

https://dspace.org/

# The perception of the impact of the Fourth Industrial Revolution on the production in South African mines

**Ledwaba, Solomon**

**2022**

University of the Witwatersrand, Johannesburg

https://hdl.handle.net/10539/38839

Ledwaba, Solomon. (2022). The perception of the impact of the Fourth Industrial Revolution on the production in South African mines [Master's dissertation, University of the Witwatersrand, Johannesburg]. WireDSpace. https://hdl.handle.net/10539/38839

Downloaded from a DSpace repository. https://dspace.org/

# The perception of the impact of the Fourth Industrial Revolution on the production in South African mines

**Solomon Ledwaba**

**Student Number: 1279943**

**A research article 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 Business Administration**

**Johannesburg, 2022**

**Protocol number:** WBS/BA1279943/970

(March 2022)

# DECLARATION

I, Solomon Ledwaba, declare that this research article 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 Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.



Solomon Ledwaba

Signed at ……Phalaborwa……

On the ……16th …….. day of ……November…… 2022

# ACKNOWLEDGEMENTS

I wish to express my sincerest gratitude and appreciation to the individuals who played an instrumental part in this research study:

- My dear family especially my wife, Mpho Sehlako who played a pivotal role in supporting me through the whole MBA journey, it was not easy and thank you for all that you have endured with me through out
- My Son Tshegofatso Letswalo, thank you for transacting these “old dog” into a technocrat in a shortest period when the World migrated to the digital space.
- Dr Pius Oba**,** my supervisor, for his informed guidance and constructive criticism of my work
- Ms Ayanda Magida, our lecturer for ARP, your patience compares to none, thank for your assistance.
- Mr. Dennis Modise, Senior Manager (Human Resource) for unconditionally permitting me to carry out my research and offer the utilisation of the company property
- Top Academic Editing for their professional service in editing the document without changing the content.
- And finally, I would like to thank Palabora Mining Company, my employer and all my colleagues and seniors who participated in the survey and provided honest feedback.

# SUPPLEMENTARY INFORMATION

| | |
|---|---|
| Nominated journal: | L. Barnewold and B. G. (2020).Lottermoser, Identification of digital technologies and digitalization trends in the mining industry, International Journal of Mining Science and Technology, https://doi.org/10.1016/j.ijmst.2020.07.003 |
| Supervisor : | Dr Pius Oba |
| Word count †: | 16556 |
| Supplementary files: | Research instrument<br>Statistical analysis<br>PIS<br>Consent Form<br>Confirmation of Ethics<br>Turn-it-in Report |

† Excluding Abstract, references, etc.

# ABSTRACT

The aim of the study was to explore the perception of Fourth Industrial Revolution(4IR) strategies and practices in relation to production process performance in the mining industries at selected mines in South Africa. The study followed a quantitative research methodology, and a sample of 110 employees at the selected mines in South Africa, consisting of 60 mine workers, 10 information technology employees, 10 middle managers, 10 operations managers, 10 health and safety personnel, and 10 executive officers were drawn using a simple random sampling approach. Primary data was collected using a questionnaire with a 5-point Likert Scale. Data were analysed using the SPSS version 4.1.

Findings from the study reveal that employee level of awareness of the concept of 4IR and associated technologies had a significant impact on how employees perceived the current 4IR strategies. Though findings show that a high percentage of employees were involved in the 4IR strategy development process, most believe that the current 4IR strategies and practices did not fully represent the interests of all stakeholders. While some were of the perception that the strategies and practices were designed to improve productivity and reduce employment costs, others believe that it puts workers' jobs at risk, as mines had started replacing humans with 4IR technologies such as robots and drones. However, findings reveal that the adoption of the 4IR technologies according to the perception of employees, has improved health and safety within the mines.



**Keywords:** Fourth Industrial Revolution(4IR); Employee perception; strategies; practices; production process performance; mining.

# Table of Contents

**DECLARATION** ..... ii
**ACKNOWLEDGEMENTS** ..... iii
**SUPPLEMENTARY INFORMATION** ..... iv
**ABSTRACT** ..... v
**LIST OF ACRONYMS** ..... viii
**LIST OF FIGURES** ..... ix
**LIST OF TABLES** ..... x
**CHAPTER ONE: INTRODUCTION** ..... 11
1.1 BACKGROUND TO THE STUDY ..... 11
1.2 PROBLEM STATEMENT ..... 12
1.3 AIM OF THE STUDY ..... 13
1.4 OBJECTIVES OF THE STUDY ..... 13
1.5 RESEARCH QUESTIONS ..... 14
1.6 SIGNIFICANCE OF THE STUDY ..... 14
1.7 FORMAT OF THE RESEARCH ..... 15
1.8 CONCLUSION ..... 16
**CHAPTER TWO: LITERATURE REVIEW** ..... 17
2.1 INTRODUCTION ..... 17
2.2. MINING PRODUCTION, TECHNOLOGY, AND OPERATIONAL EFFICIENCY ..... 17
2.3 FOURTH INDUSTRIAL REVOLUTION (4IR) ..... 20
2.4 THE IMPACT OF PERCEPTION ON ORGANISATIONAL PERFORMANCE ..... 22
2.5 FOURTH INDUSTRIAL REVOLUTION TECHNOLOGIES ..... 24
2.6. FOURTH INDUSTRIAL REVOLUTION STRATEGIES AND PRACTICES ..... 27
2.7. EMPLOYEE PERCEPTION OF 4IR ..... 31
2.8 THEORETICAL FOUNDATION ..... 32
2.9 4IR OPPORTUNITIES, CHALLENGES, AND BARRIERS ..... 33
2.10. CONCLUSION ..... 36
**CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY** ..... 37
3.1 INTRODUCTION ..... 37
3.2. RESEARCH DESIGN ..... 37
3.3. THE RESEARCH STRATEGY ..... 38

3.4. RESEARCH APPROACH ..... 38
3.5. RESEARCH PHILOSOPHY ..... 38
3.6. RESEARCH METHODOLOGY ..... 39
3.7 DATA COLLECTION APPROACH ..... 40
3.8. VALIDITY AND RELIABILITY ..... 41
3.9 DATA ANALYSIS ..... 43
3.10 PILOT STUDY ..... 43
3.11. LIMITATIONS OF THE STUDY ..... 44
3.12. ELIMINATION OF BIAS ..... 44
3.13 ETHICAL CONSIDERATIONS ..... 45
3.14 CONCLUSION ..... 46
**CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS** ..... 47
4.1 INTRODUCTION ..... 47
4.2 RESEARCH INSTRUMENT ..... 47
4.3. SAMPLE CHARACTERISTICS STATISTICS ..... 48
4.4 FINDINGS, INTERPRETATION, AND DISCUSSIONS ..... 49
**CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS** ..... 64
5.1 INTRODUCTION ..... 64
5.2. FINDINGS FROM THE STUDY ..... 64
5.3 CONCLUSIONS OF THE FINDINGS ..... 72
5.4 RECOMMENDATIONS BASED ON FINDINGS ..... 73
5.6 CONCLUSION OF THE STUDY ..... 74
5.7 FUTURE RESEARCH OPPORTUNITY ..... 75
**REFERENCES** ..... 76
**APPENDIXES** ..... 87
Appendix A: Ethical Certificate ..... 87
Appendix B: Informed Consents Letter ..... 88
Appendix C: Participation information Sheet ..... 89
Appendix D: Research Questionnaire – Instrument ..... 91

## LIST OF ACRONYMS

**4IR** Fourth Industrial Revolution

**ICT** Information and Communication Technology

**KPI** Key Performance Indicator

**PA** Performance Appraisal

**PM** Performance management

**PMS** Performance Management System

**LIST OF FIGURES**


| | | |
|---|---|---|
| Figure 2.1 | Four Stages of the industrial revolution | 21 |
| Figure 2.2 | The top Ten 4IR technologies today | 24 |
| Figure 2.3 | The Well steps engagement model | 29 |
| Figure 3.1 | Research Onion | 37 |
| Figure 4.1 | Gender Distribution | 49 |
| Figure 4.2 | Age Distribution | 50 |
| Figure 4.3 | Highest qualification | 50 |
| Figure 4.4 | Length of service with organisation | 51 |
| Figure 4.5 | Awareness of the concept and technologies of 4IR | 52 |
| Figure 4.6 | Employee involvement in 4IR strategy development | 53 |
| Figure 4.7 | Alignment of 4IR to organisational strategy | 55 |
| Figure 4.8 | Technologies used at the selected mines | 56 |
| Figure 4.9 | Employees Perception of the current4IR strategies and practices | 57 |
| Figure 4.10 | Perception of adopted 4IR Technologies | 59 |
| Figure 4.11 | Perceived ease of use | 63 |
| Figure 5.1 | Number of unsure responses across entire data | 66 |

**LIST OF TABLES**


| | | |
|---|---|---|
| Table 3.1 | Population and sample framework | 39 |
| Table 4.1 | Summary of participant demographics | 48 |
| Table 4.2 | Response Rate | 48 |

# CHAPTER ONE: INTRODUCTION

Like the ongoing Covid-19 pandemic, industrial revolutions served as reminder that sudden emergent changes in the environment can bring about permanent changes in the ways of life both for household and organisations in a way that bring about exposure of organisations and sectors to the possibility of extinction, with a need to reengineer strategies and practices. The fourth industrial revolution is no exception in the delivery of such impact, and so is the mining sector no exception to the phenomenon. As mining companies align themselves to the fourth industrial revolution by adopting appropriate strategies and practices, the perception of individuals of such fourth industrial revolution strategy and practices and how such practices may engender slow adoption or impact on implementation and adoption of 4IR strategies which may have consequences for production performance, may not be overlooked.

The aim of the study is to explore perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the industries at selected mines in view of making recommendation for enhancing productivity. Discussions relating to the proposed topic are discussed in the subsections below, commencing with a brief background to the study, a presentation of the problem statement, and an enumeration of the research objectives and questions. A focus will then be shifted to the discussion on the significance of the study, a preliminary review of literature, as well as the chosen research methodology and design which will be used during the execution of the study. Finally, the chapter structure of the dissertation detailing the chapter-by-chapter organisation along with brief summary of what each chapter contains, will be presented.

## 1.1 BACKGROUND TO THE STUDY

Regardless of the scale of mining activity whether large or small, mining remains a dangerous activity, not just because of the possibility of accidents, but also because the activity comes with exposure to dust and toxins as well as

high stress levels due to the working environment, or pressure from management which often result in a variety of diseases (Stewart, 2020) In a study conducted in mines in Ghana, Kyerematenng-Amoah and Clarke (2016) in evaluating the causes of injuries in the Ghanian mining industry, found that the collapse of the mine pits and falls of ground included most common causes of injury. However, evidence exist that 4IR technologies such as the Internet of Things, robotics, artificial intelligence, and machine learning have the capabilities in providing signalling support after an analysis of underground temperatures that my result in fall of ground, high levels of harmful toxins, in ensuring the safety of mine workers and averting of possible injuries (Hoosain, Paul and Ramakrishna, 2020). However, despite the benefits of the 4IR technologies, most mines are slow to the uptake of such technologies and the full development and deployment of 4IR strategies and practices ((Venter, 2019)), while the mines that have deployed the 4IR strategies and practices have not attained the level of employee motivation and performance expected since the deployment of the 4IR strategies and practices. While some employees have expressed fear of job insecurity, the complete perception of the employees regarding management 4IR strategies and practices within the selected mines, where production processes and activities are concerned are unclear. This has provided an impetus to explore the perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines.

## 1.2 PROBLEM STATEMENT

Even though the Minerals Council CEO Roger Baxter indicate that “Adoption of innovations emerging out of the 4IR did not go into lockdown during the COVID-19 pandemic. In fact, the COVID-19 pandemic accelerated the application of 4IR technologies helping Minerals Council members and others to manage the pandemic more effectively’’ many mines in South Africa are slow to adopt 4IR strategies and practice, along with its technologies. Conversely, mines that have deployed the strategies and practices have met with employee demotivation, with rising feeling of job insecurity being expressed. Perceptions

of employees in these mines that have deployed the 4IR strategies and practices in the production processes regarding the deployment of the strategies and practices in the production processes are unclear, and management of the selected mines fear that this may impact on employee performance, if employee perception of the 4IR strategy and practices in the company is not fully understood, to take proactive action. This has called for an exploration into the perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines.

## 1.3 AIM OF THE STUDY

The aim of the study is to explore perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines, by carrying out a quantitative study, in view of improving mining operation at the selected mine

## 1.4 OBJECTIVES OF THE STUDY

The objective of the study is as follows.

- To determine the perception of employees and management on Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance at selected mine
- To determine employee perception on the adoption of Fourth Industrial Revolution(4IR) technologies on productivity at selected mine
- To offer recommendations to management in selected mines of way of improving mining operations through 4IR strategies, practices and technologies.

## 1.5 RESEARCH QUESTIONS

The research questions are as follows.

- What is the perception of employees and management on Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance at selected mine?
- What is employee and management perception on the adoption of Fourth Industrial Revolution(4IR) technologies on productivity at selected mine?
- What recommendations can be offered to management in selected mines of way of improving mining operations through 4IR strategies, practices, and technologies.

## 1.6 SIGNIFICANCE OF THE STUDY

Through finding from the study, the management of the selected mining companies will benefit, as finding may reveal unique elements of resistance to the acceptance and adoption of fourth industrial revolution strategies and technologies. The study will furthermore reveal positive and negative 4IR practices that may impact on the productivity of employees, and the productiveness of the mining processes positively or negatively, and with such knowledge, management can revise its strategy to reinforce 4IR positive practices and strategies and discourage negative practices in a way that results in better operational efficiency and productivity.

The study would also be beneficial to the world of research, especially in the area of ICT deployment, change management and operations and productions management. These benefits are expected to emerge from findings from the study that contribute to new knowledge, which have not been covered in prior studies.

## 1.7 FORMAT OF THE RESEARCH

This section provides details of the proposed format of the dissertation chapter by chapter. The section also presents a brief summary of what it chapter will be about.

**Chapter One: Introduction**

In this chapter, an introduction of the topic of study will be presented along with the problem statement, aim and objective of the study

**Chapter Two: Literature Review**

A review of existing literature relating to the challenges faced by small businesses will be carried out in this chapter, with the aim of formulating a theoretical background for the study through existing knowledge provided by existing literature.

**Chapter three: Research design and methodology**

In this chapter, the methodology and the research design chosen for the study will be discussed along with the sampling method, data collection instrument, how data was validated as well as the data analysis method chosen for the study, along with how they were implemented.

**Chapter four: Research findings and discussions**

This chapter will provide a detail discussion of the findings from the primary data analysis. Interpretation of the finding will be presented in this chapter.

**Chapter five: Research conclusions and recommendations**

Conclusions and recommendations based on the findings from the primary data analysis and interpretation will be presented in this chapter, recommendation made will also be presented and discussed.

## 1.8 CONCLUSION

This chapter forms an introductory chapter of the dissertation, in this chapter, a brief background to the study and a description of the research problem have been discussed. Furthermore, the study's aims objective and research questions to be answered were enumerated, while the significance of the study along with the chapter structure of the dissertation was presented. In the next chapter, an in-depth literature review will be carried out on investigate perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 INTRODUCTION

In this chapter, a preliminary literature review is presented. Winchester and Salji (2016:308) in highlighting the importance of a literature review in a study, describes a literature review as a systematic evaluation of knowledge provided by prior studies on the topic of investigation. The authors further explain that a literature review is conducted with the aim of providing an in-depth understanding of the subject matter, as well as unveiling the gaps in the literature. While aims at exploring perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines.

## 2.2. MINING PRODUCTION, TECHNOLOGY, AND OPERATIONAL EFFICIENCY

Prior studies have shown that technology permeates different facets of human lives and activity, and its continuous advancement has brought both positive and negative consequences for households, organisations, sectors, and economies at a global scale. According to the (South African National planning commission, 2020). While technology is disruptive, digital technology specifically is developing at an unprecedented rate, bringing about the way work is done, and how humans live and play. The concept of technological determinism forwards the assumption that technology plays a central role in societies' evolve and development, and while technology drives development, policymakers are advised to note that technology has the potential to drive socio-economic inequalities (National planning commission, 2020). The mining sector is no exception to this phenomenon.

In understanding how technology is driving and impacting mining activities, some studies have provided an insight into trends in the mining industry that is requiring the use of technology. A study by Igogo, Lowder, Engel-Cox,

Newman, and Awuah-Offei (2020), reveals that trends shaping activities of the mining industry, and also calling for further adoption of new technologies include the mining industry's interest in renewable energy use in mining operations, the declining of ore grade reflected in the depletion of high-grade and easily accessible ores, as well as the need for operational and production efficiency, requiring new ways and technologies for extracting, loading, hauling, transporting, and processing, minerals at the mines. Other factors relate to volatile Prices, that result in inconsistent production costs. Increasing environmental concerns, that stem from mining activities and their impact on communities and the ecosystem is another factor that calls for the use of mining technologies that can support environmental sustainability, while extracting and processing minerals are concerned. Furthermore, rising political and social concerns, as the mining sector has been found to be constantly under pressure from both shareholders as well as external stakeholders such as international organisations, host governments, local communities, and end-use product producers (metal buyers and their customers along the supply chain) to reduce dependence on fossil fuels and improve their environmental and social performance in the places where they operate (Igogo et al., 2020).

Attempts to isolate the effect of technology and innovation on labour productivity within the mining industry have been around for a while. Analysis of the behaviour of labour productivity in specific mining industries has been carried out in a bid to isolate the effect of innovation. First to introduce the importance of new technologies and innovation in the growth of labour productivity is Tilton and Landsberg in 1999. The authors in studying the decline and recovery of the copper industry in the United States during the 1970s, 1980s, and 1990s, found that labour productivity increase was to be ascribed to the incorporation of the solver extraction and electrowinning technology (SX-EW), as well as the use of larger trucks, shovels and drills, in-pit mobile crushers and conveyor belt systems, computerized scheduling of trucks, and real-time process controls. Aydin, and Tilton (2000), found that technologies such as the hydrometallurgical production method SX-EW have been a contributor to productivity growth in the US copper industry over

the last decades of the twentieth century, so has continuous mining equipment in underground coal mining, along with draglines and bucket wheel excavators in surface coal mining, were key advances to reach new levels of productivity in coal production.

