among people of different races, ethnicities, genders, sexual orientations, socioeconomic status, age, physical abilities, religious beliefs, political beliefs, or other ideologies can result in diverse perspectives, different solutions, and a higher level of innovation.

“Innovation can be brought upon by different creative minds, and also you know different contributions, so I think it's really no brainer that the more diverse any organisation is that they enable an environment where innovation strives.” – PTP 015

4.4.3.3 Governance and organisation

Participants believe that governance and organisation are essential factors in organisations that might achieve digital maturity, especially the controls and processes by which management and employees are held accountable. Compliance, risk management, and assurance are major focus areas for organisations seeking greater maturity within the mining industry.

“You got to have proper control and governance around how you run digital; you got to create that foundation” – PTP001

“You start going into more digital-based solutions and recording of information. With that comes the governance and the assurance.” – PTP007

“Compliance and governance in terms of your ‘Environmental, Social, and Governance’ data and your ‘Health and Safety’ data. You have to be very transparent on those policies to help drive digital transformation.” – PTP011

Digitally mature mining organisations incorporate all stakeholders in their vision, with an apparent focus on Environmental, Social, and Governance elements within the mining industry. Suppliers, communities, investors, customers, trade unions, and government entities must all be included in the notion of a collaborative culture, as indicated in section 4.3.3.2. This ecosystem engagement

is critical for assuring disruptive business approaches and enhanced value creation.

“This digital world we are getting into is really an ecosystem, and the undertone of co-creation should be where we must think about this right. Both Co-creation and collaboration.” – PTP001

An organisation's ability to collaborate and innovate is created through a comprehensive and purposeful change management agenda. Participants agree that awareness is a primary priority of digitally mature organisations. There is a widespread belief that older technically skilled employees lack innovative and digital know-how. In contrast, younger, inexperienced employees lack mining technical expertise – with a clear response for both concerns leaning towards a company-wide training program.

“But what's important is the culture and the ethics, and the change management. It's an important part of that process - it's a journey.” – PTP002

“To create awareness of digital transformation, what is actively happening. There are training and change management programs for every solution, that’s probably more effective.” – PTP004

“Ensuring that we have a very robust change management and training program to take older people along and understand why they are so against it.” – PTP013

The manner in which these mature organisations acquire, process, and regulate data for the effective use of information via policies, standards, and access control is a critical enabler of digital transformation. Data governance is a powerful indicator of governance and organisation.

“Of the technology itself, like architecture and so on, you need to understand that. Understanding what data is there and what data can be used for, whether it be for efficient decision-making or things like that.” – PTP012

4.4.3.4 New Value Streams and Business Models

When mining organisations employ data as a strategic asset, it allows for new opportunities like increased efficiencies, insights, and capabilities while also enabling digital transformation. New value streams are thus formed through direct revenue-generating innovations, insights and capabilities, or operational efficiencies and improved business models.

“The digital transformation is about using our data as a resource or as an asset to be able to improve our decision making both in terms of the time that it takes to make a decision, the value of those decisions, and to mine in a more sustainable way. But really, it's leveraging the data that we have or are collecting and using it in a more insightful manner.” – PTP013

Another school of thinking amongst participants holds that mature organisations achieve operational efficiency without changing their business models or value propositions. The reluctance to adjust business models is attributed to the probable impact on jobs, particularly in the South African mining industry. On the other hand, these participants recognise the necessity to innovate and adapt in tandem with the rate of technological progress.

“Efficiencies can improve without necessarily changing the business model. Now obviously in South Africa, there are sensitivities as well around labour.” – PTP012

“But then you also can't stick to one thing because the world is constantly evolving and changing, and technology is improving every single day. So, we still need to keep up with innovation as well.” – PTP014

Collaboration and coopetition emerge as repetitive themes throughout the research inquiry. Participants see this as a vital indicator to develop new and improved solutions within the mining industry, enhancing existing business models or creating new value streams. These have been noted in a few success stories, in the past as well as within and beyond the South African mining industry.

“Collaboration is very, very important in this industry, especially at the back end. And I'm talking here from a production point of view and operations excellence.” – PTP008

“Collaboration is a necessary requirement because that is the only way you're going to get to sustainable digitalisation as an organisation, and then as an industry.” – PTP013

“There's a lot of small vendors that have spawned up since the start of industrial digital transformation. These vendors come up with new innovations, new products. That helps answer some of the questions that these large mining organisations have.” – PTP004

“If you look at some of the joint ventures that have been very successful collaborating, you know in this space has definitely created the value.” – PTP015

4.4.3.5 Investment and Innovation

According to the participants, investment and funding are key components to digital maturation, as it allows for open innovation and the “fail fast” culture noted previously, accelerating the digital transformation journey of a mining organisation. Access to funds is critical, but it must be complemented with a strategic agenda and lean methodologies in order to realise maximum value with minimal waste.

“Make sure you got the pocket for it. You got the money to do it. A half-baked solution can sometimes be as useless as nothing. So be very clear about your funding around this. It's an important point to understand upfront.” – PTP001

“Budgetary issues will dictate how fast your transformation will happen.” – PTP011

“If I don't put any investment in the next 10 years in digitalisation, it is going to become unsustainable.” – PTP013

“You have to be clear about where you are going to get the money or how much you're looking at investing into this.” – PTP001

“It will take quite a lot of effort, time, cost, money and innovation from miners.” – PTP005

Creating an environment that enables innovation is critical within digitally mature organisations. The majority of participants agree that a strategic approach to innovation is fundamental in enabling new and improved ways of working that are aligned with the digital (and business) strategy. Open innovation is not

segmented to a group of individuals but instead allows for broader internal and external stakeholder collaboration.

“How we use innovation in terms of gaining competitiveness and in terms of digital devices and value.” – PTP015

“Innovation is not a catalogue of what innovative technologies but it's also a mindset. It's driving a culture where people can feel they can come up with ideas of transforming the organisation.” – PTP015

“The benefit is to take the learnings from other industries in and draw it into this.” – PTP007

4.4.3.6 Digital ethics

The concept of transparency has surfaced as a major consideration, by participants, against regulatory and compliance requirements within the mining industry and as a means that digitally mature organisations use to create the necessary awareness and elicit participation through reasonable access to information. This ensures board-to-floor cultural alignment necessary for maturity.

“Digital technologies have a strong ability to enhance compliance or make compliance easier for a mining organisation.” – PTP004

“In all aspects of ethics, digital transformation as a has the capability to improve and optimise, and I currently see it in in in the organisations that I've worked for.” – PTP004

“Governance and policy in terms of transparency; to say this is where I got it from, and this is where the data was read.” – PTP011

The digital maturation of the South African mining industry through technology implementation cannot be separated from the subsequent ethical ramifications on job losses. There is a notion, conveyed by participants, of new jobs and careers being created by the fourth industrial revolution, which digitally progressive organisations look towards reducing the impact on existing jobs. Creating new and enhanced opportunities is an essential consideration for the South African mining industry.

“We are living in a country where the protection of the people's job is a very high mandate…The fact that you [are] sitting with executives who are debating not the value of digital transformation but the license to operate.” – PTP015

There are many opportunities that are really nothing now, but that we can read.” – PTP010

4.4.3.7 Customer orientation and engagement

Due to the lengthy tenure of individuals that emerges from a mine's long existence, the mining industry is primarily driven by customer relationships. Digitally mature organisations understand customer needs and involve them in governance, solutions, and other administrative activities.

“Within the mining sector, a lot of people stay in the industry for a very, very long time. It's very much driven by relationships, building those customer relationships.” – PTP003

“You've got to have your finger on the pulse of what the customer is looking for and also ensuring their buy-in. Otherwise, you end up with this very waterfall approach and creating software that's not fit for purpose.” – PTP013

The utilisation of digital communication channels, dashboards, and analytics emphasises customer engagement and participation. These channels ensure effective customer relationship and expectation management and foster user adoption of technological solutions that assist customers in decision-making.

“Any digital innovation that you have, even though it might be to their [the customer’s] benefit, I think there’s always an issue to say before you sell me that, have you done what I asked you to do? Are you excelling at it? I think an opportunity will be missed to have those digital communications which could assist.” – PTP001

“A critical factor in maturing digitally purely because it will allow people to interact with that technology and the data. So once you see what you can do, it's a step to user acceptance.” – PTP011

“Communicate through dashboards through online platforms. Have access to real-time data, which helps make quick decisions. It helps pick-up high-risk areas faster.” – PTP014

According to some, customer orientation isn’t a primary focus for digitally mature organisations. Unlike other industries, the mining industry has a limited number of long-term contracts. As a result, a deliberate focus on customer engagement, marketing, and analytics does not significantly shift the transformation dial.

“Customer focus in the mining industry is not really a dimension…because the mining industry usually has set customers. It's very few customers that they have, and the contracts are long-term, so market analytics and customer-centric transformation has little impact in that aspect.” – PTP004

4.4.3.8 Digital product innovation

Digitally mature organisations recognise the need to maintain a product/service enhancement and innovation culture as they progress through the digital transformation process. It is not a means to an end but rather a continuous process ingrained in these organisations' maturation.

“That culture of product and innovation is not something that happens overnight, and it's a process. I would see it being part of the journey of getting to a digitally matured organisation.” – PTP001

The digital product innovation process must prioritise user experience. The rate of technological advancement and types of solutions allow for continuous user experience enhancements in line with customer requirements or, better yet, beyond customer expectations.

“If you've got a happy customer, it's going to make you want to even innovate a lot more. So, I think the user experience is probably one of the biggest enablers.” – PTP005

“If we can give the clients a better experience that's got a lot more information or data that they can use that's at their fingertips on a daily basis, I think that is a major contribution to digital transformation, and I think that will accelerate it.” – PTP005

According to most participants, operational safety is a fundamental driver of digital transformation in the mining industry, which introduces social functionality into the digital product/service development process. This supports the idea that technology, through information-based solutions, can provide real-time monitoring, early warnings, remotely operated mining assets, and a high degree of integration and machine-to-machine communication to reduce the hazards posed by the mining industry's hazardous conditions.

"Once an organisation has reached that maturity then you know that they are quite far and advanced and having better real-time data and not having any nasty surprises and being able to manage, especially the social aspects are one of the things." – PTP012

"Being able to put in machines instead of people or people in machines to do certain activities that are seen as high risk." – PTP014

"I think when you talk about integration…in what way is both the information side and operational side quickly integrated in providing the value." – PTP015

4.4.3.9 Workforce enablement and performance

Digital transformation must be a company-wide priority, not simply among leaders and executives. As a result, a shared vision is developed and disseminated throughout the organisation, enabling the entire workforce. Within digitally mature organisations, awareness is a critical component of the agenda. According to the research participants, a co-creation, knowledge sharing, and learning environment must be developed.

“It doesn't just take the leadership, but leadership is imperative. It does need the greater workforce to pull together to see the same vision as well as to make it happen.” – PTP001

“It has to filter through to all levels below, right down right down to the feet on the ground.” – PTP001

“And then there's also a challenge of awareness. The challenge of awareness, the way digital transformation is driven.” – PTP008

“You do need the older people and the young minds working together. The older people, the mature minds to skill the young people and to chisel their brains a certain way to get to the final product. Also need the young minds to channel and to challenge the status quo of things.” – PTP002

Digital skills development is vital in an industry where the bulk of the workforce is semi-skilled or un-skilled. Digitally mature organisations can only take the entire workforce along the journey if there is a level-appropriate understanding of using digital tools and fostering an innovative culture. This approach may be strengthened further by implementing performance management with key performance indicators across the entire workforce, as stated by the participants.

“We need to upskill, not dumb-down, we need to upskill. Make sure that the users know what they're doing.” – PTP002

“We need to educate these people and change this.” – PTP006

“Performance manage people more closely. Have very, very specific KPIs [key performance indicators] that they've got to achieve.” – PTP003

4.4.3.10 Core process digitisation

The capacity of an organisation to digitise core processes is a quick win and high impact component of digital transformation within digitally mature organisations - a shift from traditional, manual, and paper-based processes. Participants highlight how data intelligence and dashboard views of information enable digitally mature organisations to monitor business and operational processes easily and provide the transparency required to break down the silos within immature organisations.

"They've got things like dashboards, for example, where they keep on monitoring all sorts of financial [and] operational data that should be incorporated…now they've also included aspects such as ESG [Environmental, Social and Governance], and that tells you that they've now matured." – PTP012

"A shift from purely just production orientated to how we can 'see' it and give me a red, green and yellow dashboard to how can we really use our data and breakdown the silos to better the company." – PTP011

Visual data presentation via dashboards and other comparable techniques also enables quick decision-making. This fosters an agile business environment in digitally mature organisations, allowing them to deliver high-quality, collaborative solutions that quickly adapt to changing needs.

"The dashboards - it's such a visual representation of your data, it just makes it easier to analyse data to see where things are going wrong very quickly so you can make decisions a lot quicker and so the business becomes a bit more agile." – PTP005

Automation is an important indicator of core process digitisation because it enables accurate and high-quality data to be gathered in real-time, without the risk of human error or oversight. This facilitates quick decision-making and data presentation via dashboards for real-time monitoring and action.

“Incorporating a bit more of automation in terms of machinery on the production side but also making life easier in terms of automation just for capturing data.” – PTP011

“There's always an element of human error, so where you can digitalise processes, it's important that you actually digitalise the process.” – PTP002

An often-overlooked component of digitisation is that organisations may and do simply visually encode data to impress a customer while still retaining manual processes in the background. PTP001 warns that digital maturation is attained successfully through end-to-end process automation.

“In creating automated reports, some of it can be done almost semi-automatically where there's no real automation in the background. And that's why I say it gives a facade that there is maturity, but if done correctly, it is a good sign of your maturity, and it could be done correctly.” – PTP001

4.4.3.11 Information technology and system excellence

The provision and performance of information technology and information system services are critical parts of digital solutions within digitally mature organisations. When it comes to digitally mature organisations, a plethora of solutions are used to ensure optimal service delivery and performance. This is especially significant in organisations that operate in South Africa's remote areas.

“They deploy local IT infrastructure at a site and…use satellite networks for condition monitoring of equipment of a tailing dam and other environmental factors that happen on the mine so that we can have a global view or real-time access to information anywhere.” – PTP004

Another idea is that there should be no need for complicated network and connectivity solutions. Effortlessly operating in a connected environment is an aspirational condition that digitally mature organisations in the South African mining industry must aspire towards.

“We have talked to international clients that say they don't have a communication problem and they don't even have to do localised [solutions] because the entire country is on 5G or something like that, and you basically just connect into the systems, and off you go.” – PTP007

Digitally mature organisations recognise that information technology and operational technology are increasingly convergent if not increasingly the same. IT/OT convergence leads to cost-, performance-, and productivity- gains, optimising and transforming the organisational landscape.

“You can do your machine learning and all of your fancy digital [information] technologies in a safe and effective manner, which does not compromise the integrity of your OT [operational technology] systems. And from experience, the organisation that I've been working with do this very effectively in bridging the gap; what we call IT/OT convergence.” – PTP004

The strategy in managing and mitigating IT security threats is seen as a critical component of risk management and compliance by the participants. Whatever

the cause, many participants think that a level of caution is important in digitally maturing organisations, which might be accomplished by a risk management strategy, as stated by PTP001, or through a controlled infrastructure implementation approach, as portrayed by PTP004.

“It's more a case of the mining industry understanding what their profile around this is. Around what are the points of exposure that they could be potentially at risk in. What data potentially do they need to protect? How do they manage security with their staff, customers, vendors, etc.? So, it's more an understanding of what your risk is around this and finding a way to solution.” – PTP001

A different perspective suggests that IT security is not critical in digital maturation. This is due to the assumed rudimentary nature of cybercrime in the South African mining industry or that it has not been identified as a significant indicator that digitally transforms organisations.

“I don't think it's a deciding factor. We still have a long way to go versus other countries. We are still on our way; cybercrime is still very primitive.” – PTP014

“I'm not so sure what the relationship between our ability to become digitally mature and cybersecurity is. From the conversations that I have heard with digital maturity, cyber security has actually never come up ever as an inhibitor or a challenge.” – PTP009

4.4.3.12 Results

Organisations that might achieve digital maturity realise that fundamental shifts need to happen to keep abreast with changes in the business environment and market requirements, aligned with the aspiration to become sustainable and

remain competitive by generating value. In the South African mining industry, the concept of shared value amongst a broader stakeholder complement must be adopted.

"Eventually, we know that as metals and minerals that the mining industry does beneficiate, they do actually impact the society. It is that visible value that people can actually measure." – PTP015

"And this sort of shared value; how do you bring it all in one place? There has to be some sort of transformation, right? And you can only achieve that with organisations that are quite mature." – PTP012

In order to assess functional and process improvements, mature organisations ensure continuous monitoring and measurement of the transformational processes in order to produce results. Measuring transformational processes may involve, among other things, safety measures and the value placed on sustainability indicators like environmental and societal impact.

"From a business point of view, it touches on one other point that is very important. Measuring the success of digital transformations. You must determine how you measure success before you execute." – PTP001

"There are different ways that we can measure all of these. With safety [it] can be things like injury frequency rates. It could be how much critical control monitoring you have in a period compared to this time last year…On sustainability, there are various measures; things like carbon emissions, greenhouse gases, water usage, environmental footprint. Those are things that may not necessarily be able to translate into a monetary value, but we obviously know the link between

sustainability, those goals, and being able to mine. So those are the value leavers." – PTP013

4.5.3 *Conclusion for Proposition 1*

In order to construct a benchmark of what constitutes a high level of digital transformation in the South African mining industry, the research instrument elicited participants' understanding of digital transformation, the factors that contribute towards digital transformation, and an ideal maturity state for organisations in the South African mining industry.

Although participants placed emphasis on different factors and used different nomenclature for certain factors, there was a general understanding and perspective on a high level of digital maturity in the South African mining industry. Emerging themes were aligned with the reference unified model of digital maturity that included (1) vision and strategy, (2) culture and engagement, (3) governance and organisation, (4) new value streams and business models, (5) investment and innovation, (6) digital ethics, (7) customer orientation and engagement, (8) digital product innovation, (9) workforce enablement and performance, (10) core process digitalisation, (11) IT/IS excellence, and (12) results.

Disagreements centred mainly on customer attention, with the justification that the mining industry had a limited number of long-term contracts. As a result, an intentional focus on customer engagement has little impact on transformation. Similarly, some participants argue that IT security is not a significant feature of digital maturation because of the presumed under-developed nature of

cybercrime in the South African mining industry or because it has not been identified as an important indicator that digitally transforms organisations.

The presentation of the results for Proposition 1 sets the tone for examining the current digital maturity of the South African mining industry and the apparent shortcomings in comparison to the identified benchmark.

4.6 Findings pertaining to Proposition 2

4.6.1 *Identification of themes for Proposition 2*

The research inquiry pertaining to Proposition 2 yielded 63 primary codes through the open coding methodology, with several overlaps and duplications. The thematic analysis combined comparable and duplicate codes before organising the primary codes into 10 categories, as shown in Table 8. Following that, emergent themes were discovered between the primary codes and the generated categories. The emergent themes described in Table 8 were assessed in accordance with RO2.

Table 8: Codes, categories, and emerging themes for Proposition 2

Primary Enquiry	Coding
Status Quo of Digital Transformation	Experimental/trial-and-error phase
	Digitisation vs. Digitalisation
	Little value created, no major shifts and/or changes
	Lots of investment, little return
	Linear value creation through digital adoption, not exponential
	Cost reduction being a major driver for digital transformation
	Significant movement in operational transparency
	Improvement in operational efficiency and production
	Laggard, relatively immature to other industries, infancy
	Identified requirements, but little progress to close the gaps
	Complex environment and industry
	Stronger leadership required around digital
	Digital transformaiton is incredibly slow paced, no urgency
	Impact no realised, since the core focus in getting ore out of the ground
	Hesitation caused by impact to the workforce
	Great affinity to transform digitally due to external pressure
	Complancent culture, reluctant/resistent to change ways, ageing workforce
	Covid-19 excellerated digital process transformation, and digitisation
	Low level and younger employees not consulted or involved in the process
	Focus on the "pretty picture" instead of reliasing the true value
	Many employees are underqualified/low skilled, basic matric
	Greater expectations from the new generation of workforce
	Mismatch btewwen the digital teams and the general workforce
	Immature capability, immature culture
	Value in instances still only seen in revenue increase
	Majors and juniors are significantly different in their maturity
	Progress on strategy and digitisation, but not overall implementation
	Ability/budget to transform is imapcted by the depleting resources
	Labour laws and trade unions protecting job security
	Vendors, suppliers, contractors also impact the slow transformation
	Majors are backed by international support and can invest aggresively
	Return on onvestment not thoroughly realised
	South African mining is playing ctach-up to other geographies
	No urgency to transform, mining/business is not threathened by old methods
Gaps to achieving Digital Maturity	Awareness and education of employess and unions
	Priority of budgets, lack of available funds
	Older generation, complacent mindsets, not willing to change
	Lack of experimentation, current methods work well
	Cost vs. benefit or value
	Culture, maturity of the workforce, inability to "bend" the rules
	Location of mine sites, and the mining environment
	Government regulatory compliance
	Capacity and capability to mature digitally
	Customers are few, and customer requirement/needs are low
	Availability of suitable operational technology
	Lack of focus on basic digitisation
	Not understanding the different types of value
	Lack of information sharing, and transparency
	Lack of collaboration and shared value, "value beyond compliance"
	The approach of "reinventing the wheel"
	Infrastructure (network) and instrumentation
	Lack of network (and other) service provision
	Job security, fear, and unemployment

Categories
Maturity
Value/Results
Governance and Ethics
Stakeholders/Customer
Vision/Strategy
Workforce Enablement
Accelerator
Culture/Collaboration
Investment and Innovation
Technological Capability

Themes
Digital Maturity
Governance and Strategy
Culture and Collaboration
Technological Readiness /Capability
Engagement and Enablement
Digital Impact

4.6.2 *Participant views for Proposition 2*

This section focuses on the research participants' views on the current state of digital maturity in the South African mining industry and the gaps to obtaining a high degree of digital maturity as conveyed in section 4.4. This will allow the research inquiry to explore the level of variance, if any, in order to address the research question.

4.5.3.1 Digital maturity

The South African mining industry's present level of digital maturity has been consistently categorised as being a laggard by all participants that represent the mine owners/operators, mining workforce, and mining contractors stakeholder groups. The South African mining industry is considered to be in an experimental phase that has been ongoing for at least a demi-decade. This might be attributed to the minimal impact of technological disruption on mining operations' core business compared to other industries.

“I think we are still in our infancy stages. I don't think we have made enough progress to even call it a step towards digitalisation or in embracing digital transformation. I think we are still very far behind.” – PTP006

“We are in an experimentation phase right now. There's a trial-and-error phase which has been going for a long time now.” – PTP001

“I haven't heard or seen anything that's really revolutionised the mining space in the last four-five years that the mining industry has really started getting their fingers into this. There hasn't been a massive benefit.” – PTP001

“Where we [are] seeing things at the moment is that it's almost a linear value creation through digital adoption. It's not that what we call that exponential.” – PTP001

“In the banking industry, you're going to have a lot more advanced staff in terms of digital transformation because it's part of their core business…compared to the mining sector, which is not. Being digital is not part of their core business. Mining is their core business and getting that [ore] out of the ground.” – PTP003

For decades, operational techniques in the South African mining industry have remained unaltered. Regardless of the advent of the fourth industrial revolution and subsequent technological capabilities that have resulted, the method of mining and processing ore remains fundamentally the same. Having said that, some value has been created, mostly in the form of revenue generation, cost reduction, and risk management (with a strong emphasis on operational safety). External pressures on the South African mining industry to mature digitally is cited as a contributing factor to the value created to date.