Barnewold and Lottermoser (2020), allude that over time, techniques and technologies for mining have evolved, with mining production processes seeing the use of explosives, and the use of mechanised and motorised mining equipment. When comparing the past to the present where mining activities and performance is concerned in relation to mining technologies and techniques, each technical achievement and its implementation at mine sites have been found to have led to better practices and strong industrial growth (Barnewold and Lottermoser, 2020). Igogo et al., (2020) however, argue that mining industry design and investment structure makes it more difficult to phase out old technologies for more contemporary ones, such as renewable energy and electrification equipment before end-of-mine-life. Diverse terminologies have been found to emerge in mining sectors of the present day, that reflect the level of adoption and implementation of digital innovation. Some buzz words or terms such as ‘‘digital revolution”, ‘‘smart mining”, ‘‘fourth industrial revolution”, and/or ‘‘digitalisation”, have been found to be used to describe technological advancement and associated imminent changes. Barnewold and Lottermoser (2020:747) describe digital mining as **‘‘**the use of computerised or digital devices or systems and digitised data that are to reduce costs, improve business productivity, and transform mining practices’’ Technological advancements however have been found to impact production output, fostering large rates of production, while using the same workforce, or resulting in a direct reduction of the needed for personnel through the automation of different organisational processes (Felipe Sánchez1 and Philipp Hartlieb, 2020).

.

In a study conducted by Barnewold and Lottermoser (2020:747), it was found that while mining companies find it hard to decide which digital technologies meet the needs and requirements of their company, the actual implementation of digital technologies in 158 active surface and

underground shows that there is limited uptake of digital technologies in general and that the uptake increases with the run-of-mine production. While Large-scale mining operations, select and apply digital technologies suitable to their needs, conversely, mines with lower production rates were found not to implement the currently available digital technologies to the same extent.

## 2.3 FOURTH INDUSTRIAL REVOLUTION (4IR)

In a bid to effectively explore perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines, it is imperative to understand what the Fourth Industrial Revolution (4IR) really is and possible trends surrounding its emergence. Prior studies indicate that megatrends shape the future of the world. Frost and Sullivan Consulting (2015), define megatrends as ‘‘transformative and global forces that shape our future world with their impact on business operations, societies, economies, cultures and personal lives’’ According to McKinsey 2020, the world is undergoing a dramatic transition, which can be ascribed to the influence of four major disruptive forces, namely, accelerating technological changes, urbanization, greater global connectivity, and challenges of an aging world. While there is a shift in economic activities to emerging markets such as China, the second force involves the increasing technological impact on using information and communication technology, while the third disruptive force highlights that the human population is getting older and the fertility rate especially in developed countries is decreasing. With consideration to how fast the world is changing due to megatrends, which technological advancement is an element of such megatrend, Markowitz (2019), posits that African countries cannot afford to fall further behind the technological frontier or to worsen the existing digital divides within their borders. Adopting new technologies has been predicted to have the potential to drive rapid and sustainable productivity and economic growth. To this end, policy makes are advised to endeavour to create an enabling environment that supports investments and improvements of information and communications technology (ICT) infrastructure. Data access and affordability, digital skills, and innovation

ecosystems are necessary building blocks for 4IR high-tech investments (Markowitz, 2019). In a paper by the South Africa department of science and innovation (2020:1) the fourth industrial revolution has been described as a revolution characterised by ‘‘a fusion of technologies resulting in the blurring of lines between the physical, digital, and biological spheres’’ these technologies include the cloud technology and big data, internet of things, blockchain, artificial intelligence, and Robotics. While it has been noted that Industrial revolutions are characterized by ‘exponential change’ which are and unstoppable, and with the potential of rendering tried and tested solutions obsolete or ineffective, Quian, Zhong, and Du (2020:156) provide a brief history of the industrial revolution and they change they brought about as depicted in figure 2.1 below.

Three distinct features of the Fourth Industrial Revolution have been identified by Schwab (2016) which include scope, velocity, and systems impact. According to the author, while Velocity refers to the speed at which 4IR technologies are spreading and evolving. Scope refers to the wide range of sectors, industries, and occupations affected by these technologies, and systems impact refers to the breadth and depth of changes that are already occurring and are expected to continue to develop in entire systems of production, management, and governance. Patters of human existence are envisaged, when the velocity, scope, and impact of the 4IR are combined (Schwab, 2016).

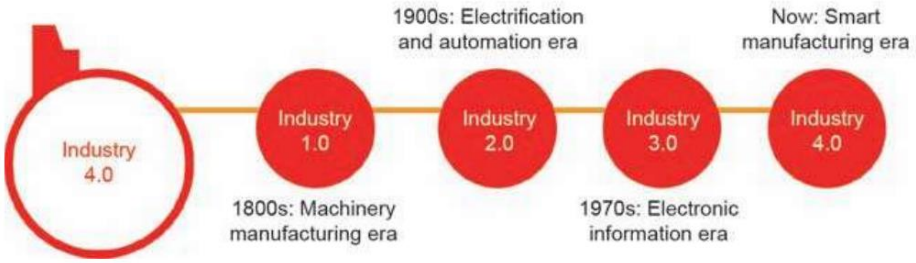



Figure 2.1: Four stages of the industrial revolution

Source: Quian, Zhong, and Du (2020:156)

## 2.4 THE IMPACT OF PERCEPTION ON ORGANISATIONAL PERFORMANCE

As it is the aim of the study to explore perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines, it is imperative to understand what perception is, as a critical element strong enough to impact on the acceptance of the organisational implementation of 4IR practices and strategies, as well as 4IR technologies, which eventually may impact on mining operational efficiency and performance. Saini, Kumar, and Kaur (2020:186), define perception as ‘‘a procedure by which environment and connotation of sensual motivations are identified and construed. Perception can be predisposed by consideration and can occur subliminally, without cognisant cognizance’’. However, other studies have indicated that perception is the unique experience of an individual, as a person can only formulate perception from what is known to them (Mcdonald, 2011). This means that employee perception of 4IR practices and strategies may differ on an individual basis. Though individual perception is key in understanding the behaviour of an employee, especially where the acceptance of 4IR policies and practices are concerned, an employee does not work alone, but with other employees where socialisation is inevitable, which may engender group perception. Walker and Avant (2005), posit that for perception to occur, the following attributes must be present, such as sensory awareness or cognition of the experience, personal experience, and comprehension that can lead to a response.

Prior studies have shown that social influences may affect an individual’s perception, regardless of gender and socioeconomic status (Kimura,2004; and Geary, Gilger, and Elliott-Miller,1992). Sociologists define socialisation as the “multifaceted process through which individuals *learn* and *internalise* cultural norms, codes, and values” (Šaras & Perez- Felkner, 2018). Within the context of the organisation, Organisational socialisation has been described as the process through which “an individual acquires the social knowledge and skills

necessary to assume an organisational role" (Van Maanen & Schein, 1979:211). Drawing from the definitions, employee interaction and knowledge sharing take place in the organisational socialisation process. This may also include the sharing of sentiments, and opinions that may induce a change in the perception of employees within the chain of interaction or socialisation, bringing about an entire group sharing the same perception. This influence of perception is critical to the study, especially where resistance to change due to negative perception, acceptance, and adoption of 4IR strategies and practices are concerned.

Studies have also revealed that perception of risk can inform employee behaviour and response to specific activities and processes. Jaeger et al. (2001, 16), define risk as "a situation or event in which something of human value is at stake and the outcome is uncertain." While Michael and Schopler (1982) defined risk as "the probability of an event occurring together with its consequences". Klinke and Renn (2002,1071) echo this by noting that risk is "the possibility that human actions or events will lead to consequences that damage aspects of things that people value." A study by Grima, Hamarat, Özen, Girlando, and Dalli-Gonzi (2021), which investigated the influence of Risk Perception (RP) and Risk Definition (RD) on the Risk-Addressing Behaviour (RB) of individuals, found that a relationship between employee's risk perception and their employees' level of fear, as well as peer influence level. Taking from the definitions, an understanding of employees' response to 4IR strategies and practices can be further understood, where employee perception of risk is concerned. Employees who perceive the implementation of 4IR strategies as something that puts what they value such as their job at stake and see uncertainty in their future may not want to accept the adoption of the 4IR strategies and practices. Furthermore, perception has been found to impact on employee level of motivation (Zaina, Ab-Rahmana, Ihsana, Zahrima, Norb, Zaina, Hipnia, Ramlia, and Ghopa, 2011), where motivation has been described as the driving force which stimulates an individual to initiate and sustain a behaviour (Saini et al., 2020).

## 2.5 FOURTH INDUSTRIAL REVOLUTION TECHNOLOGIES

For the purpose of this study, it is worth giving a closer look at some of the technologies that make up the 4IR. Hoosain, Paul Ramakrishna (2020:4) identifies what the authors regard to be the top ten 4IR digital technologies of today, as depicted in figure 2.2 below.

The ten top 4IR digital technologies as presented by Hoosain, Paul, and Ramakrishna (2020:4) are discussed below.

### Advanced materials

According to Hoosain, Paul, Ramakrishna, Raza (2021), materials passport is a value tracking tool capable of restoring residual values to the market. Materials Passports always ensures the availability of information, from production stage to purchase, all the way through to use and maintenance. Passports consists of a set of information relating to a specific product, material, or system. The required information relates to properties of the specific product or material, such as physical or chemical, safety data sheets (MSDS, TDS), bill of materials (BOM), logistics, disassembly, and recyclability. Generating a passport involves different stakeholders and companies. Some popular materials passports databases include: Madaster and Buildings as Material Banks (BAMB) (Hoosain, et al., 2021)

### Artificial intelligence

John McCarthy (2006), the father of artificial intelligence described artificial intelligence in the 1990s as “the science and engineering of making intelligent machines, especially intelligent computer programs”. However, according to (Moore, and Mellon, (2020), the term “AI” is generally used to describe machine simulation functions associated with human minds, such as learning and problem solving (Moore, and Mellon, 2020).

### Blockchain

The term “blockchain” from a technical perspective, have been described as a data structure that stores information in blocks and forms a chain in which new blocks are linked to previously formed blocks. First used in the bit coin

cryptocurrency, the blockchain technology was aimed at recreating cash in a digital version in a way that it could be transferred between individuals without needing to involve a third party who will act as an intermediary or one that attests to the transaction (Nakamoto, 2008).

**Cloud technologies**

According to Elameer (2020:1) the term 'CLOUD' '**C**ommon **Location-independent O**nline **U**tility on **D**emand. While Common: implies multi-tenancy no single or isolated tenancy, Utility implies pay-for-use. On-Demand implies infinite, immediate, invisible scalability'' generally, Cloud Computing is a term used in describing a new class of network-based computing that takes place over the Internet, where data and applications are stored on remote servers and accessed using the internet.

**Drones**

According to Gupta (2020) Drones are also called Unmanned Aircraft Systems or Vehicles (UAS UAV) and refer primarily to an unmanned aircraft guided by remote control. Though the earlier designed Drones were created for military purposes, the early-2010s, saw Drones being used for a whole new range of activities, due to their ability reach different kind of environment at low cost. Drones are now being used by countries, governments, and business organisations, for different purposes, which include but not limited to surveillance, rescue operations, delivery of goods to transporting time-sensitive medical supplies, not to mention stock taking in mines

**Biotechnology**

Naz (2015:1) describes biotechnology as 'the use of living things especially cells and bacteria for production of various products for benefiting human beings. It is a combination of various technologies, applied together to living cells, including not only biology, but also subjects like mathematics, physics, chemistry, and engineering'' The application of biotechnology, cuts across different industries. As a 4IR technology, Biotechnology uses advanced genetic

engineering and synthetic biology to develop human therapeutic proteinsm for instance, plant cells are used to express human recombinant proteins with increased safety, production speed, clinical efficacy, cost and scalability (Arzagen, 2019)

**Robotics**

According to World Economic Forum and A. D. Bank, (2017), ‘robotics is an electro-mechanical, hybrid and biological machines supported by Artificial Intelligence (AI) that computerize, augment or aid human activities, autonomously or according to set instructions’’ An intelligent robot has been described as a machine which collects information from its environment and executes the application of knowledge in a significant, safe and purposeful manner (World Economic Forum and Bank, 2017). Robots play a critical role in operations in the mines, as they help ensure the health and safety of employee, for instance, robots can be used for underground movement in an environment that may be too risky for humans, due to the high risk of the ground caving in (Marshall, Bonchis, Nebot and Scheding, 2014).

**The Internet of Things**

While Porter and Heppelmann, (2014) describe the “Internet of Things” as a “reflection of a situation where ‘a growing number of smart, connected products’’ Dobbs et al (2015) in their description of the internet of things describes it as “physical sensors and actuators embedded machines and other objects that have been used for data collection, remote monitoring, decision-making, and optimization processes in all areas from production through infrastructure to health care”

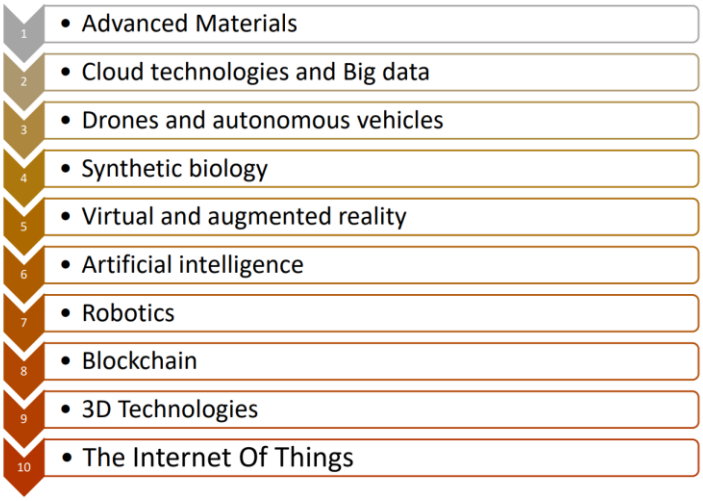



**Figure 2.2:** The top Ten 4IR digital technologies today

## 2.6. FOURTH INDUSTRIAL REVOLUTION STRATEGIES AND PRACTICES

It is imperative for an organisation to have a strategy by which it responds to a fast-changing environment. Bailey (2018) describes a business strategy as the medium through which an organisation determines its long-term direction, area of focus, and how resources will be generated and allocated in a manner that effectively meets the needs of markets which it serves, as well as stakeholders. Abdulwase, Ahmed, Nasr, Abdulwase, Alyousofi, and Yan (2020) posits that if a strategy is to be good, such strategy need to take into consideration variables such as resources, people, power, money, existing barriers, and such strategy must also be consistent with the organisation's vision, mission, and overall goals. It is to be understood that 4IR strategies and practices within an organisation do not happen in a vacuum, as its effect on employees and other stakeholders must be put into consideration, Dombrowski and Wagner (2014) posit that that organizational strategies induced by this fourth industrial revolution, need to give consideration to employee awareness and realignment regarding their integration and cooperation with such ground-breaking digital technologies and the related significances (Dombrowski and Wagner, 2014). While the 4IR strategies translate into practices within the organisation, how employees perceive the 4IR practices may result in positive or negative responses that may in turn have positive or negative outcomes.

- **Health and safety practices**

According to Corfe (2018) the use of 4IR technologies such as the use of robots and connected devices can help make the workplace safer significantly. The author posit that robots have the potential to take on tasks that are dangerous to humans, such as the moving and lifting of heavy objects, while connected devices within the office place can help take the needed breaks from their computers and at the same time help avoid eye strain, The devices are also able to alert employees to move away from their desk and do some excurses. 4IR systems also provide data analytics, artificial intelligence, assistance, while connected devices provide improvement in employee mental health while at work. Al-Rodhan (2015), also found that in the mines, the internet of things along with other 4IR technologies that handled location and proximity sensing and warning, were used to communication, integrate people tracking, video surveillance and analytics, and real-time personal health management to assist mines to continuously improve help and safety, by providing analysis on hazards, incidents, near misses and safety observations.

- **Maintenance practices**

As companies try to emerge from the negative impact if the covid-19 pandemic and meet up with market demands, it is imperative that timely delivery of product to customers are of great importance. This means that mines have to ensure that production activities and systems are not down suddenly, putting pressure on delivery timelines and revenue, Peters( 2017),found in a study that current development in the internet of things aimed at the mining industry will assist mines in predicting downtime, creating real-time multi-dimensional models for optimising the mine layout and operation, expedite decision making and organise all the moving pieces for the most efficient operation (Peters, 2017).

- **Data management practices**

The processes of mining have been said to be characterised by highly hazardous, demanding and complex, which can be ascribed to changing of physical elements such as cold, heat, noise, vibrations, and conditions which are unpredictable for work. the unpredictable conditions of work (Lööw, and Nygren, 2019). (Lööw, and Nygren, (2019) posit that such unpredictable environment, when combined with human error and mining equipment that are defective, and natural hazards can prove to be highly risky. Given that most mining risks arise from the use of heavy mining equipment, as well as occurrences of different forms of energy such electrical, mechanical, other, the overtime contribute to a volatile environment (Lööw, Nygren, 2019). Given the nature of the mining environment described, Wojaczek, and Wojaczek, (2017), indicate that is vital to monitor mining processes, mining site, as well as equipment used, continuously, and comprehensively, with monitoring data collected from different sources which relate machinery monitoring systems, employee locations, working environment. This provides a reason for the digitisation of the mining processes for data collection that will assist in controlling mining activities and improving productivity is vital (Lööw, Abrahamsson, and Johansson, 2019). Ghattas, Soffer, and Peleg, (2014) posit that acquiring large amount of data from machines used in the mining process, allows for the mine managers to have a more complete picture and deeper knowledge of the how efficiently mining processes are carried out, especially data relating to geometrical dimensions of the excavation, and a detailed operating state of machines. While the collected data should relate to a particular process and should be analysed within the context of the process, in a bid to in-depth efficiency analysis (Brzychczy, Gackowiec and Liebetrau, 2020), the outcome of the analysed data provides support to managers for effective decision making especially regarding areas where efficiency need to improve are revealed (Ghattas, Soffer, Peleg, 2014).