“Because we're still largely mining and processing in the same way that we have for the last few decades. So, definitely, we've not been disrupted. Any change or value has been incremental definitely compared to other industries” – PTP013

There's been some value created, but there hasn't been massive shifts and changes or what we call moving the dial.” – PTP001

“It would either be optimising revenue which would involve decreasing costs or increasing your production, or it can be something that enables safety or culture.” – PTP009

“The pressures that [are] causing the organisation or industry to digitally transform. The mining history has much more external pressure to transform.” – PTP004

Recently, COVID-19 can be attributed to increasing digital transformation, specifically regarding the digitisation of manual and paper-based processes. Digitisation had long been on the agenda to transform the industry; however, COVID-19 has accelerated that process. That said, COVID-19 has had a negative impact on the industry’s ability to transform digitally in that it has reduced the risk appetite to invest in innovation and digital transformation.

“COVID has helped a bit with that. I think it certainly made us leap forward probably a few years because we had to adapt very quickly to changing things the way we used to do it. We were all working towards a paperless environment before, but it just never happened then. In the last year [we] probably printed a lot less than we used to. It [has] actually showed us that certain things are possible, and you just need to actually put your mind to it and say, ‘this is actually how it's going to be and how it should be’, and let's just do it. So, I think COVID has certainly helped a lot with that.” – PTP005

“I guess COVID kind of put some of this a little bit back and in some ways accelerated some other aspects of it.” – PTP001

The digital maturity and capabilities of major and junior mining operations range significantly. Because of improved resource availability, major mining operations are somewhat ahead of the curve and have contributed considerably larger investments to advance their respective maturity. Regardless of the disparity in

maturity, much more has to be done to improve the overall maturity of the South African mining industry.

“Your spectrum is actually a bit vast…companies that can afford to are well advanced while a majority of the other smaller companies [are] lagging far behind.” – PTP010

“Your big mining companies are probably slightly ahead of the curve, but I think there's still a lot that can be done.” – PTP005

4.5.3.2 Governance and strategy

Digital strategies and investment allow mining organisations to create a unified, purposeful vision towards realising and creating appropriate value for the organisation. It is observed that the South African mining industry does not receive the investment and attention that it did in the past. As a result, organisations are perplexed as to what the value of digital investment should be. Those organisations that do have adequate funds do not appear to prioritise digital transformation in their strategy and budget discussions.

“The reason is that you know if you look at our return-on-investment numbers compared to the ‘techs’ of this world, we are not a great case for investors. I think that would be the first hindrance. How much of that capital would be given just for the highest maturity, so there is that discussion around what should be, the balance of the breakeven point.” – PTP015

“There's a lot of changes that have been happening in the mining industry. What this tells us is that digitalisation is not sitting in the high priorities. The question is what are those high priorities?” – PTP002

It has been found that mining organisations that have purposefully engaged in digital initiatives prefer to focus somewhat on the marketing components of the solution. This not only creates a misleading picture of the organisation's digital maturity, but it does not result in substantial and long-term transformative improvements such as enhanced data capability and intelligence.

“If you think about strategies, research and development budgets, and even capital spend, especially with the big mining houses in what we see, there's a bit of a misconception on some of these things. For some people, it's about the pretty picture that you see or the big control room that you have. It's almost an idealistic type of what digitisation means. Not really understanding the data, the intelligence and those things that sits behind all of that. Where the real value that sits in these things.” – PTP007

“The few people that try to come across as digitally mature or trying to get digitalisation in their mines without putting in risk, end up not really doing [digitalisation]. Just maybe you end up just putting a sensor here and there.” – PTP006

The strategic process of digital transformation must encompass all stakeholders, including the workforce that is expected to experience the shift in digital maturity. Participants convey an appreciation of the different levels of involvement; however, the premise is that the younger, newer employees, general workers, and other lower-level personnel are not involved in the strategy conversations.

“The senior managers focus on doing those strategies, your executives try to implement those strategies, but no one bothers to involve the up-and-coming

people to say 'when we do such strategies, maybe let's have such forums where the youth are allowed to have an input'" – PTP006

"When [new employees] are absorbed, they are treated like the normal general labour people, so they are not contributing in terms of strategies or day-to-day technological implementations." – PTP006

Organisations must recognise that in order to progress digitally, a new or upgraded set of skill sets is necessary to shift or accelerate the transformational agenda. Different capabilities are required than what the South African mining industry is used to, especially with the onset of innovation, which necessitates new concepts, ideas, and ways of thinking.

"And capacity; [the] mining industry probably don't seem to employ a lot of, in the past, innovative people because things have been done a certain way for so many years and it works. Now to try and get people in that thinks a bit more innovative or different or thinks out of the box is now another resource that you have to employ." – PTP005

The required digital capabilities need to be looked at from an entire organisation's perspective, from board to floor. Stronger and more innovative leadership is required than what is currently evident to dispense a compelling vision and create the appropriate awareness through the organisation and amongst all relevant stakeholders.

"Perhaps [we] need stronger leadership a stronger vision. The first step we've done, which is awareness, is always a good start. But you can't swim in the

awareness. It's what do you do with what you know and how to get there?" – PTP002

Following on from that, the sluggish pace of digital transformation in the South African mining industry may be traced back to the rate of investment, which is tied to the realised value of digital maturation. Perhaps the most underlying issue with mining organisations' delay is a lack of urgency or pressure to sink or swim. Or, perhaps it is due to decreasing resources and resultant investor disinterest in the South African mining industry as a whole.

"There is a bit of catch up, and if you hear the conversations that you have with executives, catch up mostly has to do with just the investment and the return on investment. Because there isn't really a pressurised urgency that either you transform, or you die." – PTP015

"The mining industry in South Africa has shrunk over the years. Actually, on the gold and platinum, that's where the pain points are in terms of transformation. The gold resources are so depleted now that people are like: 'do we need to invest in there?' So, there's a reluctance as well probably [by] shareholders and those decisionmakers to make that investment." – PTP012

The hesitancy of intentional and aggressive investment in digital transformation is very much in line with the expected impact on the workforce. Not only is the mining industry extensively monitored and regulated, but trade unions and other similar entities exist to safeguard mining workers' jobs and stimulate further employment in order to alleviate the societal effect of South Africa's struggling economy.

“The heavy regulatory side of things that the mining space is exposed to. We make a decision about safety, [then] a ton of Union conversations must happen before you can even implement. That becomes a lesser issue about the technology, but more an issue around whether you [are] meeting the Union requirements around how you monitor and measure or track employees on the ground and that starts becoming the inhibitors around this.” PTP001

“We are living in a country where the protection of the people's job is a very high mandate. We know that [the] mining industry has been seen for many years, except recently, as one of the economic centres in terms of the industry. The fact that you [are] sitting with executives who are debating not the value of digital transformation but the license to operate. If we want to be bullish in terms of that digital transformation agenda, that's where sometimes the hindrances are sitting, and we need to comply.” – PTP015

It should be noted that the South African mining sector has achieved some progress and improved operational transparency as a result of the same rigorous regulations that have been identified as barriers in other instances. This has resulted in a higher degree of efficiency in mine production.

“The one area that they're starting to show a lot of benefit in is the operational transparency. Operational transparency from pit-to-port type monitoring, using the IoT integration point of view, the data collection, picking up volumes as they move through the system, picking up any exceptions of volumes that don't make sense between the whole process that doesn't filter through properly…There's been lots of insights created around efficiency, bottlenecks, etc. in the values.” – PTP01

4.5.3.3 Culture and collaboration

There is a reoccurring theme of culture having a fundamental influence on the rate of digital transformation in the South African mining industry amongst all participants. The current culture is characterised by legacy thinking, complacency, reluctance, and resistance to technological adoption and, to some degree, to improving the mining workforce's capabilities. The protection of jobs and the influence of digital transformation on job losses are considered key motivators for this resistance.

"The mining space comes with legacy thinking which is probably one of the inhibitors to the way that this is being managed right." – PTP001

"The current culture, especially in the mining industry, is very much: 'this is the way we do things, and it's worked for so long.' I think people are complacent. They don't really want to learn how to use technology." – PTP005

"Typically, what we see is that if we get somebody who is doing their job for the last 30 years, those type of people typically won't be inclined to move or upgrade their skills towards digital transformation or won't be keen on adopting [technologies]." – PTP004

"There's a challenge of resistance, and this resistance is justified because when you come with digital system and [say] I'm a miner, I am justified to think that you are bringing this digital system, so you want to take my job. Will I have a job tomorrow? I don't think the industry has strategised in terms of how will this be a just transition." – PTP008

The ageing workforce, which isn't as nimble as the younger generation in comprehending digital concepts and dealing with current technology, is a contributing concern to this complacent, reluctant, and resistant culture. Furthermore, it has been observed that the current level of digital maturity in the South African mining industry is unappealing to a younger, more technologically savvy generation.

"Your ageing workforce; it's not so easy for you to just walk there with technology and say: 'ladies and gentlemen, here's a new way of capturing production reports, checklists and everything'. You might end up creating more problems, so I think that's what is making this industry move with a lot of caution." – PTP008

"I just think when I started with the older generation geologists that they refused to put anything on a computer. Everything was on paper and just the transformation and the willingness to embrace input technology for data before it even went as far as proper database development." – PTP011

"There is no way a young person of today whose tech-savvy would want to work in an environment that the mines operate [within] today. So, for them to attract these young skills, the mining industry has got to look at advancing digital transformation." – PTP008

"The young man of today - you take them, you put them in a mine with a matric certificate…this person wants to progress. So, they introduce a different complexity in terms of: 'how are you going to make your business stable?'" – PTP008

The ability of a mining organisation to transform its culture and foster a collaborative environment is measured against the reduction of silos that exist between levels of teams and individuals. While leadership is expected to drive the digital transformation agenda, there is evidence of a mismatch between wider digital teams and the greater workforce. The right culture must allow for collaboration at all levels within the organisation.

“I think that, again, this mismatch between the digital teams, and the guys on the ground, and kind of fundamentally different cultures is a challenge.” – PTP009

The remote location of mine sites and round-the-clock operations raise additional concerns about culture and change management. According to PTP003, the greater mining workforce does not work at the same location and at the same time, as is typical in the retail industry. Managing the many stakeholders is difficult, let alone the effort and access needed to achieve efficient change management, particularly concerning a collaborative culture.

“Where sites are all located, I think it's very difficult. If you've got, for example, a retail organisation and your staff are more concentrated, it's a lot easier to manage them, communicate and drive that culture. If, for example, you have a whole lot of different sites, different shifts, or you've got your service companies and contractors all over, it's very difficult to manage them and really drive the digital transformation culture to those individuals. So, access to people I think is a lot more difficult.” – PTP003

4.5.3.4 Technological readiness/capability

Historically, IT infrastructure, network, and connection have been significant impediments to digital transformation and technology adoption within mining organisations. The remote location of South African mining activities and the demand for and relative cost of implementing the required infrastructure in these rural places are key contributors. Several participants believe that the technology is now available to address these long-standing challenges.

"If your sites or mines are in areas that connectivity and access to connectivity are too expensive to create connectivity in those areas, then [that] could potentially be a risk here, but I don't think that that sits in the majority category at the moment. I think that's a minority category and something that is improving daily." – PTP001

"Because of the advancements of these satellite comms, I do see that South African mining companies are making use of it, and I don't see it as an inhibitor anymore." – PTP004

All participants do not share this view. Others believe that the infrastructure in many mining operations is inappropriate and incapable of addressing the requirements for more digital operations. The stringent regulations and deprioritised digital budgets are a recurring theme amongst some participants. Furthermore, the mining environment is complex as it requires networks on the surface and underground connectivity, which poses its own risks. PTP011 highlights a further issue localised to South Africa around the theft of infrastructure in remote regions, bringing to light a broader socioeconomic consideration within the South African mining industry.

“In the mines that I have seen, you get a lot of patchy network areas. These Wi-Fi issues and then the control and instrumentation cover certain important areas, but not others and then the ability to implement and install and get the capital to plug in any infrastructural gaps takes a long time because we have annual planning cycles, a lot of bureaucracy, and a lot of cost-cutting that happens.” – PTP013

“I don't think so much for the mines that I've worked on in terms of like surface operations, but the ability to get connectivity underground is still a huge challenge. I think if we could get connectivity underground and figure that one out, then you know it will be a huge win.” – PTP009

“The fact is do we have the relevant infrastructure because we do. The problem we have is, is it maintained and is it sabotaged and is it being stolen from? It's not the technology or the bandwidth of all the infrastructure that's the problem. It's the socioeconomic input factors around that that will be hampering or limiting it.” – PTP011

At the same time, some participants continue to experience the effects of interrupted connectivity and the lack of appropriate infrastructure to support their digital transformation agendas. This has less to do with the available technological capability and more around service provision and access to the relevant services.