**Other operational practices and activities**

- **Planning**

Integrated Real Time Resource Planning: An Opportunity across the value chain to work on the recurrence of mine planning and scheduling through computerized surveying and reconciliation of assets combined with gear, material and labour force tracking and visualization, would empower ideal coordinating of assets and machinery, which requires planning and performance management. (Venter, 2019)

Adaptive mining Planning: Mines as of now accumulate mineral body data from various sources, including drill hole information and face inspections. Joined with geographical data, the opportunity presented is to utilize modern data analysis methods to comprehend this better and to do so faster. This will empower fast transformation of mining intends to build yield effectiveness and decrease non-productive mining time. (Venter, 2019)

- **Automated SHEQ processes and predictive safety:**

Wearable equipment empowers worker fatigue monitoring and correspondence, joined with position tracking, digital compliance, logging, and intellectual prescient examination of safety incidents can assist with diminishing utility utilization, improve functional proficiency, and drastically decrease safety incidents. (Venter, 2019)

- **Short interval control:**

Near real time tracking of execution against plan at an assignment level. This will empower authority to oversee procedure on input measurements and leading performance indicators and give the perceivability to eliminate execution waste. (Venter, 2019)

## 2.7. EMPLOYEE PERCEPTION OF 4IR

As organisations respond to changes that may emerge from the internal or external environment, which may require the development and deployment of new strategies and processes, understanding employee perception of changes becomes imperative to the success of such strategy and new practice. The response of the mining industry to the movement into the fourth industrial revolution has not been an exception. A myriad of studies has been conducted on how employees perceive the changes that accompany the fourth industrial revolution, especially where the increased use of technologies such as Artificial intelligence (AI) and Robots are concerned. While Kovacs, (2018), posits that 4IR strategies and practices must form part of an extraordinary socio-economic configuration, the author highlights that 4IR comes with unexpected consequences the stem from automation, and security uncertainty. In a study conducted by Soukupová, Adamová1, Krninská1 (2020) Czech Republic aimed at testing employee perception of 4IR, found that in the Czech employees perceive the 4IR a potential threat to their existence. The study also found that the perception however differed on the across demographic variables such age, gender, education, and the job position of the employees. However, most employees perceive the 4IR to be causing increase in job losses, as employees substitution humans with robots, and this may result in barriers to implementation of 4IR. Another study, found that employees perceive that 4IR technologies would bring about a pay-cut, given the efficiency of machines over that of humans (Stentoft et al., 2019), While employee perceive a lack of trust from employees, in the implementation of 4IR strategies and practices, in the production process, as employees use connected devices to monitor workers in a manner employees deem intrusive, as these devices also have the capacity to monitor after hours activities, including evenings, holidays and weekends (Corfe,2018).

## 2.8 THEORETICAL FOUNDATION

This section presents a discussion on the theoretical foundations on which the study is anchored as presented in subsections 2.7.1 and 2.7.2 below.

### 2.8.1 The Technology Acceptance Model (TAM)

While the study is aimed at exploring perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the industries at selected mines it is imperative for such perception to support the adoption and use of 4IR mining technologies, along with 4IR strategies and practices in the selected mines. Liao, Hong, Wen, Pan, and Wu, (2018), explain that the Technology Acceptance Model (TAM) gives reason and explains what can prompt organisation or any individual to take a decision to adopt and use a particular technology. As introduced in 1985 by David, the Technology acceptance model was developed in view of providing an explanation as well as predicting why a specific information technology can be acceptable. The model was also to help explore and examine factors that determine the acceptability of information technology. In the Technology Acceptance Model, it is indicated that the perceived usefulness (PU) and perceived ease of use (PEOU) of information technology, are two main factors that influence the behavior, attitude as well as the decision of an individual or organisation to adopt, acquire and use a specific technology. The technology acceptance model is relevant to this study, as it helps provide an evaluation of the perception of employees at the selected mines, where the acceptance and adoption of new and innovative 4IR technologies and related strategies and practices in the selected mines are concerned.

### 2.8.2 The theory of creative destruction

As revealed from prior discussions, different industrial revolutions have in one way or the other brought about the disruption of old ways of doing things or entire industries. Charles Schumpeter's theory of 'creative destruction' dating back to the 1940s, continues to be relevant to technological development. Schumpeter postulated that while advancement in technology

will bring about new opportunities, for growth and employment in emerging technologies and industries, it will also bring about a decline in employment opportunities in traditional industries (Markowitz, 2019:6). This has been found to be true, especially in African countries While the adoption of the 4IR has the capability of bringing about benefits such as efficient production across Africa, increased automation can also put jobs at risk. Traditional paths to economic development have all followed a similar trajectory from the Second Industrial Revolution: manufacturing underpinned by low-cost, labor-intensive production, which creates mass employment. However, these growth paths are now threatened by the automation of low-skill activities. According to a 2019 McKinsey report, the importance of labour cost advantages in determining production locations has declined, and only 20% of goods production is currently based on labour–cost arbitrage. Countries' industrial development strategies across many sectors in Africa are being impacted upon, as Low-skill production outsourced to emerging markets is increasingly insourced closer to home markets. Considering the fact that there is inherent uncertainty in future technological developments predicting what impact technological change would have on employees is not possible. However, evidence exists that the competitive advantage of an organisation can be determined by where there are high levels of digital skills, as the demand for technically skilled employees is predicted to reach a high of 55% by 2030. This will also increase the need for more longer-term policies and strategies relating to 4IR technologies (Markowitz, 2019:6)

## 2.9 4IR OPPORTUNITIES, CHALLENGES, AND BARRIERS

Though the fourth industrial revolution has been found to hold many benefits, as noted in discussions from previous sections, evidence exists of ongoing challenges, impending challenges as well as variables that serve as barriers to the deployment and uptake of the 4IR. Wolf, (2015), highlights that the fourth industrial revolution poses challenges to the labour markets, as it causes disruption of the markets, citing the automation processes which substitutes for labour across the entire economy, and the net displacement of workers by

machines that may result in the exacerbation gap between returns to capital and returns to labour. The author further explains that as digital technology continues to drive the era of the fourth industrial revolution, the most scarce and valuable resources will neither be ordinary labour or ordinary capital, as the future, will see talent, more than capital, become the critical factor of production (Wolf, 2015). The desire and pursuit of talents will engender an increasingly segregated job market, as computers and digitisation replace low-skilled and low-wage jobs, which may further lead to an increase in social tension (Wolf, 2015). In the same vein, Wolf and Lambert, (2017), posit that the threat of massive job displacement resulting from the ongoing fourth industrial revolution is bringing about a variety of challenges relating to risk assessment, cybersecurity, hacking, and others (Wolf and Lambert, 2017). While other studies agree that the 4IR may result in massive job losses, recommendations have been made on how governments of nations can avert such danger. A study by Zervoudi (2019), advises that governments should invest in education and training of employees of all ages to be able to better their adaption to new technologies and digitisation, and if exposure of employees to the risk associated with automation is to be averted and mitigated. The author proposes that to mitigate the negative impact that may result from digitization on a country's labour force, the government should carry out different forms of interventions which can include providing practical training and education to children and young people in new technologies, which can help them be able to enter into the labour market with the relevant skills and knowledge. Secondly, professionals should be trained through the practical training of professionals should be provided with practical training through job-related re-skilling and up-skilling programs so as to help people to get familiar with new technologies and become more competitive in labour market, Thirdly, there should be a direct link established between education and the labour market the Fourthly, the government should increase training programs in the areas of Science, Technology, Engineering, and Mathematics, and encourage the participation of young people in the program, finally, there should be the establishment of internships and practice for young people, in order to help them gain work experience during their studies, while adult long-life learning should also be encouraged (Zervoudi, 2019).

It has also been revealed that the issue associated with the emergence of the Fourth Industrial Revolution is the possible widening of the income inequality gap, as global income inequality is currently said to be high, with the richest 8% of the world's population earning estimated to earn half of the world's total income and the remaining 92% of people the other half. The widening of the income inequality gap has been ascribed to variables such as rapid technological advancement and the introduction of new technologies across all sectors, including factors such as the inadequate regulation of financial integration and the growing competition in product and service markets. Furthermore, education has also been found to widen the income inequality gap, most educated and highly qualified employees possess the ability and the skills to adapt well to automation, thereby ripping the benefits of technological achievements. People with already high income, skills and wealth will be further favoured by the significant increase of their assets' value because of the technological progress. Conversely, low-skilled workers will experience unemployment and constant downward pressure on their wages and their income, and they will be most negatively affected by the implementation of the Fourth Industrial Revolution strategies and practices (Zervoudi, 2019).

Goode (2018), noted that there is an increased interconnectedness of devices in the daily lives of people today, which is an indication of much technology in the fabric of society. The author further alludes that interlink of things using IoT will exponentially increase the vulnerabilities that already exist in different networks, and connections and burden of connectivity, systems would need more security. Further, companies would need to put systems in place to continuously assess risk and determine the acceptable level of risk, and how the risk should be managed, as human error, acts of nature can become unintentional sources of risk can cause connectivity vulnerability and disruption (Goode, 2018)

While resistance to change and adoption of 4IR technologies have been highlighted as a barrier for 4IR adoption (Liao et al., 2018) A report by the Australian Local Government Association, (2018) identified critical skill shortage as a challenge and a barrier to the development of 4IR in South Africa,

as there is a shortage of skills in areas such as Science, Engineering, and Technology.

## 2.10. CONCLUSION

The section of literature review has presented a preliminary review of existing literature and the knowledge provided by prior studies on exploring perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines. In the section, the chosen research methodology and design are presented.

# CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

## 3.1 INTRODUCTION

This chapter discusses the research methodology and design used during the execution of the study. The subheading of the chapter commences by discussing the research design for the study, and reasons for its suitability to the study, and further subsections discuss the research philosophy, strategy, target population, sampling, the research instrument used for the study, pilot study, design and administration of the questionnaire, data analysis method, the validity and reliability assurance of the study, limitation of the study, elimination of bias, and finally, the ethical consideration for the study.

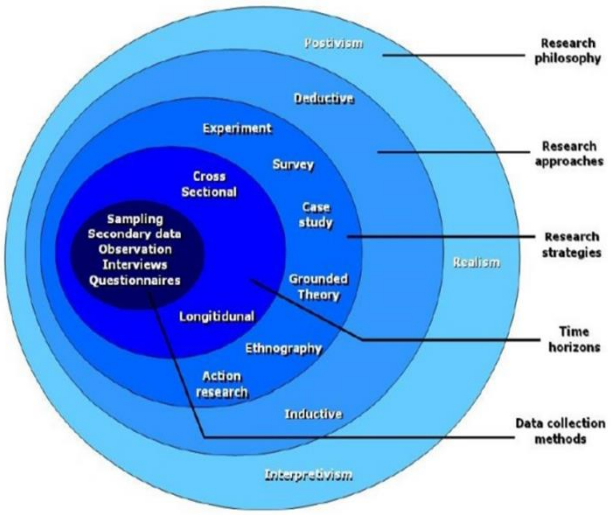



**Figure 3.1: Research onion**

**Source:** Thesismind (2019)

## 3.2. RESEARCH DESIGN

Exploratory research design was chosen for this study, because the design allowed for the in-dept probing of participant in a bid to have a deeper understanding of the factors affecting the growth possibility of Telecom companies in the South Africa Telecommunication industry. The research design also supports the qualitative research method chosen for the study.

## 3.3. THE RESEARCH STRATEGY

### 3.3.1 Survey design

A cross-sectional survey will be use in this study. The motivation behind this choice is that a cross-sectional survey allows for the collection of quantitative data and follows a quantitative research methodology

## 3.4. RESEARCH APPROACH

In this study, the quantitative research approach was followed. The implementation of the study, with samples drawn from selected mines in South Africa. The choice to use the quantitative research methodology was motivated by the fact that the qualitative research approach supports the use of a questionnaire in the collection of primary data and also support data analysis tools that allows for numeric computation and analysis.

## 3.5. RESEARCH PHILOSOPHY

The term prominence refers to what is ‘posited’ that is ‘given’. This shows the positivist’s focus on strictly scientific empiricist method designed to reward clean data and facts that are uninfluenced by human interpretation or bias. Saunders et al. (2016) positivist can be the positive impact of variable put to place to foretell links between variables. Saunders et al. (2016) also stated that it is impartial that it contains numeric measurements or statistics to examine primary phenomenon. It requires research to be valid and its realistically measurable, its strong point in delivering quantitative facts and numbers that are correct; therefore, it will be accommodated in this study.

## 3.6. RESEARCH METHODOLOGY

### 3.6.1 Target population

In this study we will be targeting 400 employees from selected mines in South Africa consisting of 150 mine workers, 50 information technology officers, 50 middle managers, 50 operations managers, 50 health and safety officers, and 50 executive officers.

### 3.6.2 Sampling strategy

To draw 110 samples from the target population of 400 employees at the selected mines in South Africa, a simple random sampling approach was followed. The motivation behind selecting this technique is that it is suited for a quantitative research approach for this study.

**Table 1: Population and sample framework**

**Table 1: Population and sample framework**

| Department | Population | Quantitative sample & method |
|---|---|---|
| IT employees | 50 | 10 |
| Health and safety personnel | 50 | 10 |
| Middle managers | 50 | 10 |
| operations managers | 50 | 10 |
| Mine workers | 150 | 60 |
| Executive personnel | 50 | 10 |
| Total | 400 | 110 |

The use of a quantitative research approach for this study served as motivation for applying a probability sampling method for sample selected. From the 400 employees at selected mines, 110 were randomly selected from the target

population, from the employee registers, and consisted of a sample of 60 mine workers, 10 information technology employees, 10 middle managers, and 10 operations managers, 10 health and safety personnel and 10 executive officers.

**Source: Researcher**

## 3.7 DATA COLLECTION APPROACH

Using questionnaire primary data was collected, where together with a consent latter, 100 questionnaires were sent to randomly chosen participants through email from the database of the selected mines. The management of the department, prior to sending the email, had already informed the employees of the study and its purpose, and had encouraged participation. A duration of up to a week was given to the employees of the study to finish and submit either by use of email or hard copy. On indication of interest by prospective participants, a consent latter was sent first, followed by the questionnaire, once the consent letter was signed and returned by the participant. Closer to the due date of receiving the questionnaire from participants, emails were sent to interested participants as a reminder of the due date. After the due date, if the people who received the questionnaires still did not return them, they were considered as non-responses. An email which was created as a depository, where participants could drop completed questionnaires, while hard copies were collected by hand, or scanned and sent by the participants. Completed questionnaires were then moved into a folder in preparation for cleaning, capturing, coding and analysis. 130 questionnaires were sent out and 110 were returned.

### 3.7.1 DATA INSTRUMENT

Based on Saunders et al. (2016) says that data collection instruments can be defined as a tool utilised in the collection of primary data from respondents in the study. An interview is a perfect tool in qualitative research for collecting primary data whereas a questionnaire is a perfect tool in collecting primary data

in a quantitative research approach. According to a definition by (Kabir, 2017). Kabir (2017) a questionnaire is an instrument of research which entails a series of questions aimed at collecting information from respondents aiming at reaching goals and objectives.

For this study a questionnaire will be selected due to the fact that it is inexpensive and is a perfect tool for primary data collection in a quantitative research approach

The questionnaire consisting of 32 questions in total, allocated in three different divisions which are, section “A”, “B1” “B2” and “B3” Section “A” entails four demographic questions, Section “B1” entailed of 17 5 scale Likert questions, based on the study objective one… Section “B2” consist of “9” questions based on the 5 point Likert Scale, based on research objectives two and section “B3” consist of 6 questions based on a 5 point Likert Scale (rating scale) and based on research objective 3.

## 3.8. VALIDITY AND RELIABILITY

To ensure reliability and validity of the research instruments utilized for the collecting data, a reliability and validity test will be conducted and to ensure the reliability of the results from the results. In the subsection below we discuss how validity and reliability will be maintained.

### 3.8.1 Validity test

This is when a research instrument measures the extent to its anticipation to measure (Kubai, 2019).theoretical and empirical evidence can be measured through the utilization of a validity test. Just as theoretical examinations consist of translation or representation of a concept in an operational form. The bases of validity on a quantitative analysis involving statistical methods are included in empirical examination. (Kubai, 2019).to ensure validity in the study a pilot study will be done through caring out different validity tests, which is discussed in the subsection below.

#### 3.8.1.1 Construct validity

This is when suggestion can in a correct way be made from the operation in a study of a theoretical construct on which are the bases for that operation (Trochim, 2020). Construct validity is set to confirm the differences between people who lack other features (Fink, 2020), research questions will therefore be deeply examined by experts in the information communication technology. It is then ensured by the operations management that the goals of the study are reached, and concepts and constructs are not stolen.

#### 3.8.1.2 Content validity

According to Middleton this is where whether a test defines all the aspects of the construct is analyzed. The contents of a trial, survey or measurement methods must include all relevant pieces of the subject it aims to measure so that it can benefit reliable results. In the absence of other relevant aspects of the measurements, validity is vulnerable. Although the study assumed a 5 scale Likert tool for primary data, the content and the score allocated to each question still makes it mandatory to be verification. It was then required of experts to spot the importance of an item when operating a construct in a set of items and score them in a rank of, essential, to useful but not important and not important. This will be ranging from 1 to -1 whereby 1 is a full agreement of members of the panel and so on in a descending manner with -1 being non agreement (Zamanzadeh et al: 2015).

#### 3.8.1.3. Convergent and Discriminant validity

Convergent validity comparison on observed values of one indicator of one construct with others of the same construct will be done to successfully attain comparison.

Discriminant validity will be attained by indicating that pointers of one construct are different. A statistical procedure called bivariate correlation will be applied to analyse items on the questionnaire using exploratory factor analysis for convergent and discriminant validity.

According to Carlson et al. (2012), convergent validity it is a sub of construct validity. This is where the construct aiming to measure a certain construct is the construct itself. It then measures two constructs that are alike and show that

they are related. Conversely, discriminant validity exposes when two measures which are perceived to be related actually aren't.

#### 3.8.1.4. Criterion-related validity

The extend of correspondence between a test measure and one or more external referents (criteria) by correlation (Mohajan, 2017). For example, when students wrote an examination and got marks and then were questioned about their marks. A correlation will be performing among the test marks obtained and the significance in order to try out the criterion-relatedness variables.

## 3.9 DATA ANALYSIS

### 3.9.1 Descriptive analysis

Loeb, et al., (2017) defines a descriptive analysis as the transforming of raw data into a form that can be understood and interpreted easily, where determination of rearranges, order and data manipulation that provide descriptive information is concerned. In the study, descriptions will be carried out using averages, frequency, range and standard deviations in a way that reveals patterns within the data.

### 3.9.2 Inferential Analysis

The study will carry out a Pearson Correlation. correlation analysis in determining the relationship between employee perception of 4IR and production performance at the selected mines. The study will also carry out other analysis and test such as the Bi-variate Regression analysis

## 3.10 PILOT STUDY

Creswell (2015) says that this is where primary data is collected prior to the main research. According to (Doody and Doody, 2015:1074) a pilot study is a smaller vision pre-study conducted with a smaller group of participants similar to the larger group for the actual study.

This study aims to test the possibility of the success of research through testing a smaller scale of participants by taking them through the actual research procedures, testing the responses of participants, contents of the questions, face validity and the feasibility of using technology in a questionnaire administration (Doody and Doody, 2015). thereafter there will be 10 participants selected as sample for the pilot study that are from the target population spotted in this study. The selected research approach for the study is qualitative whereby in conducting this study it will assist in the establishment of validity of the research and spotting items that are not quite perfect.

### 3.11. LIMITATIONS OF THE STUDY

Baker and Edwards (2015:10) says, due to lack of time when the study is conducted, the size of the data pool where from samples are extracted may be significantly small. The study is constituted by time constrains to extract and test a larger sample which also affects the feasibility of generalizing the findings in a larger target population.

### 3.12. ELIMINATION OF BIAS

Provocative an ambiguous words are shunned in an aim to ensure that bias is removed from the study. Also, in the process of structuring questions for the questionnaire imprecise words are left out to avoid them causing confusion for the respondent where the respondent might end up not responding in a correct way or not responding at all. Questions that may result in causing emotional harm or tent to be discriminatory towards the respondent's gender, cultural or religiously believe were shun as well. To keep the responses of the participants authentic, the study ensures that there are no leading or complicated questions posed to the participants

## 3.13 ETHICAL CONSIDERATIONS

Ethical considerations constitute a manner in which humans and animals are handles when participating in the study Vanzyl (2014. The research follows the law in place by considering the variables mentioned: include requirements on daily work, the protection of dignity of the participants and the publication of the information in the research (Fouka & Mantzorou, 2011:3). Below are the requirements to meet the research ethics:

### 3.13.1 Informed consent

For this study participants were fully prepped on what is to be required from them, where the information will be going and how it will be used and what penalties my come from it. This will be done through a letter with a fully detailed information which will be provided to participants which also allows them to make sane decisions to participate which are intentional and rational .this is what is included in the concept form: the reason why the study is conducted; time it will take to complete the projected; procedures followed in the study; information entailing the right of the participant to decline or pull out; prospective remunerations from the research and contact details of the person responsible for answering questions. The participants then sign a consent to confirm their understanding of what will take place in the study and what their rights are which the consent will thereafter constitute a contract between the researcher and the participants. A short carefully presented information sheet will be used to obtain the informing aspects of the consent.

### 3.13.2 Ensuring no harm comes to participants.

The study ensures the wellbeing of the participants by protecting them against questions that may trigger emotional disparities or even create stress for them. Identities of participants were kept secret to protect them from any physical or mental harm posed to the by the public or people who might not like their responses to the research questionnaire, and they were also the questionnaire is formed in a way that will prevent respondents from any sort of embarrassment, victimization, fear, offence and any mental or psychological harm.

### 3.13.3 Anonymity and Confidentiality

The terms confidentiality and anonymity are related but they differ in concepts. Sim & Waterfeld (2019) Say that in confidentiality the information given by the respondent is kept a secret whereas in anonymity the respondent's identity is kept a secret. To uphold confidentiality, all the information acquired from the respondents will be kept in protection, by way of not asking them to fill out any questionnaire be it electronic or hard copy that is not part of r from the research. And also, all completed questionnaires in hard copies are locked up in a safe while soft copies are locked up with a pass-word.to ensure anonymity, questionnaires do not require any information to do with the respondent's names, physical or postal addresses and their names are not disclosed in the course of the analysing and publicizing the report.

### 3.13.4 Ensuring that Permission is obtained.

Bargaining for access to participants and obtaining information from the company that will be helping in the collection of data, are too the most vital parts of the study. Through a proper request for permission to perform a study, it is vital that official channels are opened. Ethical clearance will be taken to the university after permission has been granted from selected mines to do the study.

## 3.14 CONCLUSION

In this chapter, discussions relating to the research philosophy, design and strategies chosen for the study, as well as samples and target population for the study. In the chapter, the research instrument as well as data collection approach was discussed. The administration of the questionnaire, pilot conducted before the major study, data analysis approach applied in the analysis of collected data, hoe reliability and validity were ensured, as well as the limitations of the study, along with how bias was address in the study was discussed. Finally, ethical consideration which were considered during the study were discussed.

In the next chapter, results from the analysed data, along with interpretations and along with relevant discuss will be presented.

# CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

## 4.1 INTRODUCTION

The aim of the study was to explore the perception of Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines, by carrying out a quantitative study, in view of improving mining operation at the selected mine. Qualitative primary data was collected to this effect. In this chapter, the analysis of the quantitative primary data collected, and the statistical test conducted will be discussed along with relevant interpretations. Relevant literature will also be used to provide evidence supporting the findings, as results are presented based on the predefined objectives of the study.

The chapter is guided by the following research questions:

1. What is the perception of employees and management on Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance at the selected mine?
2. What is employee and management perception on the adoption of Fourth Industrial Revolution(4IR) technologies on productivity at selected mine?
3. What recommendations can be offered to management in selected mines of the way of improving mining operations through 4IR strategies, practices, and technologies

## 4.2 RESEARCH INSTRUMENT

### 4.2.1. Reliability

In ensuring reliability, a Cronbach's reliability test was carried out. Results from the rest show the reliability of the instrument is good, as it shows a reliability coefficient of 0.902, based on 5 tests, for 4 items tested (0.881), on 3 items tested (0.304), on 5 items tested (0.773) items, on a further 4 items (0.571).

Sürücü and Maslakçi (2020:2695) describe “reliability” as an indicator for measuring the stability of values obtained by measuring the same value more than once, under the same situation applying the same instrument.

## 4.3. SAMPLE CHARACTERISTICS STATISTICS

**Table 4.1.** Sample Characteristics Statistics

| | | | | | |
|---|---|---|---|---|---|
| Kurtosis | -1,082 | -1,005 | -0,678 | -0,677 | -0,898 |
| Std. Error of Kurtosis | 0,472 | 0,472 | 0,472 | 0,472 | 0,472 |
| Minimum | 1 | 1,00 | 1 | 1 | 1 |
| Maximum | 5 | 5,00 | 5 | 5 | 5 |

**Source: Questionnaire**

### 4.3.1 Response Rate

**Table 4.2: Response rate**

| **Responses** | **Frequency** | **Percentage** |
|---|---|---|
| Responses | 40 | 40% |
| Nonresponses | 60 | 60% |
| **Total** | 100 | 100% |

**Source:** Questionnaire

As indicated in table 4.2 of the 100 questionnaires administered, 40 questionnaires which represented 40% of the questionnaires were successfully completed and returned, while the other 60% accounted for a number of nonrespondents.

## 4.4 FINDINGS, INTERPRETATION, AND DISCUSSIONS

Discussions in the section and subsection below focus on providing results from the demographic data of participants in the study, along with relevant interpretations.

### 4.4.1. Demographic Data

As shown in figure 4.1, primary data indicated a higher male representation at 82%, with female representation at 18%. The result is relevant to the study in that it eliminates the problem of bias as samples were randomly selected. The results also provided a means of determining the gender differences in perception of 4IR technology adoption. However, while the result may seem to give an impression of a male-dominated work environment, such conclusions cannot be justified, given that the sample size is rather small.

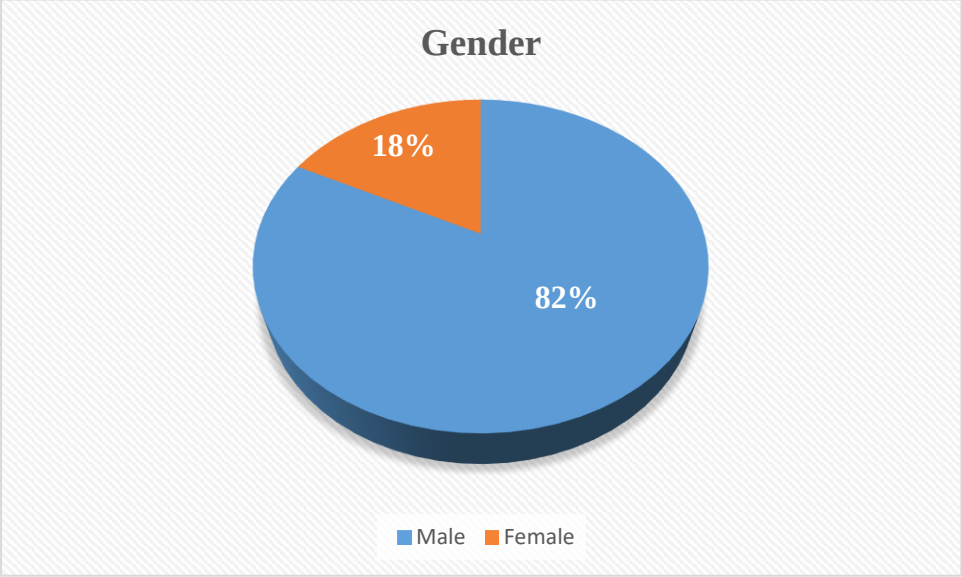



**Figure 4.1: Gender**

**Figure 4.2** below provides the age categorization as well as representation in the study. As indicated in figure 4.2, there were no participants between the ages of 18 to 24 years of age that took part in the study. While participants between the ages of 25 to 34 years of age made up 10% of the total number of

participants, participants between the ages of 35 to 44 years constituted 50% of the total number of participants. A further 30% of the participants were between the ages of 45 to 54years, the remaining participants who made up the rest of the 10% of the total number of participants were 50 years and above. While the result provided a means of identifying the difference in perception of 4IR adoption that might be induced by age differences, it did not give a true picture of what the dominant age group was at the selected mines.

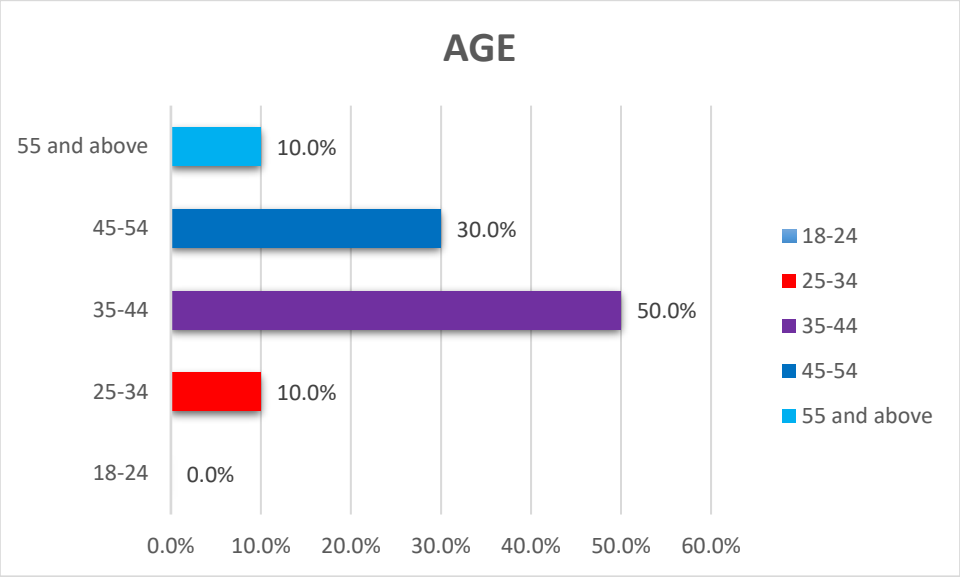



**Figure 4.2: Age**

Results from primary data as indicated in figure 4.3 above revealed no representation of participants with certificates. While 2.5% had matric certificates, 15% had diplomas, a further 45.0% had degrees, while the other 37.5% had post-graduate qualifications. A closer examination of the result reveal that at least 97.5% of the participant had a junior degree, while only 2.5% had high school qualifications. The relevance of this result to the study is that it provides a description of levels of education considered by the study to be sufficient to be able to read, comprehend and provide answers a view on the subject of investigation.

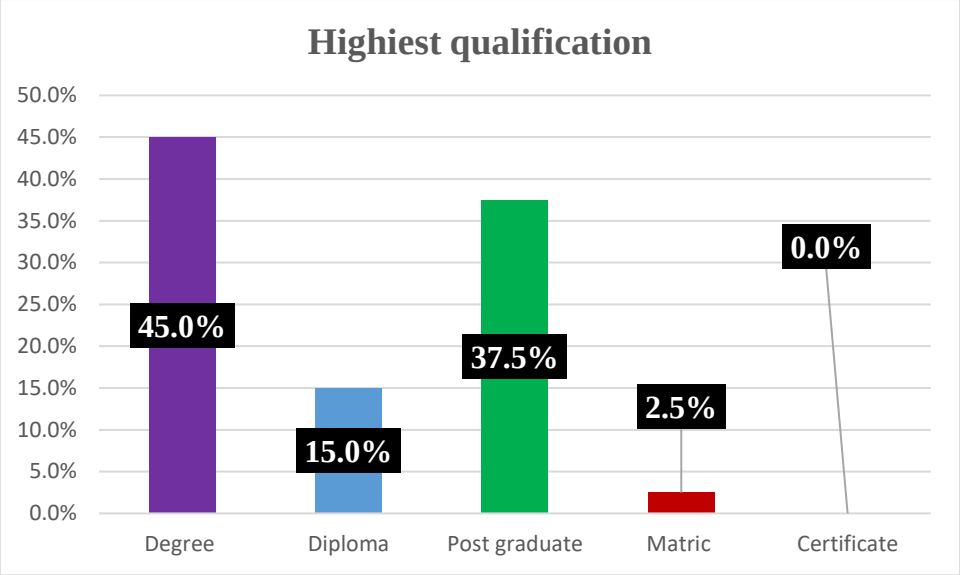



**Figure 4.3 Highest qualification**

As indicated in figure 4.4 below, while 17.5% of the participants had been in the organisation for a period between one to five years, a further 17.5% has also been with the organisation for a period between six to ten years. Other participants had been with their organisation for a period between 11 to 15 years, another 10% between 16 to 20 years, while the remaining 10% had been with their organisation for a period of 21 years and above. This means that about 82.5% of the participant have been with their company for at least not less than 6years. This period is considered long enough by the study, for a participant to have been exposed to the transformations where the use of ICT within their mines and their production process is concerned. Furthermore, while the study provides authentication of data, it served to ensure that data collected from participants truly reflect the current situation of the selected mines, where 4IR strategies and technology adoption are concerned.

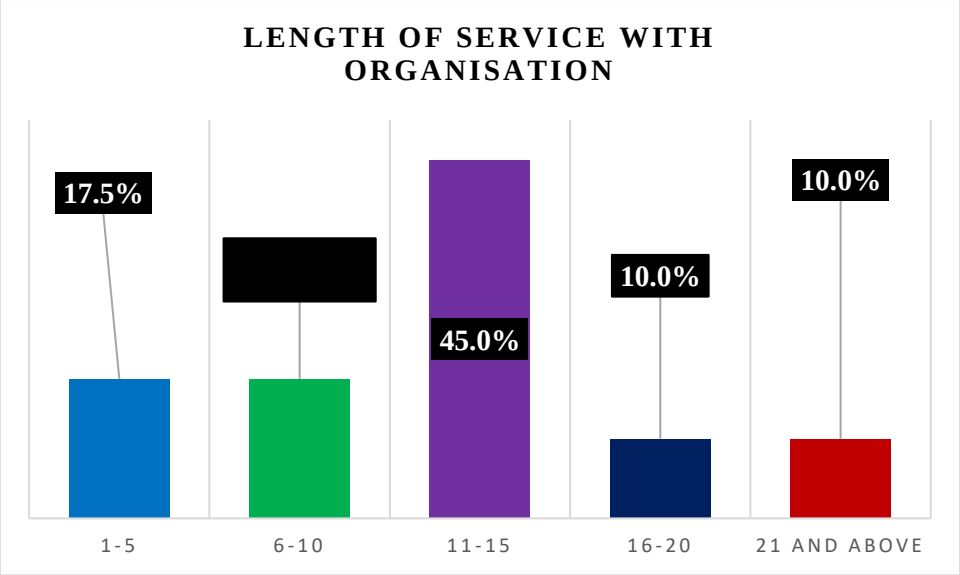



**Figure 4.4: Length of service in the organisation**

**4.4.2 Research question 1:** perception of employees and management on Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance at selected mine

**4.4.2.1 Employee awareness of the 4IR concept and technologies**

In a bid to have an in-depth understanding of what employee perceptions are with regards to the 4IR strategies, practices, and use of 4IR technologies in the production process are, it was imperative to understand the foundation on which such perceptions were formed. Questions related to employee awareness of the concept of perception as well as what types of technologies constitute 4IR were posed to respondents.

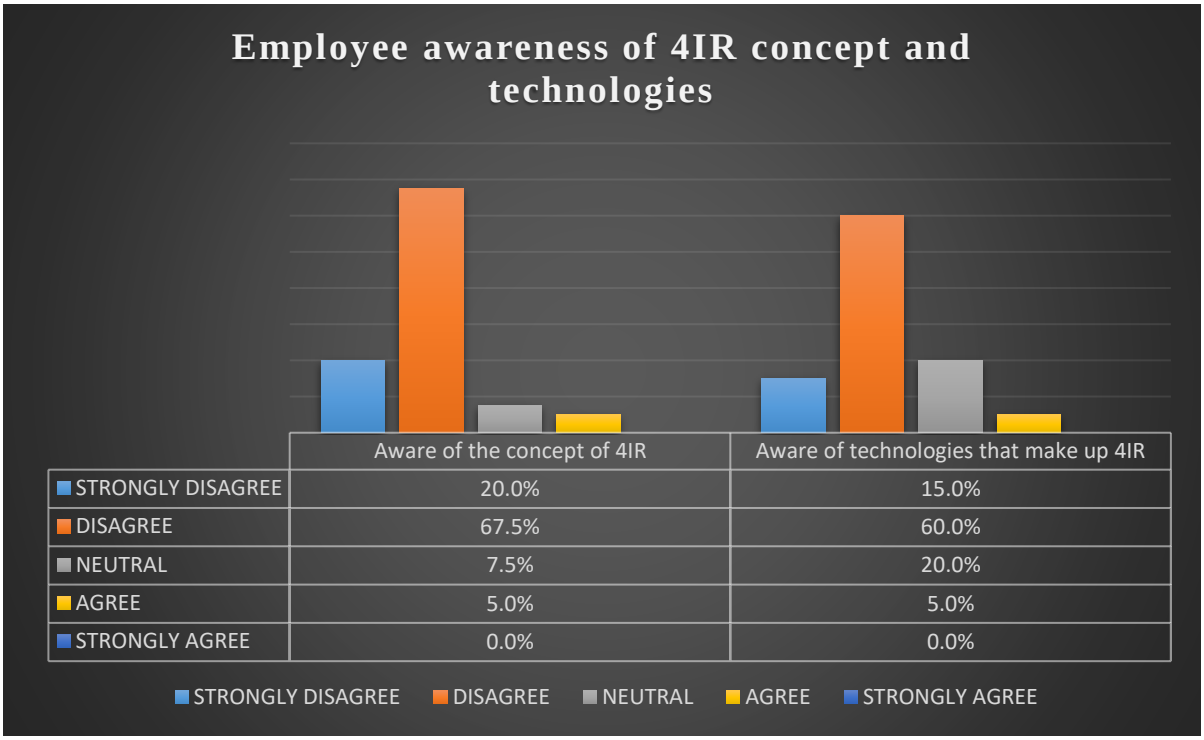



**Figure 4.5** Awareness of the concept and technologies of 4IR

Results from analysed data revealed that while 20% strongly disagreed with having any form of awareness of 4IR, a further 67.5% owned up to the fact that they were not aware of the concept of 4IR. While 7.5% remained neutral, 5% agreed to be aware of the concept of 4IR. The result was quite a revelation, as it revealed that 87.5% of the participants were not aware of the concept of 4IR, considering that these technologies are being deployed at the mines where they work. It came as no surprise that results in relating to employee awareness of existing 4IR technologies revealed that 75% of the participants said they had no knowledge of the different 4IR technologies that exist, while 201% were neutral, only 5% agreed that they had knowledge of 4IR, a percentage consistent with the number of participants that said they are aware of the concept of 4IR. While Mcdonald (2011) posits that perception is the unique experience of an individual, and a person can only formulate perception from what is known to them, Walker and Avant (2005), highlighted that for perception to occur, attributes present, such as sensory awareness or cognition of the experience, personal experience, and comprehension that can lead to a response must be present.