“Our internet structures, our 3G connections and fibre and so on; we are way behind the rest of the world and obviously underground as well. In rural areas, connectivity is a major problem because those infrastructures where these mining

houses are just don't exist, and I think that it's actually one of the biggest inhibitors at this stage." – PTP005

"There have been times on mines where we have had to phone network providers, and we were told: 'you need to wait a year until we can come and put a tower here.' I think it's just service provision in South Africa rather than any technology." – PTP013

"In my world, it's access to it because it is available in other places. We know what it is. We know what we need; it's access to it." – PTP014

4.5.3.5 Engagement and Enablement

The ecosystem within which a typical mining organisation operates provides a higher degree of complexity due to the various interests of respective stakeholders, ranging from the mine owner/operator, the mining workforce, mining contractors, communities, trade unions, governments, regulators, amongst others. Mining companies cannot simply alter their digital transformation agenda without taking all stakeholders into account and engaging them. PTP001 conveys this when pondering over the slow move to a digitally mature industry.

"It will be a combination of the complexity of the problem they've got to deal with. Complexity of the stakeholders that they've got to deal with." – PTP001

A vital stakeholder is the mining workforce and their ability to engage and participate in the transformational process. The low education requirements and levels of the mining workforce pose a threat to technological adoption and subsequent digital maturation. Most participants suggest an aggressive change management program focusing on upskilling and awareness, particularly to

remove the fear of digital transformation and perceived impact on jobs. New employment will emerge from the digital transformational process if employees are adequately upskilled, allowing them to be reappointed with new or upgraded skill sets. Some of these new abilities must be incorporated into the country's broader education system and cycle, which has been identified as an additional source of concern.

“The skill level is very low. We know the literacy levels in the mining industry [is] very, very low, and that goes together with skill. These people can drive a machine with a remote, but once you give them complex computing or equipment that requires touchscreens, etc., it becomes a challenge.” – PTP008

“The gaps that we also experience would be general acceptance of technology. I think, especially in the South African mining industry, that a lot of people are scared to embrace [technology] because they think if they embrace it, they're going to lose their job instead of thinking in terms of, ‘if I embrace it, my job might change.’” – PTP011

“Our education system is not equipped enough to receive and equip our people for the next era that is taking place which is introduced by digitisation for instance.” – PTP010

Stakeholder engagement considers the perspectives and needs of the relevant parties and encompasses a great deal of collaboration to solve organisational and industry-wide issues by leveraging digital capability. Most participants do appreciate the effort towards collaboration to date but have expressed a need for greater collaboration and coopetition amongst various entities within the South African mining industry.

“They do take advantage of the of those collaborations. I think they do make use of it, and it doesn’t create a hostile environment. They do it gradually, collaboratively, as opposed to more forceful and hostile.” – PTP004

“Mining companies could collaborate a lot more on things, for example, such as safety, where there's a mutual interest that they could benefit from. They can definitely collaborate more on that.” – PTP003

Apart from engaging with the broader stakeholders, with a focus on workforce enablement, mining organisations must take caution to avoid reinventing the wheel when digitally transforming the organisation. To this end, enabling the organisation through co-creation or knowledge sharing by procuring digital transformation expertise becomes vital.

“A lot of companies want to reinvent the wheel, and then the system falls flat. It might have to do with the project management, implementation and layout of how they want to implement systems, and then you get a bit of a problem in terms of the users saying, ‘Oh no, not again.’ Because the previous two systems didn't work.” – PTP011

“As far as delivery goes, you need to find the right partners [to] work with you and partners [who] can see the picture as well. Partners who buy into this picture. It's like a 70-30 split between internal people [and] external people.” – PTP001

4.5.3.6 Digital impact

There are strong perspectives that the success of digital efforts and initiatives that the South African mining industry has attempted thus far has major flaws in the limited value that is being realised at the moment. Participants feel that mining

organisations typically target easy wins without seeing the bigger picture of value creation. A typical case is this lack of understanding between digitisation and digitalisation.

“Because when we talk digitalisation in most instances, people understand only the digitisation part…There is very little value to be gained if you just take a piece of paper that the miner fills and you say, ‘I'm going to digitalise it’. Or even worse, you say, ‘I'm going to scan it. I've digitised it. I've made a difference in my business’. I don't think that's the way to go.” – PTP008

South African mining organisations don’t realise the complete value and don’t see appropriate results from digital transformation since their due diligence, specifically regarding digital initiatives, has clear gaps. A comparison is made between technical initiatives, that mining organisations are experts at managing and realising the return on investment, and digital initiatives that have many connected levers that must be considered if an organisation is to see results.

“We used to throwing money at sinking a shaft and in the end because we are so confident in the capabilities that we have in [the] mining engineers…the due diligence is so tight and so robust that the likelihood of you not getting your return on investment is very, very slim. In the digital space, the majors have thrown a bunch of capital into their digital programs, and because of all of the factors like immature culture, immature capability, [are] still trying to understand the landscape. We haven't seen the value from that. What is reported to the media, in terms of annual reports, you only hear the success stories, which is a very small slice of the pie. Most of the digital programs actually don't reach their value.” – PTP009

4.6.3 *Conclusion for Proposition 2*

According to the research participants, the South African mining industry is a laggard in its current level of digital maturity, having been trapped in an experimental phase for at least five years or so. Having said that, some value has been produced, mainly in the form of revenue creation, cost reduction, and risk management. It is observed that the digital maturity and capabilities of major and junior mining operations range significantly.

A contributing driver towards the limited value created is external pressure on the South African mining industry to transform digitally. Recently, COVID-19 can be attributed to increasing digital transformation, specifically regarding the digitisation of manual and paper-based processes.

Emerging themes on the current level of digital maturity of the South African mining industry and associated gaps relative to the perceived benchmark set earlier include (1) governance and strategy, (2) culture and collaboration, (3) technological readiness/capability, (4) engagement and enablement, and (5) digital value.

The capability and capacity for the South African mining industry to realise value accurately and truly from digital transformation is observed to be inadequate. There are clear inhibitors of digital transformation in the South African mining industry that must be explored in greater depth, together with key areas of improvement to mitigate the associated risks.

4.7 Findings pertaining to Proposition 3

4.7.1 *Identification of themes for Proposition 3*

The research inquiry pertaining to Proposition 3 revealed 51 primary codes through the open coding process, with some overlaps and duplications. Thematic analysis was used to merge related and redundant codes and categorise them into 13 categories, as shown in Table 8. The development of emerging themes between the primary codes and the subsequent categories followed. The emerging themes presented in Table 8 were aligned with RO3.

Table 9: Codes, categories, and emerging themes for Proposition 3

Primary Inquiry	Coding
(Candidate) Inhibitors to Digital Transformation	Application in Mine Environments
	Awareness
	Collaboration
	Communication
	Competitive Advantage
	Core Process Digitisation
	Culture/Adoption/Change Management
	Cybersecurity Threats
	Data Management
	Economic Impact
	Ecosystem Engagement
	Footprint
	Government/Regulation
	Innovation/R&D
	IT Infrastucture/Network/Connectivity
	Legacy Systems
	People/Human Error
	People/Jobs Loss
	People/Skills/Application
	Risk Aversion
	Social Licence to Operate
	Theft
	Unions/Labour Laws
	Vision/Strategy/Leadership
Improvement Suggestions	Awareness/Education
	Communication
	Culture/Diversity
	Financial Incentive/Tax Break
	Government/Regulation/Compliance
	Integration
	Operational Technology/Safety
	People/Skills/Jobs/Fears
	Shared Value
Risks to Digital Trasnformation	Nomenclature/Language
	Physical Security/Business Continuity

Categories
Operational Technology/Safety
Awareness & Change Management
Communication
People: Fears
Culture/Diversity
Shared Value
People: Jobs/Skills
Education
Leadership: Training/Skills
Integration
Financial Incentive/Tax Break
Government
Regulation

Themes
Ecosystem Engagement
Workforce Enablement
Culture and Adoption
Shared Value

4.7.2 *Participant views for Proposition 3*

The section that follows presents participants' perspectives on key areas for improvement, taking into account the gaps indicated in the preceding section as well as candidate inhibitors identified through the literature review that was discussed during the interviews. The proposals herewith offer insights into addressing the problems and resulting lag in digitally transforming the South African mining industry.

4.6.3.1 Ecosystem Engagement

The mining industry is incomparable to other more digitally transformed industries for several reasons, including the remote location of most mining operations. Digital strategies for mining organisations must consider the critical factor of infrastructure and service provision in these remote operations. Operating in South Africa has many socio-economical challenges, which more recently comprises the interrupted supply of basic electricity. PTP010 conveys that one of the most overlooked, rudimentary inhibitors to digital transformation in the South African mining industry is the ability to operate in a continuously connected environment.

“[We] definitely can't push for big mining drives to go into digitalisation, while you still have issues at Eskom. We had a breakdown a few days ago. The plant relies solely on Eskom, and Eskom had a problem. Luckily, our machines are still controlled by human beings. So, you can you imagine if the full sector was driven around energy supply.” – PTP010

The scope of the South African government's engagement and involvement extends beyond service provision. There is a strong belief that the South African government's agenda does not correspond with the requirements to improve the mining industry's digital maturity. The extent to which the South African government supports how they conduct business with the mining industry and the plans in place to assist the transformative agenda is a key area for improvement. Furthermore, the government plays a significant role in mediating the discourse between miners and trade unions, ensuring that the mining industry's best interests are prioritised over each stakeholder's own agenda.

"Getting our partners in the DMRE and MQA to also start doing work and not because most mining houses are trying to move forward and move ahead and implement things, but it doesn't help if you are you're trying to do your field inspections online on your phone where you can take actual photos and then an inspector comes and wants a paper risk assessment that you must keep for three months and for six months." – PTP014

"Government has a very precarious relationship with unions that they need to take care of…So, I think proper government support and plans as to how we are going to tackle the labour issue and a policy of some sort to drive digitalisation. I'm not saying exactly that, but those types of things could be very, very beneficial." – PTP013

One of the fundamental concerns and perceived inhibitors to digital transformation in the South African mining industry is the impact of technology and automation on the mining workforce. To ensure a more rapid transformation, participants believe that the labour issues need to be addressed on a government

level through reasonable and appropriate policy that allows mining organisations to mature digitally whilst still ensuring minimal impact on communities.

“These policies should cater for that. I'm not sure if they do currently, but they should cater. It should look at if we automate [a] portion of the mining operation, it should have some sort of framework on how to deal with the resulting void in employment that it created in those communities.” – PTP004

Furthermore, government financial incentives, such as reducing business taxes (i.e., tax breaks) in exchange for investment to ensure a collaborative transformation journey among all stakeholders, are an effective way to ensure that both the government and mining agendas are met, including the vulnerable workforce and communities.

“Given that [digital transformation] is so much in the innovation and technology space, financial incentives like tax breaks could really assist and do really assist where they are applicable for some of the larger organisations.” – PTP013

4.6.3.2 Workforce Enablement

One of the most significant areas for improvement revolves around the concern that the bulk of the mining workforce is under-skilled and unable to align with organisational aspirations to mature digitally. Concerns about the South African mining industry's level of education emerge as a periodic theme throughout the research inquiry amongst participants. Some argue that this issue should already be addressed in South Africa's tertiary education system, as noted in the previous section.

“Upskilling people from the time they are in university level. If I have to look at the curriculum when I was there, and recently speaking to quite a few graduates, [making] a trip to University A, and speaking to someone at University B*, there is no digital agenda on many of the undergraduate and honours [programmes] whatsoever.” – PTP013*

Participants recognise that further education and upskilling needs to be resolved within the mining workforce. On-the-job training is seen as most appropriate in this situation. The risk can be alleviated by establishing well-structured teams or pockets of knowledge transferability inside mining organisations.