#### 4.2.2.2. Employee involvement in the development of 4IR strategies

Results from primary data however reveal contradictions and inconsistency, as indicated in figure 4.6. following prior findings that reveal that a high percentage of employees were not aware of 4IR concepts and technologies, results relating to employee involvement reveal that 67.5% of employees agree that they were involved in the 4IR strategy development, while a significant 22% stayed neutral, 10% disagreed to being involved in the development of 4IR strategies. The result highlights possibilities of ineffective participation and involvement, which may stem from a lack of awareness of the concept of 4IR and associated technologies that can hamper the effectively contribute to the development of strategies relating to such technology. Studies have however revealed that though the terms “involvement” and “participation” are related and often used interchangeably, a difference does exist between the terms (Quain, 2018). While involvement may provide an employee the opportunity to learn, participation requires an actual contribution to the decision being taken (Durán, Jessica, Corral, and Antonio, 2016). Findings by Dede (2019) showed that when employees participate in decision making in an organisation, a good working environment is created, workers become more committed, employee morale increase and satisfaction on decisions taken is engendered since they feel recognized and part of the team players in the organization and direct consequences of all these increase productivities within the organization.

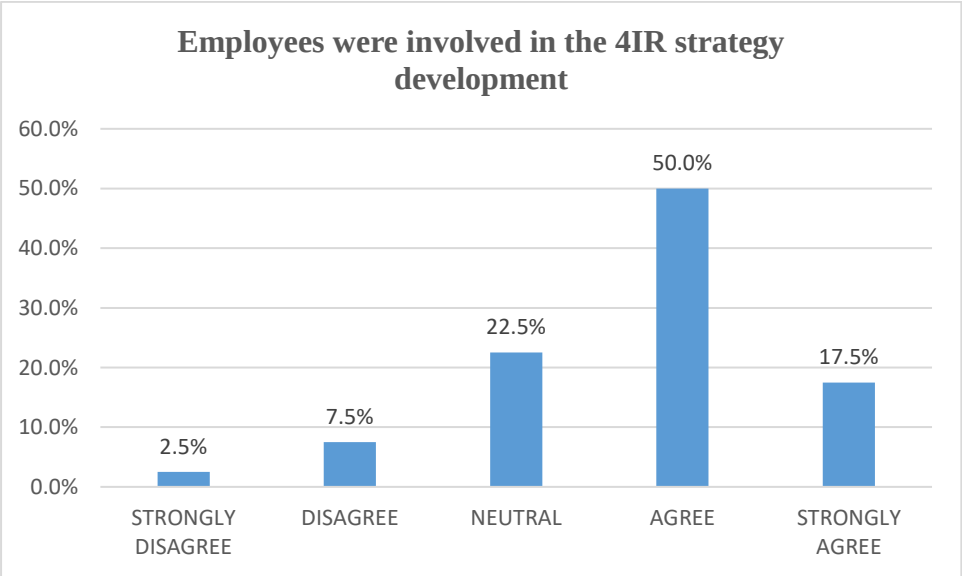



**Figure 4.6: Employee involvement in 4IR strategy development.**

### 4.4.2.3 Perception of the alignment of 4IR and corporate strategy

To further gather employee perception of the current 4IR strategy, questions relating to the alignment of the organisational corporate strategy to the 4IR strategies were posed to the participants. Results from primary data reveal that 20% disagree that there is alignment between the corporate of selected mine with the 4IR strategies. While 57.5% of the participants chose to remain neutral, 22.5% agreed that there is an alignment of the company's corporate strategy with its 4IR strategy. Regarding the alignment of the organisation's human resource strategic alignment to 4IR strategies, 12.5% disagree with the notion that there is an alignment between the human resource strategies and the 4IR strategies of the selected mines. While 45% were neutral to the question, 42.5% agree that there is an alignment between the human resource strategies and the 4IR strategies of the selected mines. Alignment of the mine operational strategies with the 4IR strategy was said not to exist by 12.5% of participants, while 42.5% remained neutral, participants that agree that such alignment exists were 45%.



**Figure 4.7. employee perception of alignment of 4IR strategy to organisational strategy**

Regarding the alignment of the organisation's production strategies to its 4IR strategies, 67.5% of the participants were of the perception that these strategies are not aligned. While 35% were neutral, 20.1% of the participants agreed that there was an alignment between the production strategies of the selected mines and 4IR strategies.

#### 4.4.2.4 Current 4IR practices at selected mines

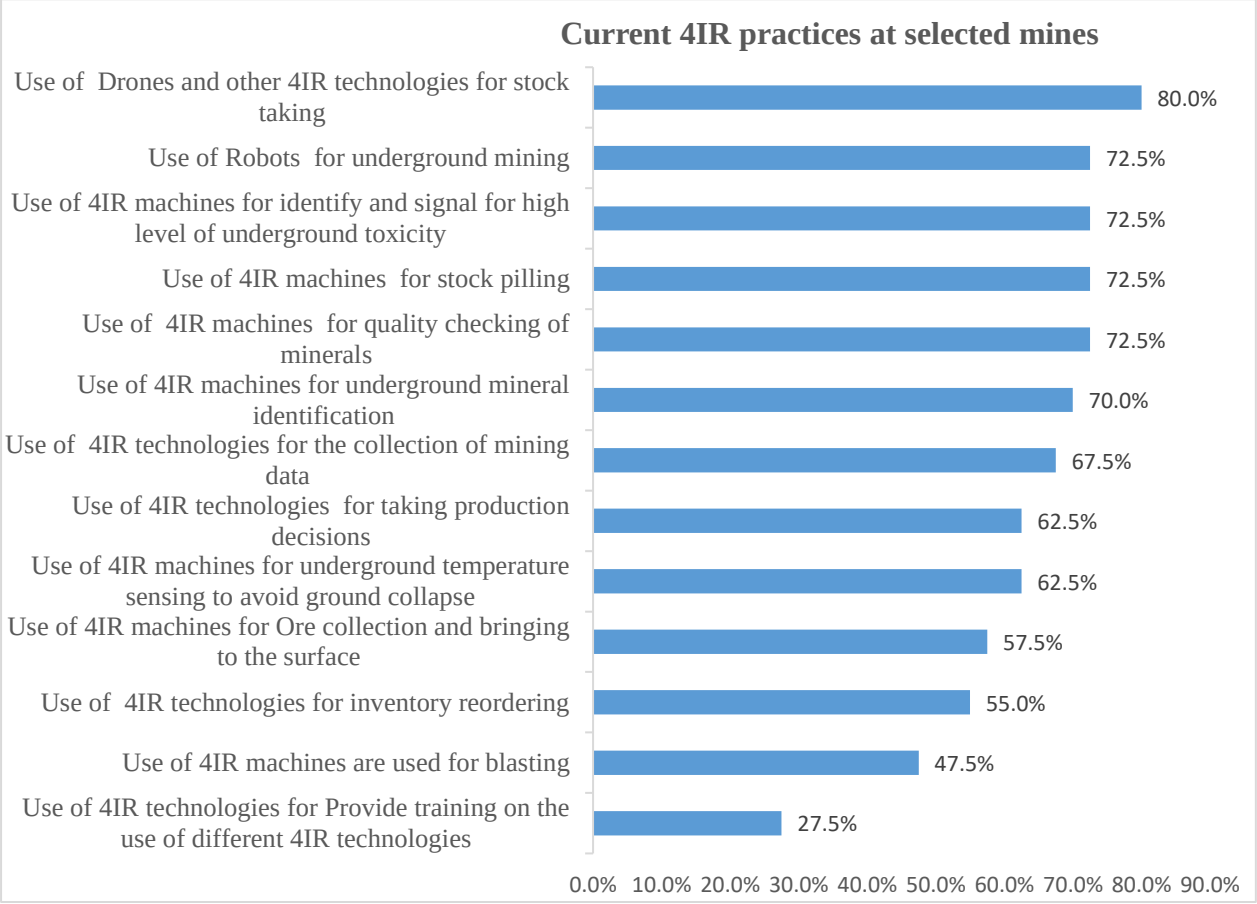



**Figure 4. 8 Technologies used at the selected mines**

Before trying to understand employee perception of the adoption of 4IR technologies, in the mines where they worked, it was imperative to first find what 4IR technologies they were exposed to by asking them to explain how different technologies were used in the production and management processes at their mine. 80% of the participants mentioned the use of drones and other

4IR technologies for stocktaking. 72.5% mentioned the use of robots at the mines, while technologies for identifying and signaling high levels of toxicity were mentioned by another 72.5% of participants. Other technologies mentioned were 4IR technology for mineral identification mentioned by 70% of the participants, and 4IR technologies for mining data collection, mentioned by 67.5% of participants. Others mentioned 4IR technology for taking production decisions, mentioned by 62.5% of respondents, 4IR technologies for underground temperature measuring to avoid ground collapse, mentioned by a further 62.5%, 4IR technologies for collecting ore and bringing them to the surface, mentioned by 57.5%, inventory reordering systems, mentioned by 55% of participants, machine for blasting, mentioned by 47.5% of participants, and 4IR technologies for providing training on 4IR. Barnewold and Lottermoser (2020), allude that over time, techniques and technologies for mining have evolved, with mining production processes seeing the use of explosives, and the use of mechanised and motorised mining equipment. When comparing the past to the present where mining activities and performance is concerned in relation to mining technologies and techniques, each technical achievement and its implementation at mine sites have been found to have led to better practices and strong industrial growth (Barnewold and Lottermoser, 2020).

### 4.4.3 Research objective 2: employee perception on the adoption of Fourth Industrial Revolution(4IR) technologies on productivity at selected mine

#### 4.4.3.1 Employee and management perception of 4IR strategies and practices

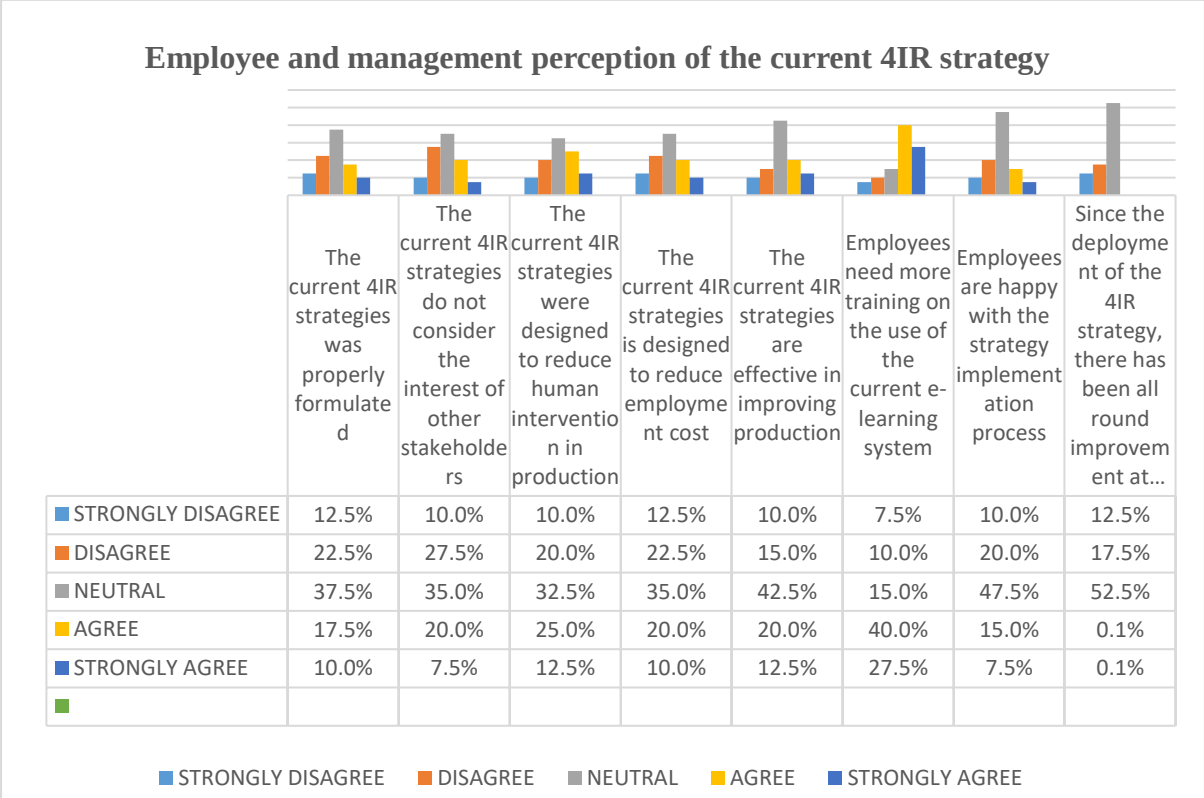
As the 4IR strategic plans become implemented, some new ways of doing things using 4IR technologies were expected to begin to impact old ways, which may require employees to adapt to the new ways. It then became imperative to get the perceptions of employees on elements of the 4IR strategies and practices implemented in the selected mines. Questions relating to this were posed and results from primary data revealed that 35% of the participants believe that the 4IR strategies were not well formulated. While 37.5% were neutral on the matter, 27.5% believe the strategies were well formulated.

Furthermore, results also revealed that 37.5% of the participants perceive that there is a division in stakeholder interest, where the 4IR strategies and practices are concerned, as some stakeholders did not consider the interest of another stakeholder. While 35% of the participant remained neutral on the matter, it was the perception of 27.5% of respondents that all the interests of all stakeholders regarding the 4IR strategy were considered. Asked what they perceived to be the reason for the development and current practice at the selected mines, 37.5% of the participants were of the perception that the 4IR strategies were designed to reduce human intervention in production at the mines, while 30% disagreed, 32.5% were neutral about the matter.

While results from primary data reveal that 35% of the participant disagree that the 4IR strategy was designed to reduce employment cost, 30% were of the perception that the 4IR strategies and instituted practices were indeed designed to reduce employment cost. However, 35% were unsure. Given that a high percentage of employees agreed to have been included in the development stage of the strategy, it is interesting to note the differences in the perception of stakeholders, especially where the purpose of developing the 4IR strategy is in question. The way employees perceive the honesty of purpose of the developed 4IR strategy and practices is critical to its successful implementation. While Zaina, Ab-Rahmana, Ihsana, Zahrima, Norb, Zaina, Hipnia, Ramlia, and Ghopa (2011) found in their study that employee perception can impact employee level of motivation where motivation has been described as the driving force which stimulates an individual to initiate and sustain a behaviour (Saini et al., 2020). According to Harvey (2019), although job disruptions are not unique to the mining sector in South Africa, understanding job disruption in the mining sector is critical, as the sector is a major employer in the South African economy. Other studies have shown that 4IR strategies bring about employment reduction. In South Africa, it is estimated that 41% of all work activities are susceptible to automation, and 39% of the core skills required across occupations will be entirely different by 2020 (Harvey, 2019).

With regards to whether the 4IR strategy was developed to improve production or not, 32.5% were of the perception that the 4IR strategies were developed to

improve production, while 25% of participants disagreed. The remaining 42.5% were unsure. According to Harvey, (2019) 4IR technologies bring about opportunities for reduction in production cost, improved profitability, improved capability for new product development, and opportunity for wealth creation.




| | The current 4IR strategies was properly formulated | The current 4IR strategies do not consider the interest of other stakeholders | The current 4IR strategies were designed to reduce human intervention in production | The current 4IR strategies is designed to reduce employment cost | The current 4IR strategies are effective in improving production | Employees need more training on the use of the current e-learning system | Employees are happy with the strategy implementation process | Since the deployment of the 4IR strategy, there has been all round improvement at… |
|---|---|---|---|---|---|---|---|---|
| STRONGLY DISAGREE | 12.5% | 10.0% | 10.0% | 12.5% | 10.0% | 7.5% | 10.0% | 12.5% |
| DISAGREE | 22.5% | 27.5% | 20.0% | 22.5% | 15.0% | 10.0% | 20.0% | 17.5% |
| NEUTRAL | 37.5% | 35.0% | 32.5% | 35.0% | 42.5% | 15.0% | 47.5% | 52.5% |
| AGREE | 17.5% | 20.0% | 25.0% | 20.0% | 20.0% | 40.0% | 15.0% | 0.1% |
| STRONGLY AGREE | 10.0% | 7.5% | 12.5% | 10.0% | 12.5% | 27.5% | 7.5% | 0.1% |
| | | | | | | | | |

**Figure 4.9**: Employee perception of the current 4IR strategies and practices

### 4.4.3.2 Employee perception of the adoption of 4IR technologies in the production process

After the different forms of 4IR technologies used at the selected mines were identified, questions relating to how employees and management perceive the adoption of these technologies in the production process were posed.

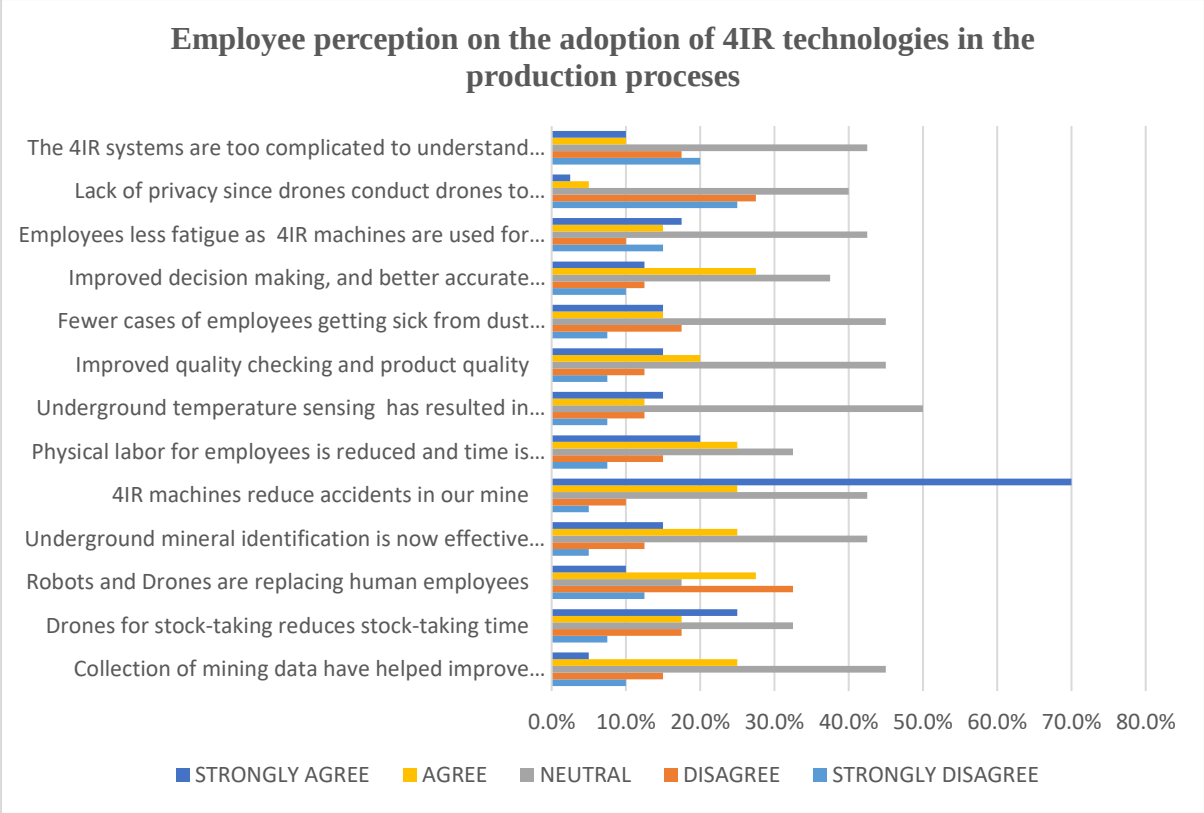



**Figure 4.10:** Perception of adopted 4IR technologies

- **Management decision making and Administration**

While 25% of participants had perceptions that disagreed with the notion that the collection of mining data has helped improve production decisions 45% were neutral, while 33% agreed that the collection of mining data has helped improve production decisions making Results from primary data further reveal that 42.5% of participants are of the perception that the adoption of 4IR drones for stock-taking has reduced stock-taking and has also helped to save time. While the perception of 25% of the participants disagreed with the notion, 32% were neutral.

- **Production performance**

Furthermore, 40% were of the perception that the adoption of 4IR technologies now assists in underground mineral identification making the identification process effective, with time saving and saving time and cost-saving. However, 17.5% disagreed, while 42.5% were neutral. While 35% of participants are of the perception that adopted 4IR technologies have helped improve quality

checks, as well as the quality of products, 20% disagreed, while 45% were neutral about the matter. With regards to accuracy of estimates, 40% of participants believe that the adoption of 4IR technologies has resulted in better material estimates, which has impacted positively on production decision making. While 22.5% disagree, 37.5% of participants remained neutral.

- **Health and safety**

With regards to health and safety activities and employee wellbeing, where 4IR technologies are used during production processes, 42.5% are of the perception that 4IR machines reduce accidents, while 15% disagreed and 42.5% were neutral. Furthermore, 45% agreed that the adopted 4IR technologies are helping to reduce Physical labour while saving time. 22.5% disagree, while 32.5% were neutral. With regards to fewer cases of employees getting sick from dust inhalation and exposure to toxins, 30% of participants agreed, while 25% disagreed, and 45% were neutral. It was the perception of 32.5% of participants that employees are now less fatigued, as 4IR machines are now used for stockpiling, while 25% disagreed with this perception, and 42% were neutral. In other safety-related adoption of 4IR technologies in production processes, 27.5% of participants were of the perception that 4IR technologies used for underground temperature sensing have resulted in fewer cases of ground collapse, while 20% did not share the same perception, 52.5% were neutral. Stewart (2019) explains that mining is physically challenging work and hazardous due to exposure to toxins and dust, as well as a high risk of work-related accidents. This informs why 4IR technologies such as robots and sensors are currently being used in mines across the world, especially in large underground mines (Gaus and Hoxtell, 2019). The authors also allude that technology such as the internet of things (IoT), provides better monitoring of underground conditions.

- **Risk perception**

Primary data revealed perceptions of job insecurity among employees, as 37.5% were of the impression that robots and drones are replacing human employees, while 45% of the participants disagreed, and 17.5% were neutral. Stentoft et al., (2019), found in their study that most employees perceive the

4IR technologies to be causing an increase in job losses, as employers substitution humans with robots, and this may result in barriers to the implementation of 4IR. Another study found that employees perceive that 4IR technologies would bring about a pay cut, given the efficiency of machines over that of humans. Other participants indicated that the use of drones for environmental monitoring is taking away their privacy. While employees perceive a lack of trust employees, in the implementation of 4IR strategies and practices, in the production process, employees use connected devices to monitor workers in manner employees deem intrusive, as these devices also have the capacity to monitor after-hours activities, including evenings, holidays and weekends (Corfe,2018).

- **Perceived ease of use and perceived usefulness**

As indicated in figure 4.11 below, 20% of the participants agree that the adopted 4IR technologies were easy to use, while 37.5% disagreed with the notion, while 42.5% were neutral. Liao, Hong, Wen, Pan, and Wu, (2018), explain that the Technology Acceptance Model (TAM) indicates that the perceived usefulness (PU) and perceived ease of use (PEOU) of information technology, are two main factors that influence the behavior, attitude as well as the decision of an individual or organization to adopt, acquire and use a specific technology. While most employees find the 4IR technology useful, they weigh its usefulness against the risk of losing their jobs. Given that studies such as the one conducted by Gaus and Hoxtell, (2019) already found that technologies have the likelihood of reducing jobs, especially in large underground mining activities, and among older employees.

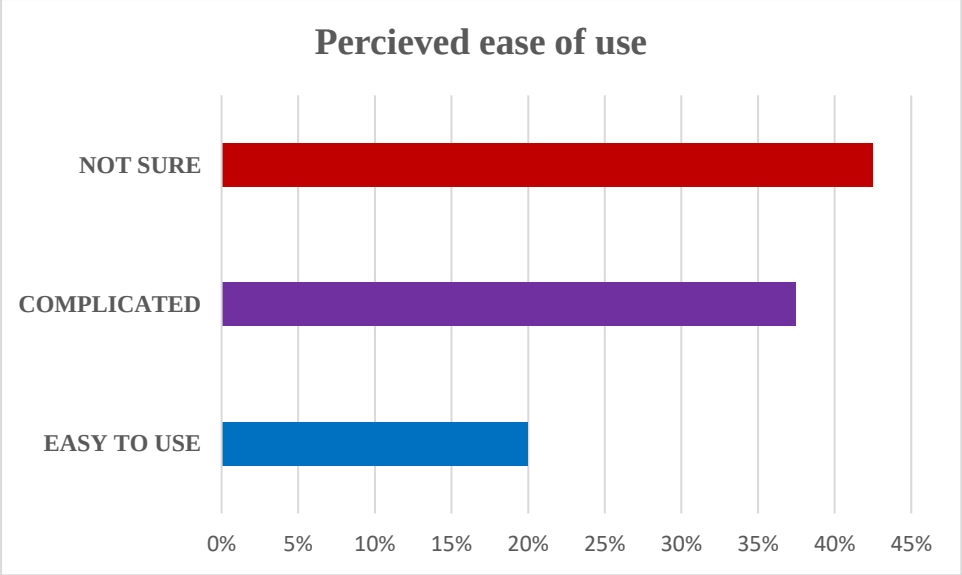



**Figure 4.11** Perceived ease of use

## 4.5 CONCLUSION

In this chapter, results from the analysis of data have been presented along with relevant interpretations and discussions. Discussions from the chapter included findings relating to the demographic distribution of participants, employee awareness of the concept, and technologies that constitute the 4IR. Discussions also covered results from primary data which relate to employee and management perception of the current 4IR strategies and practices and the selected mines, as well as their perception of 4IR technologies adopted in the production processes of the mines. The next chapter will provide a summary of the finding from the study, and literature while providing recommendations based on finding from the study.

# CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

## 5.1 INTRODUCTION

The aim of the study was to explore the perception of Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines, through a quantitative study, in view of improving mining operation at the selected mine. In this chapter, conclusions will be drawn, and recommendations made, based on the predefined research objectives, and in alignment with the research question set out to be answered, as outlined below.

## 5.2. FINDINGS FROM THE STUDY

Findings from the study reveal that employee level of awareness of the concept of 4IR and associated technologies had a significant impact on how employees perceive the current 4IR strategies. The level of awareness also had an impact on employee perception of strategy development, implementation, and 4IR practices in the selected mines. It was found that while a high percentage of employees were not aware of the concept of 4IR (87.8%), others (75%) were not familiar with most of the 4IR related technologies. Though findings show that a high percentage of employees (67.5%) were involved in the 4IR strategy development process, most believe that the current 4IR strategies and practices do not fully represent the interests of all stakeholders. While some were of the perception that the strategies and practices were designed to improve productivity and reduce employment costs, others believe that it puts workers' jobs at risk, as mines have started replacing humans with 4IR technologies such as robots and drones. However, findings reveal that the adoption of the 4IR technologies according to the perception of employees, has improved health and safety within the mines. Most employees are of the perception that since the introduction of underground sensors for temperature and high levels of toxins, there has been less ground collapse, a smaller number of sick employees due to dust inhalation, and less fatigue, as 4IR machines are now used for bringing Ore to the surface from underground and

stockpiling. While finding from the study reveal that training in 4IR technologies is required, employees familiar with the technologies express ease of use, while others find the technologies complex to use.

### 5.2.1 Findings from the literature review

Mcdonald (2011) posits that perception is the unique experience of an individual, and a person can only formulate perception from what is known to them. This was found to be true with the selected mines, as employees' level of awareness of the 4IR technologies influenced their perception of the strategies, practices, and adoption of the technologies. Studies have however revealed that though the terms "involvement" and "participation" are related and often used interchangeably, a difference does exist between the terms (Quain, 2018). While involvement may provide an employee the opportunity to learn, participation requires an actual contribution to the decision being taken (Durán, Jessica, Corral, and Antonio, 2016). Findings by Dede (2019) showed that when employees participate in decision making in an organisation, a good working environment is created, workers become more committed, employee morals increase and satisfaction with decisions taken is engendered since they feel recognized and part of the team players in the organization and direct consequences of all these increase productivities within the organization. These findings were found to be partly true with employees at the selected mines. While their involvement provided them with the opportunity to learn and contribute, involvement in the case of the employees, did not guarantee effective participation, due to a lack of knowledge and awareness of the 4IR technologies.

Barnewold and Lottermoser (2020), allude that over time, techniques and technologies for mining have evolved, with mining production processes seeing the use of explosives and the use of mechanized and motorized mining equipment. This was found to be true at the selected mines, as the mines were found to be increasingly adopting technologies for more efficient mining processes and cost savings. Especially those mentioned by Barnewold and Lottermoser (2020). Regarding the study conducted by Harvey (2019), which

found that although job disruptions are not unique to the mining sector in South Africa, understanding job disruption in the mining sector is critical, as the sector is a major employer in the South African economy, it was found to be true, as the selected mines were found to have started experiencing job disruption due to the introduction of the 4IR technologies. Harvey, (2019) found that 4IR technologies bring about opportunities for reduction in production cost, improved profitability, improved capability for new product development, and opportunity for wealth creation. The selected mines were found to be experiencing cost savings, as it was found that accurate material estimates, are reducing waste and overall production cost at the selected mines.

As indicated by Stewart (2019) that mining is physically challenging work and hazardous due to exposure to toxins and dust, as well as a high risk of work-related accidents, which is influencing the adoption of 4IR technologies such as robots and sensors, which are currently being used in mines across the world, especially in large underground mines (Gaus and Hoxtell, 2019). This was found to be true of the selected mines, as findings from the study revealed improvement in health and safety in the selected mines due to the adoption of underground heat and high levels of toxic sensing technologies. Employees perceive a lack of trust in employees, in the implementation of 4IR strategies and practices, in the production process, employees use connected devices to monitor workers in manner employees deem intrusive, as these devices also have the capacity to monitor after-hours activities, including evenings, holidays and weekends (Corfe,2018). This was also found to be true, as some employees expressed different reasons why they think the 4IR technologies were instituted, which was opposed to the reason provided by management in the strategy development process.

Liao, Hong, Wen, Pan, and Wu, (2018), explain that the Technology Acceptance Model (TAM) indicates that the perceived usefulness (PU) and perceived ease of use (PEOU) of information technology, are two main factors that influence the behavior, attitude as well as the decision of an individual or organization to adopt, acquire and use a specific technology. This model has

been found to be relevant to the study, as the study revealed that employees who perceived the 4IR technologies as easy to use had a positive attitude towards the adoption of the 4IR technologies.

### 5.2.2 Findings from primary research

#### 5.2.2.1 Findings relating to employee perception of 4IR strategies and practices

Findings reveal that an entire 87.5% of the participants were not aware of the concept of 4IR, while 75% of the participants were not aware of the different 4IR technologies that exist. This lack of awareness was reflected in how unsure participants were on a variety of issues relating to the development, implementation of 4IR strategies and practices in the selected mines, as well as reasons for the adoption of 4IR technologies at the selected mines. For instance, asked if they thought the 4IR strategies developed by the selected mines aligned to the mine's corporate strategies, H.R strategies, operational strategies, and production strategies, 57% were unsure of alignment to corporate strategy, 40% about H.R strategies, 42.5% about operational strategies, and 35% was unsure if the 4IR strategies aligned to production strategies. Results show that a high percentage of participants who remain neutral about questions asked which related to different issues on 4IR concept and technologies. This is reflected across the entire primary data, as shown in figure 5.1. This occurrence was found to be inconsistent with 67.5% of participants agreeing to have been involved in the strategy development.

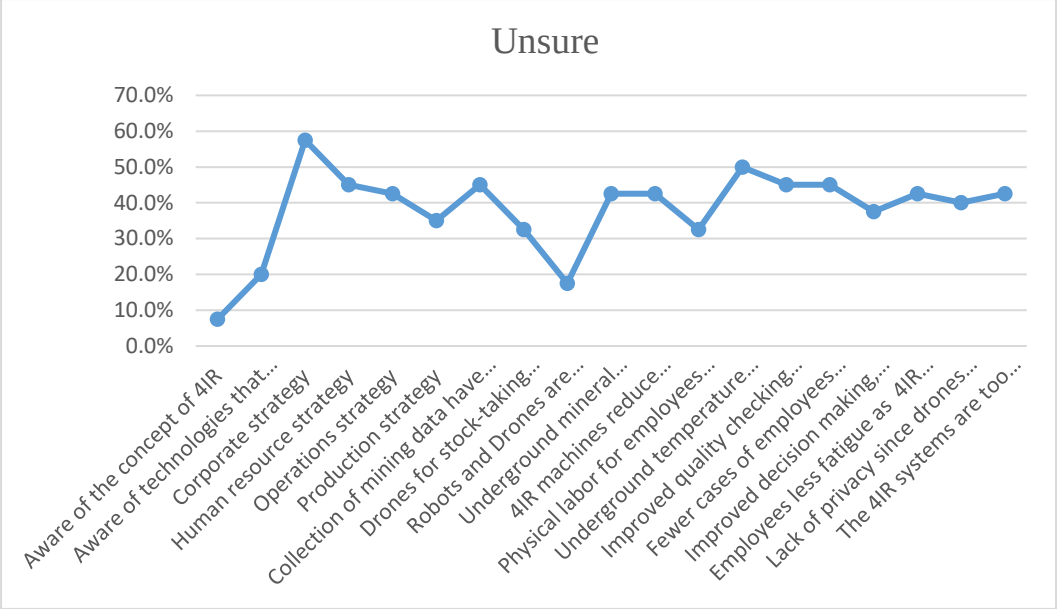



**Figure 5.1.** Number of unsure responses across entire data

#### 5.2.2.1.2 Employee involvement in strategy development and implementation

#### 5.2.2.1.3 Employee perception of the strategies and practice

Finding from the primary study revealed that while 20% strongly disagreed with having any form of awareness of 4IR, a further 67.5% owned up to the fact that they were not aware of the concept of 4IR. While 7.5% remained neutral, 5% agreed to be aware of the concept of 4IR. The result was quite a revelation, as it revealed that 87.5% of the participants were not aware of the concept of 4IR, considering that these technologies are being deployed at the mines where they work. It came as no surprise that finding relating to employee awareness of existing 4IR technologies revealed that 75% of the participants said they had no knowledge of the different 4IR technologies that exist, while 201% were neutral, only 5% agreed that they had knowledge of 4IR, a percentage consistent with the number of participants that said they are aware of the concept of 4IR.

findings from primary study however reveal contradictions and inconsistency, as indicated in figure 5.6. following prior findings that reveal that a high percentage of employees were not aware of 4IR concepts and technologies, results relating to employee involvement reveal that 67.5% of employees agree that they were involved in the 4IR strategy development, while a significant 22%

stayed neutral, 10% disagreed to being involved in the development of 4IR strategies. The finding highlights possibilities of ineffective participation and involvement, which may stem from a lack of awareness of the concept of 4IR and associated technologies that can hamper the effectively contribute to the development of strategies relating to such technology.