“The main issue is education. Not formal education; [rather] informal education. Educating the team on the ground, being the people on the ground.” – PTP010

“Where we acknowledge that some people aren't as comfortable with technology as most…look at people that have either the potential to develop that skill or already have that skill to then work with the people that might be a bit cautious towards new technology.” – PTP011

Fear often originates from a place of unawareness of the impact of digital transformation on the jobs and livelihood of the mining workforce. The reluctance to adopt digital solutions is attributed to the lack of communication with the broader organisation. Leadership is commended on the strategic nature and intent of digital transformation programmes; however, they do not detail the impact on mineworkers' jobs, where an increased focus should be placed.

“So, the awareness…I'm sure our leaders in the various conferences they are attending [provide] all the information that is out there. But what technology can

do for us and for our people. Exposure to that kind of information and making that available within the organisations. The work required to get people or the workforce to buy into that is what's holding us back." – PTP014

"There's also some element of informing and training people somehow, and the whole change management." – PTP013

"You need to introduce change slowly and have it as an everyday conversation. It will take time, but it's in the everyday conversations that people start getting comfortable with certain systems. That people started knowing about this thing. It's in everyday conversations and education and bringing in bits of it slowly and slowly then people will get comfortable." – PTP014

Communication need not filter only vertically through a mining organisation. Participants relay the importance of lateral awareness and communication. Realising that leadership responsible for driving the digital agenda does not understand the digital landscape is regarded as concerning. There is a great dependency on technical teams for digital transformation know-how; however, leadership and senior management training is vital in ensuring that the entire mining workforce is appropriately brought on board.

"I think it doesn't necessarily filter to certain areas both down, but also laterally, so there are some departments who are more open to using the technology and even geographies would be more willing." – PTP014

"You've got to educate your executives and your senior managers as you see it…There is a lack of knowledge around digital at the executive level and then definitely at the senior manager level as well. We often get into engagements

where people struggle with what we are talking about. So, we are undergoing a very aggressive communication and change plan as an organisation within Company X to try to get people to understand what we do and get their buy-in as well."

– PTP013

The key areas of improvement around workforce enablement brought to light the discussion of new jobs and careers being created by the fourth industrial revolution, as well as South Africa's ability to develop in-country and mining-industry specific solutions that affect active adoption and implementation. The creation of new and enhanced opportunities is an essential consideration for the South African mining industry.

"How do we develop those technologies in-house in South Africa? Get young people to say, 'how do you develop companies that will be used within [the] digitalisation sector within the mining industry?' There are many opportunities that are really nothing now, but that we can read." – PTP010

4.6.3.3 Culture and Diversity

Cultural aspects like social influence and diversity, amongst others, have a significant impact on the adoption of digital solutions within the South African mining industry. Smartphones are widely used in the South African mining industry, despite the older-generation workforce lacking expertise and understanding of digital concepts. This raises concerns about the adoption of more complex solutions in mining operations. It has been recognised that there are subtle diversity considerations within the mining workforce that organisations must address as part of their change management strategy.

“I'll use an example where now with COVID we started moving into self-screening applications in the workplace. We still have a 40% buy-in rate for people using that application. The [workforce] would rather stand in a queue that is very long and screen manually. Yet almost everyone in the line is holding a smartphone. Just that comfort to click the application and screen yourself and just walk through the gates is still very difficult for people to do.” – PTP014

“By driving your diversity, you can drive your strategic change and also accelerate your digital transformation. Keeping in mind that people have different needs…you need to be flexible. By really keeping your workforce in mind, you can drive some digital strategies differently and faster than the traditional methods.” – PTP011

4.6.3.4 Shared Value

The plethora of stakeholders involved in mining operations has emerged as a challenge in defining and implementing digital transformation programs in the South African mining industry. However, participants do recognise the value of a diverse set of stakeholders in an industry centred around relationships. For the greater South African mining industry to evolve digitally, the notion of shared value creation and collaboration is vital.

“We are such a reliant industry when it comes to relationships. What we have, especially with our communities. So, for me, it becomes a no-brainer to say that more than the negative impact, if you would want to have a healthier license to operate, that is sustainable in the communities; that will sustain you as an organisation, then you really have no choice but to look at it differently.” – PTP015

Often, mining organisations develop high security around intellectual property in order to gain a competitive advantage. However, there is a shared perspective that collaboration and knowledge sharing will have little effect on the competitiveness of the mining industry. Priority must be given to shared value to boost production through efficient operations.

“It starts with the data and data sharing. That's one of the critical things. People [are] too bogged down in all this by IP. It's certain that we can share to improve and collaborate to improve as a whole.” – PTP012

“One of the agenda [points] is getting this knowledge sharing and because they're the common meeting point, and they're representing all these mining companies. We can get the technology to process some of these and do something about it for better production or more efficient production. So, there's a whole lot of knowledge sharing [needed]. Everyone [is] operating in their silos.” – PTP012

The need for collaboration and integration begins at home, within mining organisations, with the removal of silos that still exist between teams and between information technology and operational technology. There must be a point of convergence between the two technologies to ensure increasing value.

“When you talk about integration, and that's where it could be. In what way is both the information side and operational side quickly integrated in providing the value?” – PTP015

One of the primary drivers for digital transformation is operational safety and the use of technology to mitigate the associated risks. The emphasis on operational safety emphasises the necessity for collaboration and the development of shared

value to benefit the South African mining industry's workforce and lives at large. Furthermore, the South African mining industry's value and contribution to the South African economy has declined rapidly over the years. The mining industry must leverage technology to mine in unreachable regions through a collaborative approach by mining houses to revert the mining industry's position in the South African economy.

"Trying to at least get the riskier operations focused on first; things where people can be killed. That will definitely be those things that you need to look at first. Then also trying to get technology into the mining into spaces where people can't get to because mines are getting deeper and deeper to get that information out."– PTP005

4.7.3 *Conclusion for Proposition 3*

The government is seen as a major stakeholder with the most significant room for improvement in the digital maturity of the South African mining industry. Proper support and participation between the South African mining industry and the government is vital and includes enhanced service provision, joint transformation agendas, suitable labour policy, and trade union mediation.

The lack of education and low-skilled mining workforce poses a massive threat to digital transformation within the South African mining industry. The fear experienced by the mining workforce is attributed to a lack of communication and the lack of training on a top management level, who are the drivers of the digital agenda. To this end, participants suggest an aggressive, company-wide change management program.

While the South African mining industry has been lauded for its collaborative efforts, participants believe that a greater focus should be made on shared value and information sharing. This immediately addresses RO3 by giving key insights to accelerate the digital transformation process within the South African mining industry, ensuring safe and sustainable mining, once again.

4.8 Summary of the findings

Proposition 1: A high level of digital transformation within the South African mining industry is focused on factors that encompass (1) vision and strategy, (2) culture and engagement, (3) governance and organisation, (4) new value streams and business models, (5) investment and innovation, (6) digital ethics, (7) customer orientation and engagement, (8) digital product innovation, (9) workforce enablement and performance, (10) core process digitalisation, (11) IT/IS excellence, and (12) results, according to participants, which is aligned to the unified model of digital maturity. Customer engagement and IT security were not seen as high focus areas by all participants due to the nature of business of the South African mining industry.

Proposition 2: The South African mining industry is considered a laggard in its current level of digital maturity, with nominal value created through revenue generation, cost reduction, and risk management initiatives. The research inquiry uncovered gaps related to (1) governance and strategy, (2) culture and collaboration, (3) technological readiness/capability, (4) engagement and enablement, and (5) digital value relative to the perceived benchmark set in Proposition 1.

Proposition 3: The South African government is viewed as a significant player with the most potential for improvement towards the mining industry's digital maturity, particularly in terms of enhanced service provision, joint transformation agendas, appropriate labour policy, and trade union mediation. The South African mining industry faces a significant challenge to digital transformation due to a lack of education, a low-skilled mining workforce, and a lack of senior management understanding of digital maturity. While the South African mining industry has been praised for its collaboration to date, participants think that a greater emphasis on shared value and information sharing should be placed.

CHAPTER 5. DISCUSSION OF THE FINDINGS

5.1 Introduction

Digital transformation serves to help organisations accomplish their strategic goals and organisational mission in the face of technology disruption, which essentially means that organisations may achieve their core purpose (Armstrong & Lee, 2021). The methodology used in the South African mining industry has remained substantially unchanged since its inception. As mining requirements increase, mineworker safety and overall mine productivity suffer, affecting mining economics in South Africa (Baxter, 2019). The fourth industrial revolution's radical innovation is crucial in the development of South Africa's mining industry (PWC & Minerals Council South Africa, 2021).

While there is widespread support for the drivers of technological disruption in the South African mining industry, assessing the industry's ability to transform and adopt digital technology is crucial for developing the industry's digital maturity. The capability and capacity of the South African mining industry to accurately and effectively realise value through digital transformation is deemed insufficient. Stakeholders such as mine owners/operators, mining workers, and mining contractors have classified South Africa's mining industry as a laggard in terms of its current digital maturity. Although the need for digital transformation is acknowledged and realised in other industries, the South African mining industry is in an experimental phase that has been ongoing for at least a demi-decade. This might be because, compared to other industries, the perceived impact of technology disruption on mining operations' core business is minimal.

There is an apparent divergence between the current state of digital maturity in the South African mining industry and the ambitions for long-term growth, employment, and development. Assessing an organisation's current digital status quo is the first and possibly most vital challenge that an organisation encounters when engaging in digital transformation programmes (Thordsen et al., 2020; Ochoa-Urrego & Peña, 2020). According to Ifenthaler and Egloffstein (2019), maturity models are a well-established method for evaluating the strengths and weaknesses of various domains within an organisation and discrepancies between the existing, i.e., as-is, and aspirational, i.e., to-be, organisational design. In quest of an empirical, well-defined digital maturity model, Armstrong and Lee (2021) introduced the unified model of digital maturity, which incorporates needs from researchers and practitioners, organisations, and academics and provides perhaps the most comprehensive model to date.

Empirical data used to inform the benchmark of what constitutes a high level of digital transformation in the South African mining industry suggests themes and factors that align cohesively with and thereby validate the soundness of the unified model of digital maturity. This perceived benchmark sets the tone for examining the status quo, the apparent gaps in comparison to the identified benchmark, as well as key areas for improvement of digital maturity in the South African mining industry in line with Propositions 1, 2, and 3. The unified model of digital maturity proposes two dimensions, *leadership and strategy*, and *digital application and impact*, based upon Westerman et al. (2012)'s digital mastery framework. The discussion will centre on these two dimensions and will include the findings reported in Chapter 4's results in relation to the models and frameworks discussed in Chapter 2's literature review.

5.2 Discussion pertaining to Propositions 1, 2 and 3

5.2.1 *Leadership and Strategy*

The Nadler-Tushman Congruence Model emphasises that in order for an organisation to achieve its strategic goals, it must consider present inputs and outputs and a strategy or roadmap towards its strategic objectives. The model is centred on the formal and informal processes of structure and frameworks, tasks, culture, and people that enable the transformational process, which are key factors in ensuring successful transformation (Nadler & Tushman, 1980). The leadership and strategy dimensions include the drivers of digital transformation as well as the frameworks and structures wherein the transformation journey takes place (Armstrong & Lee, 2021). The dimension of *leadership and strategy* includes the factors of (1) vision and strategy, (2) culture and engagement, (3) governance and organisation, (4) new value streams and business models, (5) investment and innovation, and (6) digital ethics, as proposed by the unified model of digital maturity.

Empirical evidence reveals that digitally mature organisations would have an adequate digital strategy as a critical component. The vision and digital strategy must be integrated into the business or corporate strategy to ensure proper governance. Leadership is responsible for articulating, supporting, and promoting digital agenda and strategy; however, to ensure complete buy-in, the strategy formulation of digitally mature organisations is an all-inclusive process and considers all stakeholders. Currently, the South African mining industry requires more deliberate and innovative leadership to manage the digital strategy and present influential narratives and awareness in support of it. According to

Singh (2013), organisational leadership styles must be properly coordinated in order to align with the current business culture. Furthermore, understanding an organisation's dynamics and performance is critical in planning and leading effective large-scale digital transformation. One of the most overlooked, basic inhibitors to digital transformation in the South African mining industry is the ability to operate in a connected environment uninterruptedly and the effects of interrupted electricity supply. The empirical data conveys that a key area for improvement is the consideration of infrastructure and service provision in remote locations, characteristic of mining environments.