Findings from primary study reveal that 20% disagree that there is alignment between the corporate of selected mine with the 4IR strategies. While 57.5% of the participants chose to remain neutral, 22.5% agreed that there is an alignment of the company's corporate strategy with its 4IR strategy. Regarding the alignment of the organisation's human resource strategic alignment to 4IR strategies, 12.5% disagree with the notion that there is an alignment between the human resource strategies and the 4IR strategies of the selected mines. While 45% were neutral to the question, 42.5% agree that there is an alignment between the human resource strategies and the 4IR strategies of the selected mines. Alignment of the mine operational strategies with the 4IR strategy was said not to exist by 12.5% of participants, while 42.5% remained neutral, and participants that agree that such alignment exists were 45%. Regarding the alignment of the organisation's production strategies to its 4IR strategies, 67.5% of the participants were of the perception that these strategies are not aligned. While 35% were neutral, 20.1% of the participants agreed that there was an alignment between the production strategies of the selected mines and 4IR strategies.

#### 5.2.2.2. Findings relating to employee perception of adoption of 4IR technology in the production process

##### 5.2.2.2.1 4IR technologies adopted in the selected mines

- **Management decision making and Administration**

While 25% of participants had perceptions that disagreed with the notion that the collection of mining data has helped improve production decisions 45% were neutral, while 33% agreed that the collection of mining data has helped improve production decisions making Results from primary data further reveal that 42.5% of participants are of the perception that the adoption of 4IR drones

for stock-taking has reduced stock-taking and has also helped to save time. While the perception of 25% of the participants disagreed with the notion, 32% were neutral.

- **Production performance**

Furthermore, 40% were of the perception that the adoption of 4IR technologies now assists in underground mineral identification making the identification process effective, with time saving and saving time and cost-saving. However, 17.5% disagreed, while 42.5% were neutral. While 35% of participants are of the perception that adopted 4IR technologies have helped improve quality checks, as well as the quality of products, 20% disagreed, while 45% were neutral about the matter. With regards to accuracy of estimates, 40% of participants believe that the adoption of 4IR technologies has resulted in better material estimates, which has impacted positively on production decision making. While 22.5% disagree, 37.5% of participants remained neutral.

- **Health and safety**

With regards to health and safety activities and employee wellbeing, where 4IR technologies are used during production processes, 42.5% are of the perception that 4IR machines reduce accidents, while 15% disagreed and 42.5% were neutral. Furthermore, 45% agreed that the adopted 4IR technologies are helping to reduce Physical labour while saving time. 22.5% disagree, while 32.5% were neutral. With regards to fewer cases of employees getting sick from dust inhalation and exposure to toxins, 30% of participants agreed, while 25% disagreed, and 45% were neutral. It was the perception of 32.5% of participants that employees are now less fatigued, as 4IR machines are now used for stockpiling, while 25% disagreed with this perception, and 42% were neutral. In other safety-related adoption of 4IR technologies in production processes, 27.5% of participants were of the perception that 4IR technologies used for underground temperature sensing have resulted in fewer cases of ground collapse, while 20% did not share the same perception, 52.5% were neutral.

- **Risk perception**

Findings form the study revealed perceptions of job insecurity among employees, as 37.5% were of the impression that robots and drones are replacing human employees, while 45% of the participants disagreed, and 17.5% were neutral. Other participants indicated that the use of drones for environmental monitoring is taking away their privacy.

- **Perceived ease of use and perceived usefulness**

As indicated in figure 4.11 below, 20% of the participants agree that the adopted 4IR technologies were easy to use, while 37.5% disagreed with the notion, while 42.5% were neutral. Findings reveal that 80% of the participants mentioned the use of drones and other 4IR technologies for stocktaking. 72.5% mentioned the use of robots at the mines, while technologies for identifying and signaling high levels of toxicity were mentioned by another 72.5% of participants. Other technologies mentioned were 4IR technology for mineral identification mentioned by 70% of the participants, and 4IR technologies for mining data collection, mentioned by 67.5% of participants. Others mentioned 4IR technology for taking production decisions, mentioned by 62.5% of respondents, 4IR technologies for underground temperature measuring to avoid ground collapse, mentioned by a further 62.5%, 4IR technologies for collecting ore and bringing them to the surface, mentioned by 57.5%, inventory reordering systems, mentioned by 55% of participants, machine for blasting, mentioned by 47.5% of participants, and 4IR technologies for providing training on 4IR.

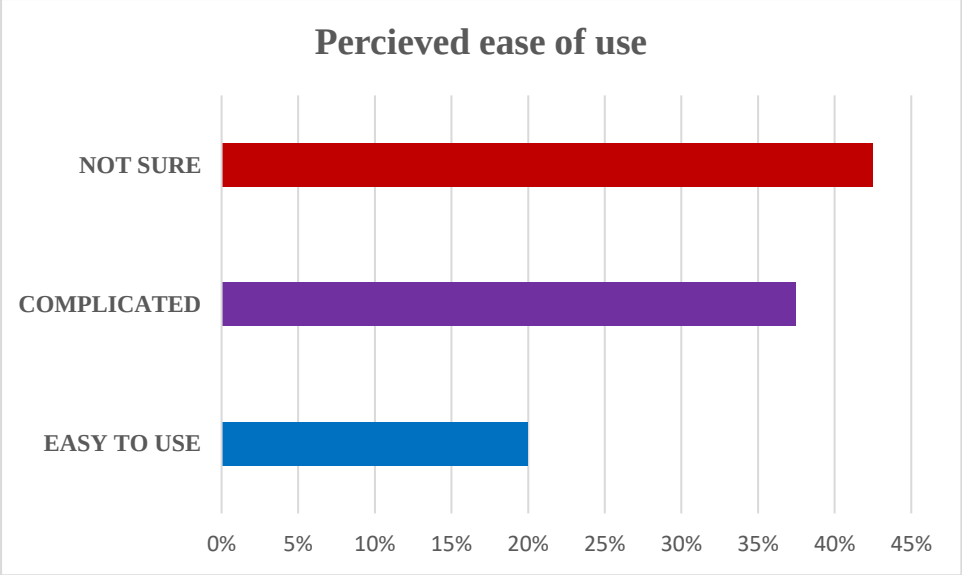



**Figure 4.11: Questionnaire**

## 5.3 CONCLUSIONS OF THE FINDINGS

In this section and the subsection below, conclusions based on the research objectives are presented.

### 5.3.1 Conclusion on the perception of 4IR strategies and practices

Based on findings, conclusions can be drawn that employee awareness of 4IR needs to be raised to a significant level. This may help improve employees' positive perception of the strategy and practice of 4IR within the mines. While the interest of all stakeholders should be revisited, ensuring that employee involvement generates an effective participation level is important.

### 5.3.2 Conclusion on perceptions of the adoption of 4IR technologies in production

Different types of 4IR technologies were found to be in use at the selected mines. While these technologies have helped improve production as well as health and safety situations during mining processes, employees have expressed fear that the adoption of technologies such as drones and robots do not only threaten the security of their job, but it also tends to violate their privacy.

## 5.4 RECOMMENDATIONS BASED ON FINDINGS

### 5.4.1 Recommendations from employees

Some employees recommended the upskilling of employees to be digitally and that companies need to invest in the "Internet of Things" by ensuring all employees are up to par with the requirements of technological language. Others recommended that to implement the 4IR the mining companies should start with areas that are more compatible with technology and also prepare those that need revamping or modifying. Others say that already, artificial intelligence is all around us, and organizations need to invest more in 4IR to close the knowledge and skills gap. Other recommendations include that there should be a platform to create awareness and learnings from those who have successfully completed tasks that are 4IR related for the rest of the business to learn from. The unsuccessful ones as well so that learnings can be taken equally. Some employees suggest the introduction of more 4IR initiatives such as communication Apps for smartphones, and interactive screens in operations to communicate critical messages and invite ideas from employees on possible 4IR technology interventions. A further recommendation was that while Robots and Automated equipment are introduced in Mining however South Africa, consideration should be given to how it impacts job security, as South Africa already has huge unemployment which needs to be balanced.

### 5.4.2 Recommendation of the study

#### 5.4.2.1 Institute knowledge sharing program and environment

Based on the findings, it is recommended that the selected mines should encourage knowledge-sharing, where employees can in a formal and informal manner share their knowledge of the 4IR technologies with other employees. This provides the opportunity not only to reduce training time and cost but also to reduce frustration and negative attitudes that employees may show from the need to use the technologies.

#### 5.4.2.2 Determine the source of job insecurity

While the temptation for employers may be too quickly associate employee exhibition of anxiety around the deployment of 4IR to just its implementation, other issues such as level of qualification and age and the importance of the job the employee is doing, and how quickly employees think a machine can replace them may all be things to consider. This will help management address employee voluntary turnover before it happens.

## 5.5 CARRY OUT A JOB SATISFACTION SURVEY INTERMITTENTLY

The study recommends that management should try to constantly keep abreast of employee perception of the 4IR strategies and practices through surveys conducted time and again, to draw up effective strategies to dispel negative and unfounded fear and perception around the deployment of 4IR technologies. This survey may also assist in helping management understand what employees are struggling with, and where the implementation of 4IR technologies is concerned.

### 5.5.1 Assess training needs in 4IR

Before concluding that training in 4IR is needed, management is encouraged to first take a proper assessment of the skills gap, to identify not only what skills are needed, but who needs them. This will help draw up an effective training program that upscales the skill of the employees based on organisational goals and objectives.

## 5.6 CONCLUSION OF THE STUDY

The aim of the study was to explore the perception of Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in the mining industries at selected mines, through a quantitative study, in view of improving mining operation at the selected mine. In this chapter, a summary of findings in the study and literature, along with relevant

conclusions and recommendations have been made. These recommendations were made based on the research objectives and questions to be answered.

## 5.7 FUTURE RESEARCH OPPORTUNITY

While this chapter serves as a concluding chapter, presenting a close of the study, opportunities for future studies exist, especially in the impact of employee 4IR awareness program on employee perception of 4IR technology adoption.

## REFERENCES


Abdulwase, R., Yan, S., Ahmed, F., Nasr, F., Abdulwase, A., and Alyousofi, A. (2020). Role of business strategy to create a competitive advantage in the organisation, Open Access Journal of Science 2020, 4 (4), pp135-138 https://doi.org/10.15406/oajs.2020.04.00162

Akhtar, I. (2016). Research Design. In Research in Social Science: Interdisciplinary Perspectives (p. 17).

Al-Rodhan, N. (2015). The Moral Code: How to Teach Robots Right and Wrong. Retrieved from https://www.foreignaffairs.com/articles/2015-08-12/moral-code

Arzagen (2019) 'Plant based expression technology.' ArzaGen. http://azargen.com/#plant-based-expression-technology, accessed 2 August 2020

Aydin, Hamit & Tilton, John E., (2000). "Mineral endowment, labor productivity, and comparative advantage in mining," Resource and Energy Economics, Elsevier, vol. 22(4), pages 281-293, October.

Bailey L. (2018). Tangible Strategy - The relevance of strategy in business and marketing. Retrieved 04 February,2022 from https://www.linkedin.com/pulse/tangible-strategy-relevance-business-marketing-levi-bailey

Baker SE, Edwards R. (2012).How many qualitative interviews is enough? Expert voices and early career reflections on sampling and cases in qualitative research. National Centre for Research Methods Review Paper. Retrieved 04 February,2022 from

2012; http://eprints.ncrm.ac.uk/2273/4/how_many_interviews.pdf.

Brzychczy, E.; Gackowiec, P.; Liebetrau, M. Data Analytic Approaches for Mining Process Improvement—Machinery Utilization Use Case. Resources 2020, 9, 17. https://doi.org/10.3390/resources9020017

Carlson, K. D., and Herdman, A. O. (2012). Understanding the Impact of Convergent Validity on Research Results. Organizational Research Methods, 15(1), 17–32. https://doi.org/10.1177/1094428110392383

Caruana EJ, Roman M, Hernández-Sánchez J, Solli P. Longitudinal studies. J Thorac Dis. 2015 Nov;7(11):E537-40. doi: 10.3978/j.issn.2072-1439.2015.10.63. PMID: 26716051; PMCID: PMC4669300.

Corfe, S.J.S.M.F. (2018) What Are the Barriers to Eating Healthily in the UK.

Corfe, S. (2018). 4IR in the Workplace: Ensuring Employers and Employees Benefit Social Market Foundation, London (2018)

Creswell, J. W. (2015). A concise Introduction to Mixed Methods Research. Sage Publications Ltd

Creswell, J.W. (2013) Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 4th Edition, SAGE Publications, Inc., London.

Curtis, E.A., Comiskey, C. and Dempsey, O. (2016) Importance and Use of Correlational Research. Nurse Researcher, 23, 20-25. https://doi.org/10.7748/nr.2016.e1382

Dobbs R. et al., 2015, No Ordinary Disruption, New York, Public Affairs.

Dombrowski, U., and Wagner, T., (2014), Mental Strain as Field of Action in the 4th Industrial Revolution.Procedia CIRP, 17, 100-105.

Doody O, Doody CM. Conducting a pilot study: case study of a novice researcher. Br J Nurs. 2015 Nov 26-Dec 9;24(21):1074-8. doi: 10.12968/bjon.2015.24.21.1074. PMID: 26618678.

Edwin Kubai, E. (2019). Reliability and Validity of Research Instruments. Retrieved 09 February,2022 from At:https://www.researchgate.net/publication/335827941_Reliability_and_Validity_of_Research_Instruments_Correspondence_to_kubaiedwinyahoocom/link/5d7e3ebaa6fdcc2f0f6fe58b/download

Elameer A. (2020). Cloud computing. Retrieved 17 February,2022 from https://www.researchgate.net/publication/338411743

Etikan I, Bala K. Sampling and sampling methods. Biom Biostat Int J. 2017;5(6):215?217. DOI: 10.15406/bbij.2017.05.00149

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of Convenience Sampling and Purposive Sampling. American Journal of Theoretical and Applied Statistics, 5, 1-4.
https://doi.org/10.11648/j.ajtas.20160501.11

Fouka, G., & Mantzorou, M. (2011). What are the major ethical issues in conducting research? Is there a conflict between the research ethics and the nature of nursing. Health Science Journal, 5(1), 3-14.

Geary, D. C., Gilger, J. W., & Elliot-Miller, B. (1992). Gender differences in three-dimensional mental rotation. Journal of Genetic Psychology, 153(1), 115-117.
Ghattas, J.; Soffer, P.; Peleg, M. Improving business process decision making based on past experience. Decision Support Syst. 2014, 59, 93–107.

Goode, L. (2018). Everything Is Connected, And There's No Going Back. The Verge. Retrieved 09 February,2022 from https://www.theverge.com/2018/1/17/16898728/ces-2018-tech-trade-shows-gadgets-iot

Grima, S.; Hamarat, B.; Özen, E.; Girlando, A.; Dalli-Gonzi, R. The Relationship between Risk Perception and Risk Definition and Risk-Addressing Behaviour during the Early COVID-19 Stages. J. Risk Financial Manag. 2021, 14, 272. https://doi.org/10.3390/jrfm14060272

Gupta S. (2020). Drones are the future: Air we ready?. Available at:https://timesofindia.indiatimes.com/blogs/voices/drones-are-the-future-air-we-ready/?source=app&frmapp=yes

Hoosain, M.S.; Paul, B.S.; Ramakrishna, S. The Impact of 4IR Digital Technologies and Circular Thinking on the United Nations Sustainable Development Goals. Sustainability 2020, 12, 10143. https://doi.org/10.3390/su122310143

Hoosain, M.S.; Paul, B.S.; Ramakrishna, S. (2020).The Impact of 4IR Digital Technologies and Circular Thinking on the United Nations Sustainable Development Goals. Sustainability 2020, 12, 10143. https://doi.org/10.3390/su122310143

Hoosain MS, Paul BS, Raza SM, Ramakrishna S (2021) Material passports and circular economy. In: Liu L, Ramakrishna S (eds) An introduction to circular economy. Springer, Singapore. https:// doi. org/ 10. 1007/ 978- 981- 15- 8510-4_8.

Igogo, Tsisilile, Lowder, Travis, Engel-Cox, Jill, Newman, Alexandra M., and Awuah-Offei, Kwame. Integrating Clean Energy in Mining Operations: Opportunities, Challenges, and Enabling Approaches. United States: N. p., 2020. Web. doi:10.2172/1659921.

Jaeger, C., Renn, O.,Rosa, E., Webler, T. (2001) 'Risk: Uncertainty and Rational Action', Earthscan, London

Kabir S.M.S (2016). Basic Guidelines for Research: An Introductory Approach for All Disciplines. Book Zone Publication, ISBN: 978-984-33- 9565-8, Chittagong-4203, Bangladesh.

Kimura, D. (2004). Human sex differences in cognition, fact, not a predicament. Sexualies, Evolution, and Gender, 6(1), 45-53.

Klinke, A., & Renn, O. (2002). A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based, and Discourse-Based Strategies. Risk Analysis: An Official Publication of the Society for Risk Analysis, 22, 1071-1094.https://doi.org/10.1111/1539-6924.00274

L. Barnewold and B. G. (2020).Lottermoser, Identification of digital technologies and digitalisation trends in the mining industry, International Journal of Mining Science and Technology, https://doi.org/10.1016/j.ijmst.2020.07.003

Liao, Y., Loures, E.R., Deschamps, F., Brezinski, G. and Venâncio, A. (2018), “The impact of the fourth industrial revolution: a cross-country/region comparison”, Production, Vol. 28, pp. 1-18.

Lööw, J.; Abrahamsson, L.; Johansson, J. Mining 4.0—The Impact of New Technology from a Work Place Perspective. Mining Metall. Explor. 2019, 36, 701–707.

Lööw J, Nygren M. Safety Sci. 2019; 117: 437-446

Maanen, J. and E. H. Schein (1979). "Toward of Theory of Organizational Socialization." Research in Organizational Behaviour, 1: 209-264.

Majid U. Research fundamentals: Study design, population, and sample size. URNCST Journal. 2018Jan10:2(1). https://urncst.com/index.php/urncst/article/view/16

Markowitz C. (2019). Harnessing the 4IR in SADC: Roles for Policymakers. South African Institute of International Affairs. Retrieved 11 February,2022 from https://saiia.org.za/wp-content/uploads/2019/11/Occasional-Paper-303-markowitz.pdf

Markowitz, C. 2019. Harnessing the 4IR in SADC: roles for policymakers. South African Institute of International Affairs. Retrieved February 7, 2022, from https://www.africaportal.org/publications/harnessing-4ir-sadc-roles-policymakers/

Marshall JA, Bonchis A, Nebot E, Scheding S (2016) Robotics in mining. In: Siciliano B, Khatib O (eds) Springer handbook of robotics, 2nd edn, chap 59. Springer International Publishing, pp 1549–1576. https://doi.org/10.1007/978-3-319-32552-1

Martinez-Mesa J, González-Chica DA, Duquia RP, Bonamigo RR, Bastos JL. Sampling: how to select participants in my research study? An Bras Dermatol. 2016;91(3):326-30.