While there is inherent subjectivity in cultural indicators in the empirical data, there is widespread agreement that culture and engagement are essential components in digitally mature organisations. A "fail fast" culture with a high-risk appetite is portrayed as desirable. In business literature, there is a strong emphasis on a culture of rapid experimentation, particularly with reference to agile transformational processes (Sacolick, 2017). The first step in establishing a learning organisation is to provide employees with an exploratory and experimental environment. Through research, observation, and experimentation, digitally mature mining organisations become savvy consumers and adopters. Collaboration among people of diverse backgrounds may further contribute to new ideas, solutions, and a better degree of innovation. According to empirical data, legacy thinking, complacency, reluctance, and resistance to technological adoption characterise the South African mining industry's existing culture. The impact of digital transformation on job losses is viewed as an important motivator for this resistance. This notion is supported and observed as a candidate inhibitor, in which a traditional and component culture is ascribed to the presence of silos,

as well as teams and projects that are neither agile nor innovative. It has been observed that employees are paralysed by fear and uncertainty caused by the fourth industrial revolution (Greane, 2021; PWC & the Minerals Council South Africa, 2021). Individuals within an organisation engage with digital technology in four ways: cumulative (learning about technology by acquiring fundamental knowledge about its functionality), assimilative (using standards and best practices to learn how to use the technology), accumulative (learning and implementing new processes based on digital technology opportunities), and transformative-expansive (individuals generate new processes based on digital technology opportunities) (Scholkmann, 2021). Boateng (2011) mentions the notion of "matching," which depicts a consulted and communicated shared understanding of which modalities of engagement, mentioned above, may match the organisational learning and transformation requirements. Acceptance of digital technology or perceived resistance to change by an individual “is an interplay between individual and organisational forces and barriers" (Boateng, 2011). An additional concern is the ageing mining workforce, which isn't as nimble in comprehending digital concepts and dealing with current technology. It has been observed that the current level of digital maturity in the South African mining industry is unappealing to a younger, more technologically savvy generation. A further contribution to the current state concerns the myriad of locations wherein the greater mining workforce is split amongst, making it difficult to manage and access the many stakeholders needed to effect efficient change management.

Organisations must recognise that in order to advance digitally, a new or updated set of skill sets is required to shift or accelerate the transformational agenda. The essential digital capabilities must be considered from the top down. According to

Armstrong and Lee (2021), the concept of an organisation's absorptive capacity aims to demonstrate that in order to integrate and use new knowledge, organisations require appropriate information, whether scientific, technological or otherwise. The resulting gaps in adoption, adaptation, and assimilation may be considerably decreased by supplementing, augmenting, and upskilling individuals, organisations, and regulators, therefore improving their knowledge-base and absorptive ability.

Open innovation and fostering a "fail fast" culture are facilitated by investment and funds, which accelerates a mining organisation's digital transformation path. Access to funds is important, but a strategic agenda and lean approaches must accompany it to enable new and improved ways of working aligned with the digital (and business) strategies. According to Leon (2012), investor confidence is critical in a capital-intensive and high-risk industry, especially given the importance of mining to the South African economy. In its current state, the South African mining industry does not receive the investment and attention that it once did, and as a result, organisations are unsure about the value of digital investment. The mining industry devotes significant resources to managing and mitigating risks and societal pressures, as well as realising opportunities; nonetheless, it is still unclear how mining companies may achieve a sustainable and responsible return on investment (Burger et al., 2019). Those organisations with adequate funds do not prioritise digital transformation in their strategy and budget conversations, whilst others prefer to focus on the marketing features of the solution, which provides a false impression of digital maturity but does not result in revolutionary improvements. Perhaps the most fundamental issue behind mining companies' delays is a lack of urgency to transform. To encourage

investment and ensure that both the government and mining agendas are met, including the vulnerable workforce and communities, the allocation of government financial incentives, such as reduced business taxes (i.e., tax breaks), in exchange for investment to ensure a collaborative transformation journey among all stakeholders is suggested.

When mining companies use data as a strategic asset, it opens new potential such as increased efficiencies, insights, and capabilities and allows digital transformation. Thus, new and enhanced value streams emerge as a result of direct revenue-generating innovations, insights and skills, or operational efficiency and enhanced business models. According to empirical evidence, collaboration and coopetition are important indicators for developing new and improved mining industry solutions that have the ability to enhance existing business models or create new value streams.

All stakeholders are included in the vision of digitally mature mining organisations, with a clear emphasis on compliance, risk management, and assurance aspects within the mining industry. Ecosystem engagement is crucial for enabling new and enhanced business models and increased value generation (Boateng, 2011). Currently, there is an acknowledgement of the various degrees of engagement among the participants; nevertheless, the premise is that the younger, newer employees, general workers, and other lower-level individuals are not involved in strategy development. Being a significant stakeholder in the South African mining industry, the South African government’s extent of support in how they conduct business with the mining industry and necessary government-driven policies to aid the transformative shift are important areas for development. However,

existing policies and regulatory frameworks are observed to be too rigid to deal with the speed of technological advancements, as well as the unexpected negative consequences on society, posing a significant challenge and candidate inhibitor to digital transformation within the South African mining industry (Greane, 2021; Cunningham; 2018).

The manner in which digitally mature organisations acquire, process, and govern data for effective information use through policies, standards, and access control is a fundamental facilitator of digital transformation. Transparency has emerged as a crucial concern against regulatory and compliance needs within the mining industry and as a tool to ensure that digitally mature organisations establish the required awareness and elicit involvement through reasonable access. It is acknowledged that the South African mining industry has made significant progress in enhanced operational transparency in its current state.

5.2.2 *Digital Application and Impact*

The majority of the challenges that organisations face as they strive for greater digital maturity are related to management and leadership roles, the development of new digital technology-related competencies, and the development of new proficiencies in values, creativity, management art, complex human relationships, and emotional intelligence (Kuzin, 2019). Awareness is a vital component of the agenda in digitally mature organisations. According to empirical evidence, a co-creation, information sharing, and learning environment must be built. In an industry where the majority of the workforce is semi-skilled or unskilled, digital skills development is critical. Although building digitally enhanced business and operational processes is one of the most significant needs for comprehensive

digital transformation, having the skills, talents, and culture to embrace digital technology and innovation is also critical (Lööw et al., 2019). This strategy may be improved even more by introducing performance management of key performance metrics throughout the entire mining workforce. Understanding and applying new technologies necessitates a distinct set of skills in order to maximise the benefits of modern technology, and as such, the South African mining industry's lack of skill and expertise is identified as a candidate inhibitor (Greane, 2021; Cunningham, 2018). Currently, the mining workforce's low education requirements and levels threaten the need to improve the industry’s ability to adopt technological solutions and its subsequent digital maturity. New jobs will be created as a result of the digital transformation process if employees are appropriately upskilled, allowing them to be reappointed with a new or updated skill set. Some of these new skills must be integrated into the country's larger education system and cycle, which has been designated as a critical focus area. In addition, empowering the organisation through co-creation or knowledge sharing through the acquisition of digital transformation competence becomes critical. The more information an organisation has access to, the more it will learn and improve (Cohen & Levinthal, 1990). It is proposed that the risk can be reduced by developing well-structured teams or pockets of knowledge transferability inside mining organisations. Furthermore, empirical evidence supports an active change management program with a strong emphasis on upskilling and awareness, specifically to alleviate the fear of digital transformation and its impact on jobs. PWC and the Minerals Council South Africa (2021) emphasize in their recent evaluation of the South African mining industry that digital technologies used in a people-centric way offer the benefit of producing

new, better-paying, safer, healthier, and more satisfying employment. Rogers et al. (2008) distinguish five types of adopters: innovators, early adopters, early majority, late majority, and laggards. According to Kaminski (2011), the purpose of this theory is to simplify innovation in order to meet the expectations of all five adopter groups, guided by peer networks, adoption frameworks, innovation characteristics, re-invention techniques, and communication channels. In this sense, communication is not to be channelled just vertically inside a mining organisation. Empirical evidence emphasises the significance of lateral awareness and communication. This method necessitates learnings from leaders and adapting and integrating information to satisfy better the demands of local contexts and, in many cases, developing countries (Cunningham, 2018). However, there are worries about the current status of the mining industry's low degree of maturity ascribed to the poor know-how of leadership and senior management, with a request to focus on leadership training as well.

Stakeholder engagement includes taking into account the viewpoints and needs of the relevant parties and involves a significant amount of collaboration to address organisational and industry-wide challenges by harnessing digital capability (Armstrong & Lee, 2021). Most participants appreciate the efforts made so far toward collaboration, but they have voiced a desire for further collaboration and cooperation across diverse organisations in the South African mining industry. Furthermore, mining companies cannot simply develop their digital maturity without considering and engaging with external stakeholders. It is suggested that the amount of engagement with the ecosystem be increased. Customers are important stakeholders in the South African mining industry. The mining industry is heavily driven by customer connections, owing to the longer

tenure of individuals that results from the mine's longer life. There are two schools of thought in this area. The first emphasizes the importance of digitally mature organisations not only understanding customer demands but also including them in solutions, governance, and other engagements. In contrast, the mining business has a limited number of long-term contracts, implying that a purposeful focus on customer interaction, marketing, and analytics does not change the transformation dial considerably. Regardless of perspective, stakeholders all agree that the customer is a vital part of digitally mature organisations and must be acknowledged in the strategy discussion.

Working seamlessly in a connected environment is an aspirational state that digitally mature organisations in South Africa's mining industry must strive for. Digitally advanced organisations understand that information technology and operational technology are becoming more convergent, if not equivalent. The convergence of IT and OT results in cost, performance, and productivity improvements, hence optimising and reshaping the organisational environment. This is accomplished by sending relevant data from each physical system (OT) to a central server (IT) for monitoring and analysis through wireless links. The results of the analysis may then be communicated back to the physical equipment, enabling more autonomous operation, higher accuracy, easier maintenance, and increased uptime (Bigelow & Lutkevich, 2021). Historically, digital transformation and technology adoption inhibitors included IT infrastructure, network, and connectivity. The remoteness of South African mining activities and the demand for, and relative expense of, establishing the necessary infrastructure in rural areas are important considerations. Empirical evidence reveals that the technology to overcome these long-standing difficulties is now

accessible. The emergence of new technology and the proliferation of new disruptive tools are reshaping enterprises (Armstrong & Lee, 2021), with the potential to change the economic dial of all industries and create value for all shareholders, including customers, society, government, and the environment (World Economic Forum, 2021). This is not the consensus among all stakeholders, though. Others believe that many mining operations' infrastructure is inadequate and incapable of meeting the demands of increasingly digital operations. Automation is an essential element of core process digitisation since it allows for the collection of accurate and high-quality data in real-time, without the possibility of human error or oversight. This allows for faster decision-making and data display through dashboards for real-time monitoring and action. Empirical data demonstrates how data intelligence and information dashboard views enable digitally mature organisations to readily monitor business and operational operations while also providing the transparency necessary to break down the silos that exist in immature organisations. The notion that technology, via information-based solutions, can provide real-time monitoring, early warnings, remotely operated mining assets, and a high degree of integration and machine-to-machine communication to lessen the risks posed by the mining industry's hazardous circumstances. Network delays caused by geographical distance, according to Equinix (2021), inhibit real-time analytics and integration and is identified as an additional candidate inhibitor to digitally transforming the South African mining industry. Mining activities create a lot of data, which causes network capacity limits, poor customer experiences, cost inefficiencies on legacy network infrastructure and increased cybersecurity concerns. Stakeholders see the strategy for monitoring and mitigating IT security threats as important risk

management and compliance components. Business literature recognises these rising dangers associated with digital maturity, which include, but are not limited to, cybersecurity risk, third-party risk, and data privacy risk (De Oliveira, 2021). Data exchanged among stakeholders from hundreds of mining applications raises cybersecurity concerns, posing a major candidate inhibitor to South Africa's digital transformation efforts (Young & Rogers, 2019; Greane, 2021). A contrasting viewpoint indicates that IT security may not be a vital part of digital maturity due to the rudimentary nature of cybercrime in the South African mining industry.