McCarthy, J., (2008).The well-designed logical child, Artificial Intelligence 172 (18) (2008) 2003–2014.

McDonald, S. M. (2011). Perception: A concept analysis [Unpublished PhD Thesis]. University of Texas at Tyler

Mitchell, P. (2016). From concept to classroom: What is translational research? Australian, Council for Educational. Retrieved 17 February,2022 from

Research..https://research.acer.edu.au/professional dev/9

Mohajan, Haradhan (2017): Two Criteria for Good Measurements in Research: Validity and Reliability. Published in: Annals of Spiru Haret University , Vol. 17, No. 4 (24 December 2017): pp. 56-82.

Moore, P., V. (2020) 'The mirror for (artificial) intelligence: In whose reflection?', for Special Issue 'Automation, AI, and Labour Protection', edited by Prof Valerio de Stefano, Comparative Labor Law and Policy Journal 41(1): 47 - 67.

Nakamoto, S. (2008) Bitcoin: A Peer-to-Peer Electronic Cash System. https://bitcoin.org/bitcoin.pdf

Naz, z (2015). "Introduction to biotechnology," November 2015

Retrieved 06 February,2022 from
https://www.researchgate.net/publication/284169166

Nikola Soukupová & Markéta Adamová & Růžena Krninská, 2020. "Industry 4.0: an Employee Perception (Case of the Czech Republic)," Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, Mendel University Press, vol. 68(3), pages 637-644.

Ponto J. Understanding and Evaluating Survey Research. J Adv Pract Oncol. 2015 Mar-Apr;6(2):168-71. Epub 2015 Mar 1. PMID: 26649250; PMCID: PMC4601897.

Porter M.,E, Heppelmann J.,E (2014) How smart, connected products are transforming competition. Harv Bus Rev 92:11–64

Qian, F., Zhong, W., and Du, W., (2017). “Fundamental theories and key technologies for smart and optimal manufacturing in the process industry,” Engineering, vol. 3, no. 2, pp. 154–160, 2017.

Ryan G. Introduction to positivism, interpretivism and critical theory. Nurse Researcher. 2018 Mar;25(4):14-20. DOI: 10.7748/nr.2018.e1466. PMID: 29546962.

Ryan, Gemma (2018). Introduction to positivism, interpretivism and critical theory. Nurse Researcher, 25(4)
pp. 41–49

Saini, M., Kumar, A., and Kaur G. (2020:186), Research Perception, Motivation and Attitude among Undergraduate Students: A Factor Analysis Approach. Procedia Computer Science 167 (2020) 185–192

Saini, M., Kumar A., and Kaur, G. (2020).Research Perception, Motivation and Attitude among Undergraduate Students: A Factor Analysis Approach.Procedia Computer Science 167 (2020) 185–192

Sánchez, F., Hartlieb, P. Innovation in the Mining Industry: Technological Trends and a Case Study of the Challenges of Disruptive Innovation. Mining, Metallurgy & Exploration 37, 1385–1399 (2020). https://doi.org/10.1007/s42461-020-00262-1

Šaras, E. & Perez-Felkner, L. (2018) Sociological Perspectives on Socialization. Oxford Bibliographies in Sociology. Oxford: Oxford University Press. doi: 10.1093/obo/9780199756384-0155

Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, Burroughs H, Jinks C. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. Qual Quant. 2018;52(4):1893-1907. doi: 10.1007/s11135-017-0574-8. Epub 2017 Sep 14. PMID: 29937585; PMCID: PMC5993836.

Saunders, M., Lewis, P. and Thornhill, A. (2016) Research Methods for Business Students. 7th Edition, Pearson, Harlow.

Saunders, M., Lewis, P. and Thornhill, A. (2016) Research Methods for Business Students. 7th Edition, Pearson, Harlow.

Saunders, M.N.K., Lewis, P. and Thornhill, A. (2019) Research Methods for Business Students. 8th Edition, Pearson, New York.

Saunders, M.N.K., Lewis, P. and Thornhill, A. (2019) Research Methods for Business Students. 8th Edition, Pearson, New York.

Schwab K. (2016). The Fourth Industrial Revolution. Retrieved 02 February,2022 from

https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab

Shaikh, A. and Soni, D., 2015. The South African Universities post-merger mess: Problems and challenges of
Transformation. Mediterranean Journal of Social Sciences, 6(3), pp. 326 - 343.

Silverman, D. (Ed.). (2016). Qualitative research (4th ed.). Los Angeles, CA: Sage.,

Sim, J., Waterfield, J. (2019). Focus group methodology: some ethical challenges. Qual Quant 53, 3003–3022 (2019). https://doi.org/10.1007/s11135-019-00914-5

Solomon, M. R., & Schopler, J. (1982). Self-Consciousness and Clothing. Personality and Social Psychology Bulletin, 8(3), 508–514. https://doi.org/10.1177/0146167282083018

Stentoft, J., and A. Haug. 2019. Business Process Optimisation. Copenhagen, Denmark: Hans Reitzels Forlag.

Susan J Loeb and Susan M. Dynarski and Daniel A. McFarland and Pam Morris and Sean F. Reardon and Sarah J. Reber (2017). Descriptive Analysis in Education: A Guide for Researchers.

Taherdoost, H. (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. International Journal of Academic Research in Management (IJARM), 5, 18-27.
https://doi.org/10.2139/ssrn.3205035

National Centre for Education Evaluation and Regional Assistance

Tilton, J. and Landsberg, H. (1999) Innovation, Productivity Growth, and the Survival of the US Copper Industry. Productivity in Natural Resource Industries; Improvement through Innovation, 109-139.

There exists two types of surveys (cross-section survey and a longitude survey) says Setia, M. S. (2016). Methodology Series Module 3: Cross-sectional Studies. Indian Journal of Dermatology,61(3), 261-264

Walker, L.O., & Avant, K.C. (2005). Strategies for theory construction in nursing (4th ed.) Upper Saddle River, NJ: Pearson/Prentice Hall.

Wen H., Liao S., Hong J., Pan Y., and Wu Y. (2018). Applying Technology Acceptance Model (TAM) to explore Users' Behavioural Intention to Adopt a Performance Assessment System for E-book Production. Journal of Mathematics, Science and Technology Education

Winchester CL, Salji M. Writing a literature review. Journal of Clinical Urology. 2016;9(5):308-312. doi:10.1177/2051415816650133

Wojaczek, A.; Wojaczek, A.K.(2017) Monitoring the environment and machines in underground mine. Zesz. Nauk. Inst. Gosp. Sur. Miner. Energ. PAN. 2017, 99, 57–70.

Wolf, M. (2015, Jul./Aug.). Same as It Ever Was: Why the Techno-optimists Are Wrong. In The Fourth Industrial Revolution. Foreign Affairs.

World Economic Forum and Bank, (WEF)(2017). To beat the robots, we have to be friends with them. Retrieved 04 February,2022 from

:https://www.weforum.org/agenda/2017/10/beating-the-robots-means-building-relationships-with-them/

York, Kay, "A Causal Comparative Study on the Effect of Proficiency-Based Education on School Climate" (2017). Doctoral Dissertations and Projects. 1439. Retrieved 02 February,2022 from https://digitalcommons.liberty.edu/doctoral/1439

Zaina, S.M., Ab-Rahmana , M.S., Ariffin Mohd Ihsana, A.K., Zahrima , A., Mohd Norb, M.J. ,Mohd Zaina, M.F., Hipnia, A., Ramlia, N.L. and Wan Ghopa, W.A. (2011) “Motivation for Research and Publication: Experience as a Researcher and an Academic.” Procedia Social and Behavioral Sciences 18: 213–219.

Zamanzadeh V, Ghahramanian A, Rassouli M, Abbaszadeh A, Alavi-Majd H, Nikanfar AR. Design and Implementation Content Validity Study: Development of an instrument for measuring Patient-Centered Communication. J Caring Sci. 2015 Jun 1;4(2):165-78. doi: 10.15171/jcs.2015.017. PMID: 26161370; PMCID: PMC4484991.

Zervoudi, K.E. Parallel banking system: opportunities and challenges, Journal of applied finance & banking. Vol.9, no. 4, 2019

# APPENDIXES

## Appendix A: Ethical 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/BA1279943/970
*This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below)*

| | |
|---|---|
| **Project title** | The perception of the impact of the Fourth Industrial Revolution on production in South African mines |
| **Investigator / Researcher** | Mr Solomon Ledwaba |
| **Nature of Project** | MBA (Research Article) |
| **Decision of the Committee** | Approved, provided stakeholders and participants are guaranteed confidentialty. |
| **Issue Date of Certificate** | 27/11/2021 |
| **Expiry date** | Date of submission of the project report |
| **Chairperson** | Ms Ayanda Magida<br>+27 11 717 3953<br>ayanda.magida@wits.ac.za |

**Declaration by Researcher**

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

29/11/2021
Date:

**Appendix B: Informed Consents Letter**

Title of project: “The perception of the impact of the Fourth Industrial Revolution (4IR) on production in South African mines”

Name of researcher : Solomon Ledwaba

I , ……,agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below)

I agree that my participation will remain anonymous YES NO

I agree that the researcher may use anonymous quotes in his /her research project YES NO

I agree that the audio may be audio recorded YES NO

I agree that the information I provide may be used anonymously after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.

**Appendix C: Participation information Sheet**







Dear Sir/Madam

My name is Solomon Ledwaba, and I am a master's student in Business Administration , at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating "The perception of the impact of the Fourth Industrial Revolution (4IR) on production in South African mines"

under the supervision of Dr Pius Oba. The aim of this research project is to explore perception about Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance in South African mines

As part of this project, I would like to invite you to take part in answering a questionnaire as part of a focus group discussion.

This activity will involve answering a questionnaire and will take around 15 minutes. With your permission would like to use the answers as data collected for evidence in my research .

There will be no personal costs to you if you participate in this project, You will not receive any direct benefits from participation but there are no disadvantages or penalties, if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to.

The questionnaire will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym (false name'0to represent your participation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop or resume another time.

If you have any questions or afterward about this research, feel free to contact me or the details listed below. This study will be written up as a research report which will be available online through the university library website. If you wish to receive a summary of this report, I will be happy to send it to you via email. The data collected from this research project will be stored in my password protected hard drive and will be kept for three years post the research completion. With your permission the data collected from this research project may be used by other researchers (optional)

If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the university Human Resource Ethics committee (non-medical),telephone +27 011 1408,email hrec-medicalresearchoffice@wits.ac.za

Yours sincerely,

Solomon Ledwaba,1279943@students.wits.ac.za,+27 079 6993686

**Appendix D: Research Questionnaire – Instrument**

**Do you voluntarily accept to participate in this research study?**

**Please tick below.**

| **YES** | **NO** |
|---|---|
| | |

**Section A: Demographic Information**

Instruction: kindly complete the following questionnaire by putting an (X) on the appropriate box to rate your level of agreement or disagreement. Confidentiality and anonymity are confirmed.

**Question 1**

**Please indicate your age range**

| | |
|---|---|
| 18 - 24 years | |
| 25 - 34 years | |
| 35 - 44 years | |
| 45 - 54 years | |
| 55+ years | |

**Question 2**

**Please indicate your gender**

| | |
|---|---|
| Male | |
| Female | |

**Question 3**

**Please indicate your highest qualification**

| | |
|---|---|
| Matric | |
| Certificate | |
| Diploma | |
| Degree | |

| | |
|---|---|
| Post graduate qualification | |

**Question 4**

**Please indicate length of service in the organization**

| | |
|---|---|
| 1 to 5 years | |
| 6 to 10 years | |
| 11 to 15 years | |
| 16 to 20 years | |
| 21 years and above | |

**Section B 1**

**Objective 1:** To determine the perception of employees and management on Fourth Industrial Revolution(4IR) strategies and practices in relation to production processes performance at selected mine

**1. Current 4IR strategies**

| | | **Strongly Disagree 5** | **Disagree 4** | **Neutral 3** | **Agree 2** | **Strongly agree 1** |
|---|---|---|---|---|---|---|
| 1 | I am aware of what the fourth industrial revolution is | | | | | |
| 2 | I am aware of what technologies make up the fourth industrial revolution technologies | | | | | |
| 3 | Our company's corporate strategies are aligned with the fourth industrial revolution technologies | | | | | |
| 4 | Our human resource strategies are aligned to the fourth industrial revolution strategies | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | Our operations strategies are aligned to the fourth industrial revolution strategies | | | | | |
| 6 | Employees were involved in the fourth industrial revolution strategy development | | | | | |
| 7 | The fourth industrial revolution strategies are being implemented successfully in our company | | | | | |

**Question 2: Current 4IR technologies in use**

| | | **Strongly Disagree**<br><br>**5** | **Disagree**<br><br>**4** | **Neutral**<br><br>**3** | **Agree**<br><br>**2** | **Strongly agree**<br><br>**1** |
|---|---|---|---|---|---|---|
| 1 | Our mine uses robots | | | | | |
| 2 | In our mine we use artificial intelligence machines | | | | | |
| 3 | In our mine we use the cloud and big data system | | | | | |
| 4 | In our mine we use Drones | | | | | |
| 5 | In our mine we use 3-D technologies | | | | | |
| 6 | In our mine we use the blockchain technology | | | | | |
| 7 | In our mine we use biotechnologies | | | | | |
| 8 | In our mine we use internet of things | | | | | |
| 9 | Advanced geographical location systems | | | | | |

**Question 3: What are the 4IR practices within the organisation**

| | | **Strongly Disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly agree** |
|---|---|---|---|---|---|---|

| | | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|
| 1 | 4IR technologies are used for the collection of mining data | | | | | |
| 2 | Drones and other 4IR technologies are used for stock taking | | | | | |
| 3 | Robots are used for underground mining | | | | | |
| 4 | 4IR machines are used for underground mineral identification | | | | | |
| 5 | 4IR machines are used for blasting | | | | | |
| 6 | 4IR machines Ore collection and bringing to the surface | | | | | |
| 7 | 4IR machines are used for underground temperature sensing to avoid ground collapse | | | | | |
| 8 | 4IR machines are used for quality checking of minerals | | | | | |
| 9 | 4IR machines are used identify and signal for high level of underground toxicity, to prevent miners from getting sick | | | | | |
| 10 | 4IR technologies are used for taking production decisions | | | | | |
| 11 | 4IR machines are used for stock pilling | | | | | |
| 12 | 4IR technologies are used for inventory reordering, when materials fall below the accepted levels | | | | | |
| 13 | Provide training on the use of different 4IR technologies | | | | | |
| 14 | The use of 4IR technologies create distance and relationship barriers | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | between employees and management | | | | | |

**Section B2**

**Objective 2: To determine employee perception on the adoption of Fourth Industrial Revolution(4IR) technologies on productivity at selected mine**

**Question 1:** What is the perception on the 4IR strategies

| | | **Strongly Disagree 5** | **Disagree 4** | **Neutral 3** | **Agree 2** | **Strongly agree 1** |
|---|---|---|---|---|---|---|
| 1 | The current 4IR strategies were properly formulated | | | | | |
| 2 | The current 4IR strategies does not consider the interest of other stakeholders | | | | | |
| 3 | The current strategies are well aligned to production process | | | | | |
| 4 | The current 4IR strategies were designed to reduce human intervention in production | | | | | |
| 6 | The current 4IR strategies is designed to reduce employment cost | | | | | |
| 7 | The current 4IR strategies are effective in improving production | | | | | |
| 8 | Employees need more training on the use of the current e-learning system | | | | | |
| 9 | Employees are happy with the strategy implementation process | | | | | |
| 10 | Since the deployment of the 4IR strategy, | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | there has been all round improvement at the mine. | | | | | |

**Other perceptions**……

**Question 2:** What is the perception on current 4IR practices

| | | **Strongly Disagree**<br><br>**5** | **Disagree**<br><br>**4** | **Neutral**<br><br>**3** | **Agree**<br><br>**2** | **Strongly agree**<br><br>**1** |
|---|---|---|---|---|---|---|
| 1 | Using 4IR technologies for the collection of mining data have helped improve production decisions | | | | | |
| 2 | The use of Drones for stock taking reduces stock taking time | | | | | |
| 3 | Robots and Drones are replacing human employees | | | | | |
| 4 | Using 4IR machines for underground mineral identification is effective and saves time and cost | | | | | |
| 5 | 4IR machines reduce accidents in our mine | | | | | |
| 6 | Using 4IR machines for Ore collection and bringing to the surface reduce physical labor for employees and time is also saved | | | | | |
| 7 | Since the use of 4IR machines for underground temperature sensing there has been fewer cases of ground collapse | | | | | |
| 8 | Using 4IR machines for quality checking of minerals have improved the quality of our products | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9 | Since the use of 4IR machines for identifying and signaling management high level of high underground toxicity, there have been fewer cases of employees getting sick from dust inhalation and exposure to toxins | | | | | |
| 10 | Material estimates and usage are now more accurate since we started using 4IR technologies for taking production decisions | | | | | |
| 11 | Employees are now less fatigued since we started using 4IR machines for stock pilling | | | | | |
| 12 | We don't have privacy since the use of drones to monitor production activities, as well as the environment | | | | | |
| 13 | The 4IR systems are too complicated to understand and to use | | | | | |

**Section B3**

**Objective 3: To offer recommendations to management in selected mines of way of improving mining operations through 4IR strategies, practices, and technologies.**

| | | **Strongly Disagree**<br>**5** | **Disagree**<br>**4** | **Neutral**<br>**3** | **Agree**<br>**2** | **Strongly Agree**<br>**1** |
|---|---|---|---|---|---|---|
| 1 | Improve the current strategy to ensure job security | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | Involve other stakeholders in the revision of the current 4IR strategy | | | | | |
| 3 | Provide training on 4IR systems | | | | | |
| 4 | Implement a change management process to encourage technology acceptance and adoption | | | | | |
| 5 | Engage employees to address negative perception of 4IR technologies, strategies and practices | | | | | |
| 6 | Invest more in 4IR systems that support the safety of lives, and reduce the falling of ground as much as possible | | | | | |

**Other recommendations**……

**THANK YOU FOR YOUR PARTICIPATION**