The notion of shared value amongst a larger stakeholder complement must be applied in the South African mining industry. Digitally mature organisations continually monitor and measure transformational processes to deliver results and assess functional and process improvements. The importance of digital transformation has influenced all aspects of business operations, causing organisations to revise their value propositions (Rogers D. L., 2016). There are clear indications that the effectiveness of digital activities and initiatives made by the South African mining industry has substantial limitations in the minimal value that is currently being realised. An important idea for development emphasizes the need for shared value to raise productivity through efficient operations. According to empirical evidence, mining organisations typically focus on quick gains without considering the broader picture of value creation. Measuring transformational processes may include, for example, safety measures and the importance put on sustainability metrics such as environmental and societal effects. One of the key drivers of digital transformation is operational safety and the use of technology to manage the risks that come with it. The emphasis on

operational safety emphasizes the importance of collaboration and the creation of shared value for the benefit of the South African mining industry's workforce and the community at large. It has been observed that the value and contribution of the South African mining industry to the South African economy has declined rapidly. Organisations' concerted effort to harness technology to mine in unreachable regions would revert the mining industry's vital role within the South African economy. Recognising that the fourth industrial revolution is a vital facilitator of safe and competitive mining, the importance of its application to the recovery of a stressed industry in South Africa is considerable, given how heavily the South African economy and citizens rely on the mining industry (Marwala, 2020).

5.3 Conclusion

Stakeholders, including mine owners/operators, mining employees, and mining contractors, recognise the significance and necessity of digital maturation. These stakeholders have identified South Africa's mining industry as a digital laggard. There are evident inhibitors to digital transformation in the South African mining industry as well as critical areas for development, which supports the research objective to manage the related risks.

Empirical data used to establish the benchmark of what constitutes a high level of digital transformation in South Africa's mining industry shows themes and factors that coincide with the proposed unified model of digital maturity. Governance, strategy, culture, cooperation, technology capabilities, stakeholder involvement, workforce enablement, and digital value are the observed gaps and

inhibitors to digital transformation in the mining industry. These emerging factors correspond to various candidate inhibitors identified in the literature study. Significant areas of improvement proposed by stakeholders include increased ecosystem involvement, workforce enablement, a focus on culture and adoption, and an awareness of the underlying value and impact of digital transformation on the South African mining industry.

CHAPTER 6. CONCLUSIONS & RECOMMENDATIONS

6.1 Introduction

This chapter aims to deduce the research inquiry, associated literature review and data collection in accordance with the propositions and overarching research objectives. Additionally, recommendations are proposed in line with the significance of the research study. The research study explores the inhibitors to digital transformation in the South African mining industry to provide guidance on accelerating the digital transformational process. The study assists in acknowledging the current state of digital maturity, identifying an aspirational or to-be digital maturity, examining the resultant gaps between the two states of digital maturity, and proposing critical areas of improvement. The research inquiry considered a host of literature, models, and frameworks and the perspectives of three key stakeholders within the South African mining industry: the mine owners/operators, the mining workforce, and mining contractors. There are significant opportunities to extend the scope of this research study that are presented as suggestions for further research at the end of this chapter.

6.2 Conclusion regarding Proposition 1

Proposition 1 suggests that there exists a gap between the current state and aspirational digital maturity of organisations within the South African mining industry. To test this, the research inquiry sought to identify a perceived benchmark of what constitutes a high level of digital maturity in the South African mining industry. The research examined stakeholders' awareness of digital

transformation, the factors that lead to digital transformation, and the ideal maturity state for a mining organisation in South Africa. The following conclusions related to Proposition 1 have emerged:

1A. Emerging themes were aligned with the factors of the unified model of digital maturity that included (1) vision and strategy, (2) culture and engagement, (3) governance and organisation, (4) new value streams and business models, (5) investment and innovation, (6) digital ethics, (7) customer orientation and engagement, (8) digital product innovation, (9) workforce enablement and performance, (10) core process digitalisation, (11) IT/IS excellence, and (12) results.

1B. The focus on customers was a source of contention, with a view that the mining business had a finite number of long-term contracts. As a result, putting a deliberate emphasis on customer involvement has minimal effect on change.

1C. Some stakeholders believe that IT security isn't a prominent component of digital maturity because cybercrime in the South African mining industry isn't well-developed or hasn't been recognised as a significant indication of digital transformation.

1D. The results of Proposition 1 set the course for analysing the South African mining industry's existing digital maturity and apparent gaps in relation to the established benchmark.

6.3 Conclusion regarding Proposition 2

Proposition 2 proposes that after careful literature review of models and frameworks from practitioners, organisations and academics, the unified model of digital maturity is positioned as the most fit-for-purpose digital maturity model created to date. The premise is that maturity models are a well-established method for evaluating the strengths and weaknesses of various domains within an organisation and discrepancies between the existing, i.e., as-is, and aspirational, i.e., to-be, organisational design. Empirical evidence utilised to inform the benchmark of what constitutes a high level of digital transformation in the South African mining industry shows themes and factors that correspond cohesively with the unified model of digital maturity, verifying the model's suitability. This perceived benchmark establishes the tone for evaluating the status quo, the apparent gaps in relation to the established benchmark, and critical areas for improving the digital maturity in the South African mining industry. The following conclusions related to Proposition 2 have emerged:

2A. In its current state, the South African mining industry is classified as a laggard in its digital maturation, with minimal value produced to date in revenue creation, cost reduction, and risk management.

2B. Emerging themes on the current digital maturity of the South African mining industry and associated gaps relative to the perceived benchmark set earlier include (1) governance and strategy, (2) culture and collaboration, (3) technological readiness/capability, (4) engagement and enablement, and (5) digital value.

2C. The capability and capacity for the South African mining industry to realise value accurately and truly from digital transformation is observed to be inadequate.

2D. There are clear inhibitors of digital transformation in the South African mining industry that must be explored in greater depth, together with key areas of improvement to mitigate the associated risks.

6.4 Conclusion regarding Proposition 3

Proposition 3 explores key areas of improvements, as proposed by the research stakeholders, by assessing a catalogue of candidate inhibitors derived from the review of literature, as well as the gaps and inhibitors elicited in Proposition 2. The following conclusions related to Proposition 3 have emerged:

3A. The South African mining industry faces a significant challenge to digital transformation due to a lack of education, a low-skilled mining workforce, and a lack of senior management understanding of digital maturity.

3B. The South African mining industry has made some efforts to transform digitally, although progress has been slow.

3C. It must be acknowledged that the South African mining industry is emersed in a complex ecosystem of stakeholders that make the transformational process challenging.

3D. The South African government is viewed as a significant player with the most potential for improvement towards the mining industry's digital maturity, particularly in terms of enhanced service provision, joint

transformation agendas, appropriate labour policy, and trade union mediation.

3E. While the South African mining industry has been praised for its collaboration to date, participants think that a greater emphasis on shared value and information sharing should be placed.

3F. The key area of improvement derived from the candidate stakeholders and literature review were aligned and proposed together with other areas of development in the following section 6.5.

6.5 Recommendations

The significance of this research is to identify and investigate the challenges and complexities involved in developing, implementing, and maintaining digital transformation programs in the South African mining industry, and incidentally, provide key insights to accelerate the transformation process and increase the industry's overall digital maturity. In doing so, the research inquiry elicited key areas of improvement from contributing stakeholders, focusing on ensuring safe, sustainable, and competitive mining.

It is recommended that mining organisations within South Africa consider a comprehensive strategy on digital transformation as part of their corporate strategy. Whilst the industry realises the benefits of increasing its digital maturity, the slow move towards a transformed industry and the inappropriate identification and lack of focus on key factors of digital maturity is a major inhibitor to the progression made to date. The unified model for digital maturity provides an appropriate digital transformation framework for use in the South African mining

industry, as confirmed by the research inquiry. The government is seen as a major stakeholder with the largest room for improvement in the digital maturity of the South African mining industry. Proper support and participation between the South African mining industry and the government is vital, with a focus on enhanced service provision, joint transformation agendas, suitable labour policy, and trade union mediation. The lack of education and low-skilled mining workforce poses a massive threat to digital transformation within the South African mining industry. To this end, an aggressive change management program is recommended. The mining industry is observed to maintain a complacent, reluctant, and resistant culture from leadership to the general workforce. The fear experienced by the mining workforce is attributed to a lack of communication and the lack of training, also on a top management level – the drivers of the digital agenda. While the South African mining industry has been lauded for its collaborative efforts, stakeholders believe that a greater focus should be made on shared value and information sharing. With a collaborative vision, the South African mining industry can leverage technological capabilities to transform and reposition itself within a global mining industry context, ensuring safe, sustainable, and competitive mining once again.

6.6 Contribution to the Body of Knowledge

The research inquiry identifies and explores the obstacles and complexities in formulating, implementing, and sustaining digital transformation programmes within the South African mining industry and seeks to provide critical insights on expediting the transformational process. The study contributes to a better understanding of the current digital status quo, the growing gap, and key

inhibitors relative to a constructed benchmark of the South African mining industry's digital maturity. Furthermore, the application of the unified model of digital maturity to the South African mining industry provides insights and further validation of a model that considers both empirical and theoretical influences.

The research inquiry involves participants from strategic, tactical or operational organisational levels that are well-versed with the digital transformation and digital maturity in their respective organisations. The resources used for the research, including participants and organisations, are constrained to the South African mining industry; therefore, the application of the research results and the contribution to the Body of Knowledge is within the context of the South African mining industry.

6.7 Suggestions for further research

The ecosystem surrounding the South African mining industry comprises, and is not limited to, mine owners/operators, the mining workforce, investors, contractors, suppliers, competitors, customers, non-governmental organisations, surrounding communities, trade unions, research institutions, government entities, policymakers and regulators, and professional bodies. This research inquiry focuses on three main stakeholders: mine owners/operators, mining workers, and mining contractors. During the research study, the relevance of ecosystem engagement as well as the contributing aspects of each stakeholder to the digital maturity of the South African mining industry was discovered. Further research should consider all remaining stakeholder's perspectives to gain a more

comprehensive understanding of the inhibitors to digital transformation in the South African mining industry.

The research inquiry emphasised the growing gap between the South African mining industry's current state and aspirational digital maturity, exposing a slew of impediments through literature review and empirical analysis. There is benefit in delving further into each barrier in order to suggest pragmatic approaches to tackling such challenges, therefore guiding and directing the South African mining industry to traverse the apparent bottlenecks appropriately. Additionally, it has been discovered that the maturity of major and junior mining companies varies greatly. Further research should focus on critical inhibitors, demonstrating appropriate ways relative to major and junior mining organisations to accelerate the industry's digital transformation journey.

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APPENDIX A: PARTICIPANT INFORMATION SHEET

Dear Prospective Participant

My name is Kamal Mistry, and I am conducting a research study towards a Master of Management degree in the field of Digital Business at the Wits Business School of the University of the Witwatersrand in Johannesburg, supervised by Dr Brian Armstrong, Program Director and Head of Chair in Digital Business. This research study is sponsored by Fraser Alexander, a well-established service provider in the mining industry. You are invited to participate in a study entitled: *Exploring the Inhibitors of Digital Transformation in the South African Mining Industry*.

The significance of this research study is to identify and explore the obstacles and complexities in formulating, implementing, and sustaining digital transformation programmes within the South African mining industry, and incidentally provide key insights on expediting the transformational process, thereby ensuring safe, sustainable, and competitive mining.

The research study will employ a semi-structured one-on-one interview via a secure video-conferencing application. Participants are selected based on their skills, experience, knowledge, and exposure to digital transformation within the South African mining industry. Your participation and the information you might provide will be processed with the highest confidentiality and stored in an access-controlled cloud storage environment. You may withdraw from this research study at any time. Participation in this research study is entirely voluntary and anonymous, and as such, there will be no financial benefit for participating in this

study, neither will there be any negative consequences for choosing not to participate in or withdrawing from the study.

Should you require any further information or have any concerns about how the research will be conducted, you may contact either one of the individuals listed below:

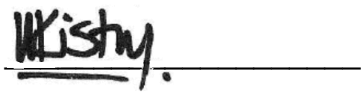
I. **Kamal Mistry**, Principal Researcher, contact number +27 72 664 4640, or by email at kamalm@fraseralexander.com

II. **Brian Armstrong**, Research Supervisor and Head of Chair in Digital Business, on contact number +27 11 717 3951, or by email at brian.armstrong@wits.ac.za

If you have any concerns regarding the ethical nature of the research being conducted, please contact the University Human Research Ethics Committee, contact number +27 11 717 1408, or by email at hrecnon-medical@wits.ac.za.

Your insight, perspective, and contribution towards this research study would be highly valuable.

Thank you,



Kamal Mistry

APPENDIX B: CONSENT TO PARTICIPATE

This Consent to Participate in a research study is between Kamal Mistry, the researcher, and the undersigned person or entity, the participant.

In consideration of agreeing to participate in the research study, I _____ (participant's name) hereby agree that:

I. I have been provided with the Participant Information Sheet, which explains the nature and processes involved in this study,
II. I was given time to read the Participant Information Sheet, or had it read to me, in a language I best understand,
III. I was given time to ask any necessary questions and found any answers given to me to be reasonable and satisfactory,
IV. I believe I fully understand why the study is being conducted and what the intended outcomes will be,
V. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but time,
VI. I understand that, even if I initially consent to participate in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained,
VII. I have been given a range of contact details via the Participant Information Sheet. If I require further information or become concerned about any aspect of this study, I am free to speak to any of these contacts.

By signing this Consent to Participate in the research study, I agree to (a) comply with the terms of the research study set out in the Participant Information Sheet and related consent forms; (b) provide true, correct, and complete information towards the research study; and (c) ensure that I engage with the research study in an honest, transparent, and good-faith manner.

I have read and understood the consent conditions set out in this agreement and agree to participate in this research in accordance with these requirements.

Signature: _____

Full Name: _____

Email Address: _____

Date: _____

APPENDIX C: CONSENT TO AUDIO/VIDEO RECORD

This Consent to Audio/Video Record in a research study is between Kamal Mistry, the researcher, and the undersigned person or entity, the participant.

I _____ (participant's name) hereby consent to the audio or visual recording of the interview and understand that:

I. The recording will be stored in a secure digital storage location with restricted access to the researcher and the research supervisor,
II. The recording will be transcribed, and any information that could identify me will be removed,
III. The recordings will be erased within either (a) two (2) years of the publication of the research findings, or (b) six (6) years if no publications arise from this research,
IV. Anyone wishing to access this information in the future will first have to obtain the approval of the Human Research Ethics Committee of the University of the Witwatersrand, Johannesburg,
V. In addition to the recordings, information including my name, designation, email address, phone number, experience, and opinions (collectively referred to as "Personal Information") might also be collected,
VI. Direct quotes from my interview, without any information that could identify me, may be cited in the research report or other write-ups of the research.

By signing this Consent to Audio/Video Record in the research study, I agree to (a) comply with the terms of the research study set out in the Participant Information Sheet and related consent forms; (b) provide true, correct, and

complete information towards the research study; and (c) ensure that I engage with the research study in an honest, transparent, and good-faith manner.

I have read and understood the consent conditions set out in this agreement and agree to participate in this research in accordance with these requirements.

Signature: _____

Full Name: _____

Email Address: _____

Date: _____

APPENDIX D: INTERVIEW GUIDE

D.1 Interview Logistics

Platform: Microsoft Teams application

Duration: 1 - 1.5 hours per interview

Design: One-on-one interview

D.2 Introduction and Briefing

The interview must commence with an introduction and briefing discussion of no longer than 10 minutes. The aim is to highlight the research interview context (D.2.1), purpose (D.2.2), and methodology (D.2.3) to the participant. Before proceeding, the participant must provide confirmation of consent (D.2.4). Should the participant not provide consent or decide not to proceed, the interview must be suspended here.

D.2.1 Research Team

Facilitator: Wits Business School; University of the Witwatersrand

Program: Master of Management in the field of Digital Business

Sponsor: Fraser Alexander (Pty) Ltd

Researcher: Kamal Mistry; Specialist: Digitalisation

Supervisor: Dr Brian Armstrong; Program Director and Head of Chair in Digital Business

D.2.2 Research Study

Topic: Exploring the inhibitors of digital transformation in the South African mining industry

Purpose: The significance of this research study is to identify and explore the obstacles and complexities in formulating, implementing, and sustaining digital transformation programmes within the South African mining industry and incidentally provide key insights on expediting the transformational process, thereby ensuring safe, sustainable, and competitive mining.

D.2.3 Research Methodology

Design: Phenomenological inquiry, via a qualitative research design, focused on gathering data from individuals' knowledge, interactions, and environments to offer a contextual view of the barriers of digital transformation in the South African mining industry.

Sampling: Semi-structured one-on-one interviews via a video-conferencing application. Participants are selected based on their skills, experience, knowledge, and exposure to digital transformation within the South African mining industry.

Unit of Analysis: Participants from the stakeholder groups of mine owners/operators and the mining workforce will provide perspectives from their respective organisations. In contrast, participants from the stakeholder groups of mining

contractors and policymakers/regulators will view the industry at large.

D.2.4 Participant Consent

Confirm that the participant has read, understood, and signed the informational and consent forms listed below and agrees to participate in the research study in accordance with these requirements:

I. APPENDIX A: PARTICIPANT INFORMATION SHEET,
II. APPENDIX B: CONSENT TO PARTICIPATE,
III. APPENDIX C: CONSENT TO AUDIO/VIDEO RECORD.

D.3 Enquiries and Guiding Topics

The enquiries and guiding topics below provide a standardised framework for ensuring that all participants have the same interview experience eliminating the possibility of bias during the interview. The researcher, however, has the flexibility to allow the conversation to prompt further questions in exploring details that arise from the interview.

D.3.1 Using Probes

The researcher should consider and remember to use probes that serve two main purposes in a qualitative inquiry (I) asks for further information, and (II) asks for an explanation of concepts prompted by the participant. Creswell & Creswell (2018) recommends some examples to consider:

I. "Tell me more" (asking for more information)

II. "I need more detail" (asking for more information)

III. "Could you explain your response more" (asking for an explanation)

IV. "What does _____ mean?" (asking for an explanation)

D.3.2 Primary Enquiries

The following acronyms are used, where *x* is a variable:

RO*x* Research Objective

PE*x* Primary Enquiry

RO1.	**Identify a benchmark of what constitutes a high level of digital maturity in the South African mining industry**
PE1.	*How do you understand digital transformation in relation to the South African mining industry?*
PE2.	*In your view, what are the factors that contribute towards digital transformation?*
PE3.	*What constitutes a high level of digital transformation in the South African mining industry?*

RO2.	**Assess the current status quo of the South African mining industry**
PE4.	*In relation to your stakeholder representation, what is the current status of digital transformation in the South African mining industry?*
PE5.	*In your view, what are the gaps to achieving complete digital transformation in the South African mining industry?*

RO3.	**Exploring the key areas for improvement, focusing on the candidate inhibitors**

PE6.	*What are your views on the candidate inhibitors (see section 2.6.3) as barriers to digital transformation? Focus on the candidate inhibitors not yet discussed by the participant.*
PE7.	*Do you have any thoughts on key areas of improvement to accelerate the digital transformational journey in the South African mining industry?*

D.3.3 Guiding Topics

The enquiries and guiding topics are centred around the Unified Model of Digital Maturity by Armstrong & Lee (2021) and the Unified Theory of Acceptance and Use of Technology by Venkatesh et al. (2003). The guiding topics below will be used to prompt questions and discussions on factors and themes not mentioned naturally by the participant. The following acronyms are used, where *x* is a variable:

DM*x* Dimension

MT*x* Main Topic

ST*x* Sub-topic

DM1.	**Leadership and Strategy**	
MT1.	*Vision and Strategy*	
	ST1.	Transformative scope of vision and integrated to business strategy, translated to a digital strategy
	ST2.	Leadership alignment and commitment
MT2.	*Culture and Engagement*	
	ST4.	Approach/appetite for risk-taking and failure
	ST5.	Culture and transformation: learning, exploration, and experimentation

MT3.	*Governance and Organisation*	
	ST7.	Agile, flexible, empowering organisational structure, roles, responsibilities, and support
	ST8.	Digital ecosystem, accessibility, co-creation, partnerships, networks, engagement
MT4.	*New Value Streams and Business Models*	
	ST9.	Use of data as a strategic asset, evolving value proposition, platform business model
	ST10.	Co-creation and partnerships with competition, business domain expansion and exploration
MT5.	*Investment and Innovation*	
	ST11.	Investment and resource allocation, level, modes and accessibility of funding
	ST12.	Lean, open, and strategic Innovation
MT6.	*Digital Ethics*	
	ST13.	Culture, participation, access, transparency, and awareness
	ST14.	Integration into product design and business processes

DM2.	**Digital Applications and Impact**	
MT7.	*Customer Orientation and Engagement*	
	ST15.	Customer value focus, customer participation and community
	ST16.	Digital engagement, marketing, analytics, channels, and tech in customer touchpoints
MT8.	*Digital Product Innovation*	
	ST17.	Products: UX differentiated, emerging, disruptive technologies, digital features, social functionality

	ST18.	The proportion of information-based products, products monetisation of data assets
MT9.	*Workforce Enablement and Performance*	
	ST19.	Employee awareness, alignment, empowerment, learning/knowledge management environment
	ST20.	Breadth, depth of current digital skills, use of digital tools, and performance management
MT10.	*Core Process Digitalisation*	
	ST19.	Automation, algorithms of core processes and dashboards for decision-making
	ST20.	Self-provisioning and external client portal and interfaces where relevant
MT11.	*IT/IS Excellence*	
	ST21.	IT performance, alignment, readiness, agility
	ST22.	Information security
MT12.	*Results*	
	ST23.	Generating of value: efficiency and process improvement, revenue etc.

DM3.	**Intention, Acceptance and Adoption of Technology**	
MT13.	*Factors*	
	ST24.	Performance expectancy and effort expectancy
	ST25.	Social influence
	ST26.	Facilitating conditions
MT14.	*Moderators*	
	ST27.	Gender, age, and experience
	ST28.	Voluntariness of use

D.4 Demographics and Profiling

Demographic and profile information provides context for the data collected, allowing the researcher to better analyse the sample population and related characteristics. Consider the following:

I. Gender,
II. Age Range,
III. Job Level,
IV. Years of Experience,
V. Location,
VI. Highest Qualification,
VII. Stakeholder Group (refer to Figure 10.).

D.5 Closing Instructions

The interview process is deemed complete once the interview has either reached a level of saturation or the maximum duration agreed upon by both researcher and participant has lapsed. The interview process should allow approximately 5 minutes to close before adjourning the session. Consider the following during the closing:

I. Ask the participant if there are any questions or concerns regarding the interview,
II. Remind the participant who to contact should there be any questions after the interview,

III. Convey the next steps in the research process, and if need be, when and how the participant will be contacted in future,

IV. Thank the participant for their time and contribution towards this research study

APPENDIX E: ETHICS CLEARANCE CERTIFICATE

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

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

Ethics Clearance Certificate

Ethics protocol number: WBS/DB2299870/759
This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below

This certificate is only valid if accompanied by formal permission from the relevant stakeholder(s).

Project title	Exploring the inhibitors of digital transformation in the South African mining industry
Investigator / Researcher	Mr. Kamal Mistry
Nature of Project	MM (Digital Business)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	2021-09-26
Expiry date	Date of submission of the project report
Chairperson	Prof Anthony Stacey ☎ +27 11 717 3587 +27 82 880 4531 anthony.stacey@wits.ac.za

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Declaration by Researcher

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

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

Signature

27 September 2021
Date: