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# The state of readiness of government school teachers in the introduction of the fourth industrial revolution

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# THE STATE OF READINESS OF GOVERNMENT SCHOOL TEACHERS IN THE INTRODUCTION OF THE FOURTH INDUSTRIAL REVOLUTION.


**By**

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**A Research Report Submitted to the Faculty of Humanities, University of the Witwatersrand, in partial fulfilment of the requirements for the Master of Education Degree in the Field of Educational Technology**

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WSoE
Wits School of Education

## ABSTRACT

The World Economic Forum (WEF) has made it clear that the world has entered a new Industrial Revolution (IR). This new revolution is identified as the Fourth Industrial Revolution (4IR). The fourth industrial revolution features in late innovations and new technological transformation such as Three-Dimensional Printing (3D Printing), Artificial Intelligence (AI), blockchain, big data, Internet of things (IoT), coding, nanotechnology, quantum computing, and Programming. The world has started witnessing such technological advancements in other sectors of the economy such as aeronautics, construction, agriculture, health and finance. While the universe is growing digitally at a rapid pace, it is significant to question the state of readiness of teachers in government schools to determine their readiness in welcoming the 4IR in schools. Considerable attention must be paid to the education sector in preparing teachers and learners to meet the requirements of the 4IR and beyond. This qualitative study explored the state of readiness of public-school teachers in the introduction of the 4IR. The aim of the study was to identify how ready are teachers in delivering fourth industrial education (4IR Education) in the classrooms, what digital skills and e-skills are required and assessing teachers' knowledge on the 4IR. The study employed qualitative methods. Interviews and Surveys were used as a mixed method of data collection. Ten teachers from the Johannesburg Central District participated in the study. Purposive Sampling was employed to sample the participants. The results were analysed using content analysis. The World Economic Forum Education 4.0 Framework was adopted as the study's conceptual framework. The results from the e-readiness criteria tool indicated that public school teachers in the Johannesburg Central District are 69% ready in terms of ICT and other digital skills. Opposing to that, the results from the interviews indicated that teachers hold insufficient knowledge on the introduction of the 4IR making it difficult to implement 4IR learning in schools. It was recommended that teachers need to be developed on 4IR, engage in STEM programmes for technology integration, invest in 4IR resources and Implement ICT structures in schools.

**DECLARATION**

I certify that this research report is entirely my own. It is submitted in partial fulfilment of the requirements for the Master of Education in Educational Technology degree offered by the University of the Witwatersrand in Johannesburg. This research has never been submitted to any other institution of higher learning for any other degree, for any other purpose of research, or for examination.



**Serema Edward Nkoana**

## DEDICATION

I would like to express my gratitude to the God of Mount Zion for providing me with the strength to pursue my studies thus far. I dedicate this work to my late grandfather Mr Serema Edward Nkoana, my parents Mr Machuene Alfred Nkoana and Mrs Kgabo Elizabeth Nkoana, my brother, Mmatlou Gift Nkoana, my sister Phuti Jerinah Nkoana, my son Karabo Tshohledi Morata, and the Matebele clan as a whole.

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Indeed, you are the heavenly father, God of Mount Zion. Thank you for instilling in me the determination to persevere and remain a diligent worker. This research report was completed not through my own knowledge, but through your wisdom invested in me. To my entire family, I want to express my gratitude for your support, encouragement, and understanding during my absence.

## LIST OF ACRONYMS

| | |
|---|---|
| **IR** | Industrial Revolution |
| **4IR** | Fourth Industrial Revolution |
| **AI** | Artificial Intelligence |
| **3D** | Three-Dimensional Printing |
| **IOT** | Internet of Things |
| **5G** | Fifth Generation |
| **WEF** | World Economic Forum |
| **4IE** | Fourth Industrial Education |
| **CAPS** | Curriculum Assessment Policy Statement |
| **ICT** | Information Communication and Technology |
| **UNESCO** | United Nations Educational, Scientific and Cultural Organization |
| **STEM** | Science, Technology, Engineering and Mathematics |
| **OECD** | Organisation for Economic Co-operation and Development |
| **VR** | Virtual Reality |
| **IBM** | International Business Machines Corporation |
| **DBE** | Department of Basic Education |
| **GDE** | Gauteng Department of Education |
| **WITS** | University of the Witwatersrand |

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# CHAPTER ONE

# 1. INTRODUCTION

## 1.1 Introduction and background of the study

The world has been facing massive technological transformations recently. With the World Economic Forum introducing the 4IR to the universe, many sectors have showed new innovations that looks at transforming the economy and the daily lives of people. The introduction of the fifth generation (5G), three-dimensional printing (3D), artificial intelligence, coding, nanotechnology, blockchain technology, robotics, nanotechnology, and programming have forced many societies to accept the 4IR as it is declared as a new way of living, Schwab (2017). While the globe continues to move more and more to modern technology, education plays a significant role in preparing teachers and learners to meet the requirements of the 4IR, Tymon (2013).

The education sector has been identified as one of the pivotal structures in introducing new set of skills required for the 4IR, Masina et al (2020). (Kehdinga & Fomunyam 2019) also supports that education is significant in shaping the strengths of every country or society. This is further contributed by a society's level of education on massive advancement on industrial knowledge, economy and technology, (Kehdinga & Fomunyam 2019). Over the decades, education have been growing and each industrial revolution demanded a certain type of approach for its goals to be successful, and the 4IR is completely foreign to that (Moloi & Marwala, 2020). Education in the past three industrial revolutions followed a monodisciplinary approach where learners would gain a narrow set of skills in schools, proceed to higher institutions to obtain a qualification for a specific job, (Moloi & Marwala, 2020). However, education in the 4IR is impacting all corners of the society (Moloi & Marwala, 2022). Advancements in technology are making profound transformations in the education sector (Xing, 2017). Despite a wide range of technology taking centre stage in education and beyond, Manasia et, al (2020) argues that the state of readiness from the education sector, specifically on teachers remain questionable. Tymon (2013) also argued that even though there are a variety of media platforms and technologies that can be used to facilitate teaching and learning, the state of readiness of teachers

seems to be lagging in accepting technology in the 4IR. Some general reasons to this are the high cost of resources and lack of training on the 4IR, Jane (2010).

Hamalik (2003), defined what is meant by the “state of readiness” in education. The state of readiness means the value or state of being prepared or ready for something, Hamalik (2003). Guliwe (2019), on the other hand questions the state of readiness in accepting the 4IR in public schools. Guliwe (2019) believes South Africa is still wrestling with the third industrial revolution. Kayembe & Nel (2019) expressed that understanding the state of readiness of teachers on the introduction of the 4IR requires breaking down the statement of “state of readiness into questions such as “what skills are already known about the 4IR? Which resources are available to implement the 4IR? What kind of support is given by the external stakeholders? And what preparations have already been done to accept the fourth industrial education?

Teachers in schools play a critical role in implementing the fourth industrial education (Xu, David & Hi Kim, 2018). The implementation of the 4IR in schools relies on teacher’s knowledge on the 4IR, sufficient resources and on-going trainings and skills of the digital age, Gwata (2019).

### 1.2 Problem statement

A study has been conducted by the World Economic Forum (2018) on the nature of the 4IR in the education sector. Their results indicated that 65 percent (%) of learners enrolled in primary schools today will end up working in jobs that don’t exist yet. This reality poses a threat to public schools on their state of readiness on the introduction of the 4IR according to Taylor & Sakyi (2016). One key factor to this threat is the readiness of teachers in public schools which makes it difficult for them to meet the requirements of the 4IR, Kayembe & Nel (2019).

In a study conducted by Kayembe & Nel (2019), the results revealed that the challenges public school teachers face in South Africa include improper infrastructure, lack of funding, lack of financial, human and technical capacity. This is supported by Taylor & Sakyi (2019), that South Africa’s education sector is undergoing devastating events that contribute to the country’s readiness to meet the 4IR obligations. Taylor &

Sakyi (2019) further express that schools continue to be demolished by violence and crime. Corruption, a lack of effective school governance, and a lack of community support in schools have resulted in significant backlogs in critical developments at many schools, Taylor & Sakyi (2019). The 4IR also requires a new set of digital skills from teachers to match the needs and changes brought forward in the digital age, however due to lack of sufficient training and development, the state of technological learning remains to be a concern (Xu et al.,2018). The acceptance of new technology by teachers has also been a major issue in preparing to meet the standards of the 4IR, Guilherme (2019). Berendt et al., (2020) describes this as technophobia. The 4IR requires an integrated learning in all subjects where skills such as creative skills, technological skills, and critical thinking skills are practiced, Schwab (2017).

The South African Basic Education (DBE) has started introducing new subjects such as robotics, programming and coding in public piloted schools (Macha, 2020). However, teachers are not trained on this new technology, but they are expected to teach the learners (Macha, 2020). Moloi & Dichaba (2017), expressed that the preparations needed to promote the fourth industrial education requires professional training and development for teachers, on-going support from districts, and well-designed curriculum specifically for the fourth industrial education.

### 1.3 Purpose of the study

The general purpose of the study was to investigate the state of readiness of government school teachers in the introduction of the 4IR in the Johannesburg central district. The study carefully examined teacher's digital skills, knowledge on the 4IR and classroom pedagogies to determine whether they comply with the requirements for the 4IR education framework.

### 1.4 Research questions

To accomplish the goal of the study, the following research questions were developed:

## 1. Primary research question

a. What is the state of readiness of government school teachers in the introduction of the 4IR?

## 2. Secondary questions

a. What digital skills and e-skills do public school teachers possess for teaching and learning in Johannesburg central district in terms of e-skills?

b. What knowledge do teachers need in the introduction of the 4IR in the classroom?

c. What kind of classroom pedagogical skills do teachers require in the introduction of the 4IR in the classroom practice?

d. How do teachers reflect on the World Economic Forum Education 4.0 framework in their teaching practice?

## 1.5 Study aims and objectives

The aim of the research was to investigate the state of readiness of government school teachers in the introduction of the 4IR in terms of digital skills, the knowledge on the 4IR and pedagogies used in the classroom.

The specific research objectives for this study were to:

- Determine what digital skills and e-skills do public school teachers possess for teaching and learning in Johannesburg central district in terms of e-skills.

- Determine what knowledge do teachers need in the introduction of the 4IR in the classroom.

- Determine what kind of classroom pedagogical skills teachers require in the introduction of the 4IR in the classroom practice.

- Explore how teachers reflect on the World Economic Forum Education 4.0 framework in their teaching practice.

### 1.6 Glossary of key terms

It is critical to define and explain key terms to avoid ambiguity and misunderstandings regarding central concepts, Brown, (2017). The terms presented below were defined by the WEF (2018).

**Table 1.6 Glossary of key terms:**

| No | Term | Definition |
|---|---|---|
| 1 | **Industrial revolution** | Industrial revolution is a period of new technology innovations that improves economic developments within that age, WEF (2018). |
| 2 | **4IR** | The 4IR is the latest revolution that offers recent technology advancements in genetic engineering and artificial intelligence, WEF (2018). |
| 3 | **Transformation** | Transformation is a comprehensive change of information systems with the aim of enhancing delivery in the digital economy, WEF (2018). |
| 4 | **Artificial intelligence** | Artificial intelligence is a theory and development of computer systems that can perform tasks that normally require human intelligence. Speech recognition, decision-making, visual perception, for example, are features of human intelligence that artificial intelligence may possess, Schwab (2017). |
| 5 | **Technology** | Technology refers to methods, systems, and devices which are the result of scientific knowledge being used for practical purposes (2018). |
| 6 | **Internet of things** | The Internet of Things (IoT) describes the network of physical objects— “things”—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet, WEF (2018). |
| 7 | **Nanotechnology** | A novel technology, preferably on an atomic scale, to produce novel materials, structures, and devices, WEF (2018). |

| | | |
|---|---|---|
| **8** | **Big data** | The large amount of data that can be accessed quickly, WEF (2018). |
| **9** | **Blockchain** | Blockchain is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network, WEF (2018). |
| **10** | **Three-dimensional printing** | 3D printing uses computer-aided design (CAD) to create three-dimensional objects through a layering method. Sometimes referred to as additive manufacturing, 3D printing involves layering materials, like plastics, composites or bio-materials to create objects that range in shape, size, rigidity and colour, WEF (2018). |

### 1.7 Research outline

The study followed the precise research structure described below:

1. **Chapter one**

   Chapter one provides the introduction and background to the study. The chapter also discusses the problem statement to the study, the research purpose and objectives, research questions, definition key terms and how the study will be structured.

2. **Chapter two**

   Chapter two provides an extensive literature review on the impact of the 4IR in education and the concepts behind the state of readiness in the digital age. The chapter also discuss the relevant conceptual framework from the World economic forum.

3. **Chapter three**

   Chapter three in the study also described as the research methodology discusses the research approach, research design, population and sampling, data collection methods, data analysis method, the quality criteria and ethical considerations.

4. **Chapter four**

   Chapter four provides details to the data analysis and discuss the findings in the study. This includes the demographic information of participants, discussion of themes and sub-themes emerging from the study.

5. **Chapter five**

   Chapter five discusses the main findings and provides a conclusion and recommendations to the study.

# CHAPTER TWO

# LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

## 2.1 Chapter Overview

Chapter one introduced and contextualized the study, defining the research problem, the purpose of the study, aims and objectives, research questions, definition of key terms and the structure of the entire research. Chapter two discussed the existing knowledge referred to as the literature review and the conceptual framework relevant to the study.

## 2.2 The education system of South Africa

The education system of South Africa has been networked into three levels which are the elementary level (foundation phase and intermediate phase), the secondary level (senior phase) and the tertiary level, Moloi & Dichaba (2017). In the past, the National Department of Education (NDE), was responsible for education in all three levels, but, after the 2009 general elections, the department was divided into two divisions to increase focus and specific skills required, (Macha, 2020). In recent years, the Department of Basic Education (DBE) is now accountable for the elementary and secondary level, while the Department of Higher Education and Training (DHET) is responsible for secondary education, technical training, and tertiary education (Mocha, 2020). The national government of South Africa invests eloquent resources on education to try to upgrade the education system of the country, Dichaba (2017). In 2013, the government spent 19, 7 percent of its budget on the education sector and roughly about 6 percent of the country's gross domestic product (GDP) in the year 2014, Macha (2020). The share on the department of basic education of total government expenditure was always the highest compared to health and social development, however in 2020 to 2021 the education expenditure was reduced from 16,8 percent to 16 percent which saw the health and social development sector receiving an increment, Macha (2020). Since then, a lot of alterations has been done in the education sector due to the strict financial support they have been receiving from the national government, this forced the education sector to drag fit in some of the projects and transformations, one of them being the technological transformations

(Moloi & Dichaba, 2017). A decline in the necessary digital skills from both teachers and learners with relevant resources has seen the education sector struggling to meet the requirements of the 4IR (Marwala, 2020).

### 2.3 The department of basic education in South Africa

From 2016, it was estimated that South Africa has established 29 749 public and independent schools (Department of Basic Education, 2018). Furthermore, 25 574 were ordinary schools and 14 177 were early development centres (ECD) and special schools (DBE, 2018). It is also confirmed that South Africa had 430 000 teachers in 2012 and 2013. This number increased with 10 151 teachers to make it 440 151 in 2016 (South African Market Access, 2020). All these teachers were divided across the districts, provincial DBE offices to administer the goals of the DBE accordingly (DBE, 2018). The Department of Basic Education (2018) identified the poor quality of education as one of the barriers in the 4IR. The education system of South Africa continues to be one of the worst education sectors in the world, Macha (2020). One of the major reasons brought forward is the lack of digital skills and e-skills from teachers to implement the 4IR learning. While the education system of South Africa has a high percentage of teachers, not all of them master the digital skills and e-skills required for the digital world, (UNICEF, 2019). It is estimated that 20 percent of children in foundation phase and intermediate phase will lack the necessary skills for the future; this is mainly because teachers still believe in manual teaching methods in the classrooms (Department of Basic Education, 2018).

### 2.4 The e-School Technology Assessment Readiness and Targets (e-START)

In August 2003, the department of education released a white paper draft on e-Education, which looked at transforming learning and teaching through information and communications technology (ICT), Marwala (2020). According to Sikwebu (2020), the mandate of this project was to introduce ICT in public schools to create new possibilities for learners and teachers to engage in new ways of acquiring and delivering information through new lenses. Upon this new ICT implementation programme, the e-school technology assessment readiness was one significant area

of focus. This feature looked at assessing schools e-readiness and preparations already been done to compliment digital learning and teaching in classrooms, (DBE, 2018). In 2019, an online application was developed to assess and evaluate the e-readiness and ICT in all government schools in South Africa, Greunen (2020). The application was called the "*e-ready ICT maturity assessment tool"*. It was an initiative of the department of science and innovation which was in line with its commitments to connect science, technology, and innovation to expand access to education. This tool was to be piloted in March and April 2020 but was delayed by the corona virus pandemic, (DBE, 2018).

Sikwebu (2020), expressed that e-schools are the future, more especially in a world full of digital transformations where households and schools have limited resources. Sikwebu (2020) further states that education can only be accessible to everyone if education can be concentrated through technology. Greunen (2020) also adds that the starting point should be teachers focusing on digital skills to master the digital world. With teachers having the necessary skills on technology in the classrooms, learners have a high chance of meeting the requirements for the 4IR. The need for ICT capacity and e-readiness in schools has been stressed for many years, with promises from the government in 2013 to deliver free broadband access to 90 percent of South Africa by 2020, and 100 percent by 2030(DBE, 2018). Regrettably, the 2020 target was not achieved. The urgent need for e-readiness for the 4IR has been highlighted with the covid-19 pandemic making the country realise that learners should be learning online at home and that teachers should make use of different learning management systems (LMS) to administer online teaching, Gwata (2019). The use of learning management systems requires deep digital literacy skills and e-skills from all teachers. Kehdinga & Fomunyam (2019) also add that teachers will need to design content using different multimedia provided by the platforms, set lessons, set activities, invite learners, provide feedback on time, and provide extra-support online. However, most importantly, teachers need to follow the correct online learning models and philosophical approaches when designing online learning, Gwata (2019).

Unfortunately, South Africa is not yet in the majority of the 26 000 schools, hence this digital tool is critical in helping schools take a transition to the digital age (Greunen, 2020). The general aim of the pilot was to test the tool's efficiency in recognizing a school's e-readiness. At each school, teachers download the app, which includes a

range of yes or no questions that can be completed offline and in areas with no or low connectivity, (DBE, 2018). The e-readiness tool assessed each school's ICT infrastructure, e-administration, connectivity, digital content and curriculum, teacher development and teacher ICT readiness and support, (DBE, 2018). At the end of the assessment, the results are sent to the central database, the app then generates a report which is available immediately and emailed to the teacher who completed the assessment and to the department of basic education. This gives the national department the information about what needs to be done in each school to achieve e-readiness, (DBE, 2018).

The whole idea is that every school should achieve a good level of e-readiness and that every teacher and learner in schools should have a device or tablet, as outlined by the president in 2019, (Sikwebu, 2020). While teaching capacity is an issue, Gruenen (2020) argues that it is not proper to be handing out tablets and laptops to schools and introducing coding and robotics from grade 1 as the department of basic education has done, when teachers are not trained on ICT, specifically on the 4IR. Based on a study conducted by Centre of Community Technologies (CCT), the results indicated that some principals and teachers who received tablets and laptops do not know how to use them, or they do not have internet connectivity and integrate ICT into their teaching experience, (Sikwebu, 2020). Gruenen (2020) also motivates that the South African government prioritizes the transformation of basic education outcomes through ICTs. The policy makers often have unrealistic expectations from teachers. Schools are expected to be able to use ICTs in a short space of time, while it takes an average of four to five years for most teachers to reach a level of technological proficiency at which they can use computers effectively, Gruenen (2020). If the 4IR is to deliver on the promise of economic development, better education, job creation through innovation and skills transfer, South Africa must quickly and instantly change its education focus (Van Laar et al.., 2017). Sikwebu (2020), also adds that if the department of basic education and other stakeholders take the e-readiness assessment tool seriously and proactively, many challenges highlighted in ICT education can be addressed.

### 2.5 The 21st century skills

The skills needed for education and the workplace in the digital age have been labelled the 21st century skills (Binkley et al., 2019). To define these skills, a few initiatives have outlined frameworks. The Partnership of the 21st Century Skills (P21, 2007) is a joint government organization that lists three types of skills namely: learning skills, literacy skills and life skills. The other initiative is the international research project Assessment and Teaching of the 21st Century Skills (ATC21S). The ATC21S focused in ten skills grouped into four categories which are: ways of thinking (critical thinking, problem solving, innovation and creativity and decision making), ways of working (collaboration; communication), tools for working (ICT literacy; information literacy) and living in the world (career skills; citizenship; personal and social responsibility) (Binkley et al.,2019). On the other hand, the 21st century skills literature emphasizes a broad knowledge of skills from teachers to integrate digital aspects in the classroom, Van Laar et al. (2017). According to Lemke (2019), the following skills are fundamental for performing teaching tasks in the digital age.

### *2.5.1 Technical skills*

Teachers need technical skills to maintain new developments arising in education to replace manual learning with digital learning (Fuchs, 2010). Teachers also need to understand that more workplaces have been supported by ICT, which more jobs require technical skills (Levy & Murnane, 2004).

### *2.5.2 Information skills*

Teachers must be able to search, evaluate, and organize information, (Silva, 2009). With the world growing rapidly, teachers need to recognize when information is needed and to be able to evaluate the reliability and relative value of information in schools (Starkey, 2011).

### *2.5.3 Communication skills*

Communication skills are very important in the economic sector, more especially in the digital era, (Katz, 2007). The ability to transmit information to ensure that meanings

are effectively expressed by considering the audience by the teachers is substantial (Levy & Murnane, 2004). The world's economy is interconnected; therefore, teachers play an important role in instilling communications skills in learners for them to respond positively in the new global economy (Voogt et al., 2013).

### *2.5.4 Collaboration skills*

Collaboration skills is a requirement from teachers in the digital age (Wang, 2010). Teachers cannot possess all knowledge and skills (Dede, 2010). Teachers should work together to find solutions and clear understanding of their new roles in a digital classroom (Bronstein, 2003).

### *2.5.5 Critical thinking skills*

Normally, in education, critical thinking skills is generally expected from the learners, but that is not true (Gut, 2011). Critical thinking skills is also required from the teachers in the classroom (Gut, 2011). Teachers need knowledge that is central to a particular domain to formulate a self-regulating, well-grounded perspective or view, (Gut, 2011).

### *2.5.6 Problem solving skills*

As schools are increasingly confronted with challenging and nonrecurrent problems (Author et al., 2003), teachers need the skills to solve specific problems. Complex situations require problem solving skills that is incorporated with prior knowledge to be able to identify necessary actions, possible gaps, and ways to obtain information (Ling, 2011).

## 2.6 Adding digital skills in the 21st century skills

Ananiadou & Claro (2009) highlights that the is a thin line between digital skills and general skills in the 21st century. For example, technical skills are similar as proposed by the notion of 21st century skills, the only difference is that from a digital perspective, teachers need to use a software or operate a digital device (Hwang, 2011).

### *2.6.1 Information digital skills*

The information caused by ICT requires teachers to have skills for searching, evaluating, and organizing information in digital environments (Song & Ling, 2011). Teachers also need the skills to store and arrange the digital information for easy retrieval (Lu & Lee, 2012).

### *2.6.2 Communication digital skills*

The use of ICT has made it easy to reach a wider audience and communicate at a rapid pace. With communication digital skills, teachers can express themselves, establish work relationships with other teachers, and interact with other teachers at any time and space (Yu et al., 2010). It is imperative that teachers understand how to effectively communicate using email, instant messaging services and social networking sites (Lu & Lee, 2012). (Brandtzaeg et al., 2010) also supports that teachers need the skills to contact with other teachers, maintain those contacts, share online content and media with their contacts.

### *2.6.3 Collaboration digital skills*

For collaboration digital skills, ICT is very useful when sharing information and making informed decisions (Wang, 2010). With the use of collaborative software such as Skype or WhatsApp, teachers can instantaneously interchange information, ideas, and experiences. Teachers need the skills to connect and collaborate with other teachers beyond constraint physical environments (Starkey, 2011).

### *2.6.4 Critical thinking digital skills*

Starkey (2011) identifies critical thinking as being particularly important because in a global online environment, people participate, and resources are created with various competences. Therefore, it is crucial for teachers to rapidly screen incoming online information and communication to be able to extract valuable information (Dede, 2010).

### *2.6.5 Problem solving digital skills*

In any society, problems can be defined differently, and various solutions can be found online. The only disadvantage is that the knowledge and solutions to solve specific problems can be made available online but possibly remain unnoticed because of lack of an integrated view (David & Foray, 2002). As such, teachers need online problem-solving skills to formulate the problem and find strategies to determine the best solution for the problem (Bark, 2018).

## 2.7 The 4IR

The WEF (2018) defines the 4IR as a convergence of technological advancements in artificial intelligence, coding, robotics, and advanced materials. Three-dimensional printing (3D), quantum computing, blockchain technology, nanotechnology, and fifth generation (5G) are just a few examples. With some considerations, the world has already witnessed new technological transformation in a variety of sectors (Moloi & Marwala, 2020). In the education sector, specifically in China, robots are implemented in schools as classroom teacher assistant, robotics and coding programmes are introduced in schools with greater financial support, and the use of faster network known as fifth generation (5G) is already available in some schools (Marwala, 2020). These are some examples that declares that the 4IR has revealed its features in the education sector, (Moloi, 2020). It is acknowledged that the 4IR will alter the way we live, enable us to view the world through new lenses, and most importantly, alter the way we learn, (Schwab 2019). The implications of the 4IR will differ from one country to the other and culture, traditional philosophies, economy, and government structures will play an important role in this regard (Schulze,2019). The 4IR appears to be prevalent in Eurocentric countries. African countries, appears to be falling behind, hence the department of basic education is struggling to implement the 4IR in schools (Guliwe, 2019). Marwala (2020), gives an important statement that for teachers to understand the 4IR, they must first appreciate the first, second and third industrial revolution.

## 2.8 The last three industrial revolutions

### *2.8.1 The first industrial revolution*

Schwab (2019) explains that the first Industrial Revolution occurred between the 1760s and 1840s, when steam engines were introduced as a source of energy. For education sectors across the globe, learning was regimented, (Prisecaru, 2016). Learners at that time were placed in grades according to their age and moved to the next grade as they mastered and achieved the curriculum. Many schools took an industrialized approach to education that was impersonal, standardized, and efficient, (Saviotti & Metcalfe 2018). According to Prisecaru (2016), teachers in the first industrial revolution had to teach what was given to them by the government, opportunities for open teaching was prohibited.

### *2.8.2 The second industrial revolution*

The second industrial revolution was revealed between the 1870s and 1940s, from the late 19$^{th}$ century into the 20$^{th}$ century, Schwab (2019). The second industrial revolution saw the development of electricity, a division of Labor, and mass production, WEF (2018). In this industrial revolution, the education systems across many countries started making educational transformations to introduce learning that develops critical thinking skills, creativity skills and a more technical curriculum, (Prisecaru, 2016). Teachers in the classroom where also forced to use newly implemented scientific principles when learners are doing research and investigations, (Prisecaru, 2016).

### *2.8.3 The third industrial revolution*

The third Industrial Revolution began in the early 1950s with the development of information technology, electronics, and automated manufacturing, (Schwab, 2019). Xu, David & Hi Kim, (2018), designates that the third industrial revolution has brought teachers to an environment where access to information is instant and free, moving the focus towards active learning pedagogies that place a quality on collaboration within diverse learning. Prisecaru (2016) also supports that the introduction of

mathematics, science, engineering, and technology (STEAM EDUCATION) in this revolution has resulted in a superior emphasis on interpersonal skills and liberal arts

## 2.9 Defining 4IR in education and establishing standards for quality learning and teaching in the new economy.

The (WEF, 2018) asserts that 4IR can only be defined by high-quality teaching and learning. However, the question is *"What does the 4IR mean when it speaks of quality teaching and learning?"* This essentially means that learners must be equipped with the necessary skills to contribute to the global economy in the future. This includes not only economic contributions but also becoming active citizens in future societies (WEF, 2018). The (WEF,2018), goes on to explain that to achieve this vision, learners must be equipped with four critical skills: (1) global citizenship, (2) innovation and creativity, (3) technology, and (4) interpersonal skills. This necessitates a redesign of the Curriculum Assessment Policy Statement (CAPS) in South Africa to address the most pressing needs and to incorporate agile mechanisms for skill adaptation to ensure learners remain future-oriented, (Marwala, 2020). This also requires government teachers to develop teaching strategies that are compatible with the new revolution (Moloi & Marwala, 2020).

### *2.9.1 Skills for global citizenship*

Poverty and a lack of adequate income in households have continued to grow at a rapid pace. This is primarily due to economic challenges. Other challenges, according to the (WEF, 2018), include opportunity inequality, market concentration, technological change, and globalization. These trends result in unequal opportunity distribution and exacerbate social polarization. This can be seen further in the diverse economies of various countries. The currency and wealth of Eurocentric countries are significantly superior to those of Africa (Guliwe, 2019). Furthermore, the (WEF, 2018) emphasizes the importance of countries cooperating to achieve growth and equality because of technological advancements. For education to be effective, children must be equipped with the necessary global citizenship skills to navigate this potential

change and comprehend the world through a more digitally transformed lens, Schwab (2019). Jaimovich & Siu (2017) also believe that learners should be prepared in schools with the ability to address global issues, not just local or national ones. The curriculum implemented in schools must provide opportunities for learning and teaching in a global context. In other words, education policymakers must rethink their educational goals and objectives from a national to a global perspective, Wim (2017).

UNESCO (2014) also supports the idea of incorporating global citizenship skills into the curriculum. Schulze (2019) intensely criticizes the South African curriculum that it only teaches learners about South Africa's diverse cultures, traditions, and history. Schulze (2019) further add that this impairs learners' ability to reason globally, making it more difficult for them to interact with the world effectively.

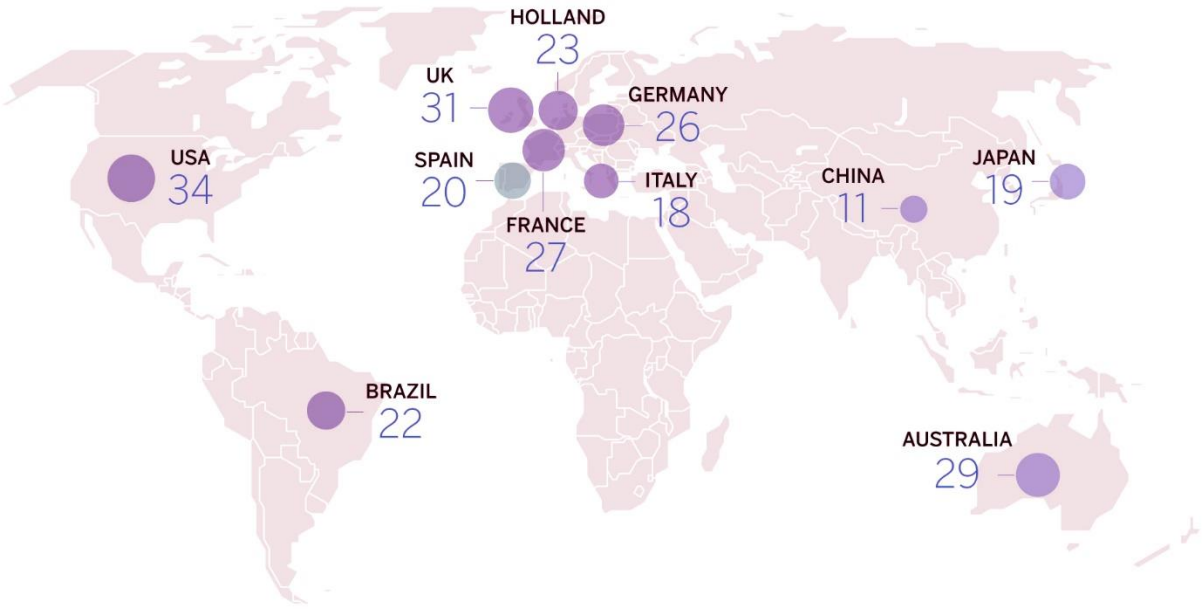
Moreover, the (WEF, 2018) emphasizes the critical role of new technologies in enabling global citizenship education. Video conferencing and virtual classrooms enable learners and teachers to collaborate and learn about global trends to foster a greater global understanding. Menon (2019) also posits that teachers can share teaching strategies online. The use of social media has also played a significant role in assisting learners worldwide in identifying themselves. Such technologies can aid learners in their quest for a better understanding of the world, Wim (2017).

### *2.9.2 Skills for innovation and creativity*

Innovation, adaptation, and flexibility have become growth factors in the 4IR (WEF, 2018). Countries that can rapidly generate and adopt new ideas, processes, and products will have a significant advantage and chance of achieving the 4IR. The (WEF, 2018) published data on which countries possess the digital skills necessary to succeed in the 4IR. Surprisingly, South Africa came nowhere near the top (Schulze, 2019; Moloi & Marwala, 2020; Marwala, 2020).

***Figure 1:*** *Countries with the digital skills necessary to master the 4IR, (WEF, 2018).*

Contribution, in percentage terms, of the digital economy to GDP as a whole.




This figure shows that a countries ability to form effective innovative systems strongly depends on their human capital and economy (WEF, 2018). This therefore tells that an economy of a country plays a significant role in innovation and creativity skills (Xu et al., 2018). The government should invest in the education system of its country. For the education sector to achieve the 4IR, teachers must be provided with the necessary skills to generate new ideas, products, and systems. The WEF (2018) further adds that teachers must provide teaching that includes curiosity, critical thinking, and problem solving, creativity and system analysis to promote innovation in and outside the classroom. The Organization for Economic Co-operation and Development (OECD, 2019) also supports that the skills of curiosity, problem solving, and critical thinking will be in high demand in the next coming years, it is therefore important that teachers set great lessons and reform their teaching ways to prepare learners for the 4IR. The WEF (2018) further expresses that the process of innovation requires active, rather than passive learning. Active learning requires learners to discuss, think, analyse information, and challenge ideas (Magout & Magout, 2020). Learners must be actively engaged from an early age. The point of learning through play is also significant to build innovation according to the LEGO Foundation (2017). Play can

enable innovation skills. LEGO foundation (2017) goes on to explain that through structured and unstructured play activities in schools, learners can touch on their natural curiosity, learn through trial, and error and think of new solutions or ways to achieve their play (games).

It is a requirement that innovation and technology should work together to achieve the 4IR, (Schwab, 2019). Therefore, digital tools in schools can help encourage innovation skills, (Dassault Systemes, 2019). Coding games and online education can help learners to contextualize learning while driving their creativity to have their own understanding of the digital world. Applications such as LEGO can help learners express themselves to promote creativity, design, and early engineering skills according to the Real Play Coalition (2019). However, Alsedra (2019), reassures that these skills need support with interactive teaching methods. Encouraging innovative and creativity skills requires a transition from normal teaching methods to more interactive methods of teaching where teachers work as coaches, facilitators, and inspectors rather than being lecturers (Alsedra, 2019). This also requires a great collaboration between the education system and private sector to shape learners in these new skills and prepare them for the digital world (UNESCO, 2014).

### *2.9.3 Technological skills*

Manda & Dhaou (2019) state that technology design and programming skills will be in high demand in the coming years. This will result in the creation of new job opportunities that do not currently exist, thereby affecting the business's growth. Jama (2019) also shares similar sentiments that to achieve the 4IR, businesses, schools, and economies must promote future-ready technology skills. Numerous countries, particularly in the African continent, have fallen behind in terms of acquiring numerous new digital skills, Staunton (2017). Therefore, African countries continue to hire scientific professionals from Eurocentric countries to assist them, Jama (2019) stresses. In the United Kingdom, 99 percent of teachers agree that technology skills should be included in the curriculum; this means that technology should be integrated into all aspects of learning, not just STEM subjects (Google for Education,2019). By making these changes, learners will develop healthy relationships with technology, gain an understanding of the fundamentals of the digital world, and increase their

awareness of and responsibility for technology interaction, (Google for Education, 2019). On the other hand, teachers must provide instructional methods that promote computational thinking, collaboration across STEM disciplines, and digital literacy to help learners understand how to approach problems in today's computer-based world, Jama (2019). Learners can use YOUTUBE to stream videos to gain a better understanding of the material being studied, (Google for Education, 2019).

CodeAcademy (2019), designates that educational technology can also be used to improve students' technology skills. Online tools such as Google Classroom, YOUTUBE, Nearpod VR, Kidblog, National Geographic Kids, and CodeAcademy can be used to teach programming and assist learners in developing an understanding on how to use digital technology through the creation of games, stories, music, and animations, Real Play Coalition (2019). This, however, necessitates the establishment of adequate infrastructure to support digital learning in schools. Schools must have adequate resources to educate students about technology, Macha (2020). According to a study conducted by the Digital Quotient foundation (2019), numerous businesses have begun collaborating with schools to provide the necessary support for students to prepare for the digital world. Their assistance includes providing teachers with free technology education and training, providing teachers with free internet access, and providing teachers with technology learning content to upgrade curricula, (DBE,2018). International technology competitions are critical for promoting technological capabilities (DQ Institute, 2019). The education sector in the United Arab Emirates (UAE) has launched an artificial intelligence and robotics competition, which annually attracts over 3000 students. This competition takes place on a national and international level, (DQ Institute, 2019).

## 2.10 Characteristics for the 4IR

Erboz (2017:2), states that each industrial revolution has its own distinct characteristics. This holds true facts for the 4IR as well according to Schwab (2019). It is critical to understand the characteristics of each era to respond positively to human activity, (Liao et al., 2018). While other authors identify the internet of services, smart

factories, cyber systems, and the internet of things as key characteristics of the 4IR, Erboz (2017) argues that industry 4.0 includes a plethora of additional characteristics and features such as 3D printing. artificial intelligence, blockchain technology, cryptocurrency, robotics, nanotechnology, bioengineering, and quantum computing are all examples of cutting-edge technologies. According to Skilton and Hovsepian (2018), these technologies define the 4IR and transform the way products, services, and materials are manufactured. Erboz (2017) also attributes a significant role to the use of (ICT) in the formation of the 4IR. Lee (2018) also adds that the use of (ICT) shapes and defines technological transformation across all industries. The adoption of (ICT) in organizations is the first step toward embracing the 4IR according to Jones & Pimdee (2017). Temelkova (2018), also makes an important statement that the characteristics of the 4IR also provide direction for the education sector in terms of the relevant focus and skills required.

### *2.10.1 Big Data*

Taylor and Sakyi (2016) define big data as "large sets or the availability of data." This can be structured or informal. Big data is the collection and processing of large amounts of data or information at a rapid rate, Karabegovic (2017). Big data is a cost-effective and innovative method of processing information that enables rapid decision making and process automation which can assist organizations in analysing and making meaningful decisions about their data according to Schwab (2019).

Nowadays, information about any country can be obtained in a short space of time. Google, YOUTUBE, and Wikipedia have enabled the collection of as much data as possible for public access. According to De-Mauro, Greco, and Grimaldi (2015), one of the primary reasons for big data in the 4IR is to expand information and make as much data as possible available. Governments and businesses make decisions based on the volume of data collected and generated via technological means, Schwab (2019). In other words, education sectors can redesign their curricula based on available data. Taylor and Sakyi (2016) emphasize the importance of information protection and storage as well. The requirement for sufficient storage space for information is critical. It is for this reason that new technological advancements have

resulted in the creation of applications such as Online BACKUP, Google Drive, ICLOUD, and online storage purchases, Real Play Coalition (2019).

### *2.10.2 Artificial Intelligence*

Alsedrah (2017), states that the term "artificial intelligence" is not new; it was coined more than 60 years ago. It is the capacity of computers or robots to perform human-like functions. However, Alsedrah (2017) significantly highlights that artificial intelligence is quicker than humans. It consists of a much more developed capacity than humans. Alsedrah (2017) defines artificial intelligence as the field of study that examines machines' ability to work and learn in the same way that humans do, as well as their ability to respond to specific behaviours. In artificial intelligence, machines are programmed to perform tasks in the same way that humans do. The fascinating aspect of artificial intelligence is that it enables machines to perform functions such as planning, reasoning, learning, and perception (Perez, Deligianni and Yang, 2018). As a result, artificial intelligence can be a computer software that performs or portrays human-like behaviours according to Alsedrah (2017). In today's world, self-driving cars, Apple's Siri, and Google are all available. All these applications depict human characteristics, Cilliers (2018).

### *2.10.3 Robotics*

Perez (2018) emphasizes the importance of robotics in the 4IR. Robotics is based on advances in electrical engineering, computing, and mechatronics, Perez (2018). In the automobile manufacturing industry, robots have been demonstrated to be functional. Karabegovi and Husak (2018) go on to state that in today's world, it is physically impossible to imagine any industrial sector operating without robots. In a study conducted by e-Skills Malta Foundation (2019) in Japan, one of the largest automobile manufacturers namely Toyota, produced approximately 3 270 000 vehicles in 2014. Dividing this figure by the number of production days' results in a daily production rate of 13 400 vehicles. This is accomplished quickly and efficiently using robots. Therefore, it is critical for schools to promote robotics education so that learners can keep up with new developments and technologies in the digital generation, Manda & Dhaou (2019).

### *2.10.4 The Internet of Things*

The (IoT) is extremely interesting in terms of technological transformations. This new concept incorporates modern technology, allowing devices such as television sets, mobile devices, refrigerators, and computers to communicate with one another via the internet, Gartner (2016). Gartner (2016) expands on this definition by defining (IoT) as a network of physical objects equipped with embedded technology that enables them to communicate and sense online. According to Karabegovi and Husak (2018), the (IoT) is at the heart of the 4IR. It is alleged that in the coming years, everything will be controlled online, Perez (2018).

### *2.10.5 Three-dimensional printing (3D)*

3D printing is another characteristic of the 4IR. Eisenburg (2013) defines 3D printing as the process of creating solid objects from a digital file, also referred to as additive manufacturing. This new technology is being used in a variety of fields, including automobile manufacturing and medicine. Chow-Miller (2018) also describes 3D printing as a much faster and more affordable method of creating objects. Numerous businesses are beginning to invest in this emerging technology, Jama (2019).

### *2.10.6 Quantum computing*

In a study conducted by Microsoft (2019), results indicated that scientific complications that normally takes millions of years to get answers can be explained using quantum computing in a short space of time. This emerging technology can be found in a variety of industries, including energy, environmental systems, health care, and smart materials. On the same note, Dassault Systems (2019) explains that quantum computing can assist us in forecasting the future and advancing medical, scientific, technological, and structural advancements, as well as financial strategies. Marshall (2016) asserts that quantum computing is critical for the education sector because it

presents both challenges and opportunities for the future. It paints a clear picture of what to anticipate in the coming years.

### 2.11 Pedagogical Innovations in the 4IR

The (WEF,2018), argues that a transformed learning environment and redesigned curriculum are not the only factors to consider when introducing and preparing for the 4IR. The forum views pedagogy, or teaching, as a critical strategy for enabling 4IR in schools. Furthermore, the forum supports innovative teaching strategies for implementing the 4IR. Macha (2020), also argues that we cannot use traditional methods of instruction to introduce new concepts. The (WEF,2018) proposed five innovative ways of teaching to propel education forward in the 4IR based on their research.

The first strategy is to instruct and educate through **play (playful).** This approach generates exciting experiences that enable learners to connect learning to their lives through active thinking and social interaction. Moreover, this approach allows for both free and guided play by teachers, as well as the use of games to foster curiosity and critical thinking (Eisenberg,2013).

Experiential teaching and learning are the second strategy **(experiential).** This approach requires teachers to create hands-on lessons that allow learners to reflect on their experiences. In other words, it facilitates the incorporation of content into real-world applications (Schwab, 2019).

Computational learning and teaching constitute the third strategy **(computational).** This approach requires teachers to incorporate computers into the classroom to assist students with problem solving. The more frequently teachers incorporate computers into the classroom, the more quickly learners grasp the digital world and are prepared to address the issues that arise in the new era (WEF, 2018).

Embodied learning is the fourth strategy **(embodied).** This approach necessitates that both learning and teaching occur through movement. Gone are the days when learners were required to sit, and the teacher was the only one speaking and moving

in the classroom. Teachers should be able to effectively utilize space, movement, and social context to facilitate learning (WEF, 2018).

The fifth strategy is to incorporate multiple literacy practices into teaching and learning **(multiliteracies).** This approach encourages teaching and learning to occur in a variety of ways to promote diversity by utilizing a variety of languages and cultures to formulate knowledge and information (WEF, 2018).

### 2.12 Required digital literacy skills from teachers for the 4IR

Jones & Pimdee (2017) positions that digital competence, digital literacy and digital skills are mostly featured in policy documents for the 4IR and are sometimes used interchangeably. Jama (2019) also elucidates that with immense technological transformations taking place, teachers are required to keep up with the pace. Jones & Pimdee precisely enlightens that teachers in the 4IR need to have access to a mobile phone, tablet, laptop and be able to use them to their full specifications. Understanding online applications and being able to share online content is very pivotal in the 4IR, Jama (2019). Lankshear (2016), also identified the following fundamentals that institute digital literacy: information content evaluation, knowledge assembly, navigation of hypermedia content and internet searching. The other digital skill required from teachers is the ability to know and understand concepts arising in the 4IR such as data analysis, cloud computing, virtual reality in the classroom, machine learning and online learning, Staunton (2017).

### 2.13 Required e-skills from teachers for the 4IR

With the evolving economy built on disruptive innovation, which takes place at a very fast pace, the prior argument recognizes creativity as the advocate of the new economic generation within the context of the 4IR, Temelkova (2018). Manda & Dhaou (2019) further states that innovation is the driver for the 4IR and that a need to pay attention to research and development is required from teachers. Since technology is the fundamental pillar and denominator of the 4IR, Gary (2016), proposes that teachers need to upgrade from digital skills to e-skills for them to achieve the 4IR. E-

skills and digital skills are often used interchangeably according to the e-Skills Malta Foundation (2019). The only difference between digital skills and e-skills is the level of competence or how advance is a person in terms of digital skills and (ICT), Bacon & Machinnon (2016). To understand these two concepts better, Van Deursen & Van Dijk (2009) provides a clear example that digital skills would focus on which tool the teach can use (e.g., Twitter) and how to use it, while e-skills would include in-depth questions such as *when would you use Twitter and why would you use it?* This then confirms that for e-skills, teachers need to understand online teaching from an advanced level and be able to use appropriate online tools and resources that can meet the learners needs, Stauton (2017). On the other hand, e-skills comprises the skills needed to create and develop ICT products such as designing a learning content through an approved learning management system (LMS) platform, Martine (2018).

### 2.14 Criteria and dimensions of e-readiness applied in teacher development

In 2011, the Gauteng Department of Education (GDE) under the guidelines developed by the eLearning directorate designed an e-readiness criteria that can be used by teachers to describe their levels of e-readiness and knowledge on ICT digital skills (DBE, 2018). The criteria consisted of four levels describing a process of a teacher starting to use ICT, then becoming more comfortable and accepting the use, then making changes in behaviour, approach, and systems to use ICT more effectively, and finally adopting them as the means to achieve aims and objectives, DBE (2018). The criterion is explained in greater detail in the below table.

*Table 2: GDE e-readiness criteria for teachers (DBE, 2018)*

| Level | | Applied to the teacher |
|---|---|---|
| **Entry** *(Starting point)* ***(10%-29%)*** | 1 | The teacher is computer literate. He/She can use a computer. However, the teacher also lack confidence in ICT. Insecurities and frustrations are common in the introduction of ICT. |
| **Adoption** *(The process of accepting something)* | 2 | The teacher can use a variety of ICTs including computers to support teaching and learning in the classroom. The teacher is also able to teach learners on how to use ICT. |

| | | |
|---|---|---|
| ***(30%-49%)*** | | |
| **Adaptation** *(The state of change to fit a new environment)* ***(50%-69%)*** | 3 | The teacher can use ICT to support everyday learning at an appropriate CAPS level, assess learners online and ensures progression. The teacher can reflect critically on how ICT resources can enable him/her to re-design the teaching and learning processes and use ICT learning management systems. |
| **Appropriation** *(Taking something for your own use)* ***(70%-90%)*** | 4 | The teacher has an inclusive understanding of the ways in which ICT can contribute to teaching and learning. The teacher has the confidence and experience to reflect on how ICT can influence teaching and learning approaches. The teacher can develop new learning environments that use ICT as a flexible tool so that learning can become interactive and collaborative. |

*2.14.1 Usage of the criteria*

The DBE (2018) makes it clear that the criteria discussed above can only be active if a school has a functional ICT committee. The ICT committee is responsible for encouraging the use of ICT for teaching and learning and develop its own ICT policy to cover goals and objectives for ICT usage, the application of ICT to support curriculum delivery and management of physical usage of ICT in the school which includes management of assets and data, as well as budgeting and planning, Moloi & Dichaba (2017). The criteria can be applicable based on the observations by the ICT committee and the questionnaire tool designed to investigate teachers' e-readiness. The committee will issue out a questionnaire tool to the teacher with questions based on the investigated phenomena. Each question will consist of a mark(point), then the total marks will be added to get the total percentage. If the percentage is 60 percent, that means the teacher is on level 3 which is adaptation, DBE (2018). A clear example can be found from the following questionnaire example designed by the department of education.

***Table 3:*** *Questionnaire ratings of teachers on e-readiness components, DBE (2018).*

| Teacher | E-readiness score | Able to use a computer | The teacher has at least two gadgets | The teacher understands online operating systems and offline operating systems | The teacher make use of at least one LMS platform | The teacher uses mobile lab | Access the internet frequently | Total |
|---|---|---|---|---|---|---|---|---|
| | 90% | 2 | 2 | 2 | 2 | 1 | 1 | 10 |
| 1 | 54% | 2 | 1 | 0 | 0 | 1 | 1 | 6 |
| 2 | 36% | 2 | 1 | 0 | 0 | 0 | 1 | 4 |

The above tool shows two teachers who were tested for e-readiness. The total mark was 10 marks. Teacher one obtained six marks out of ten. The teacher's score is divided by the total mark of the questionnaire marks to obtain the percentage (6/10x90%=54%). This means teacher one obtained 54 percent which is located under level three in the e-readiness criteria. Sikwebu (2020) strongly agrees that this method is very efficient and significant when investigating teachers' readiness in ICT. Sikwebu (2020), further emphasize that schools can use the same method to investigate the state of e-readiness in terms of digital skills and digital literacy development.

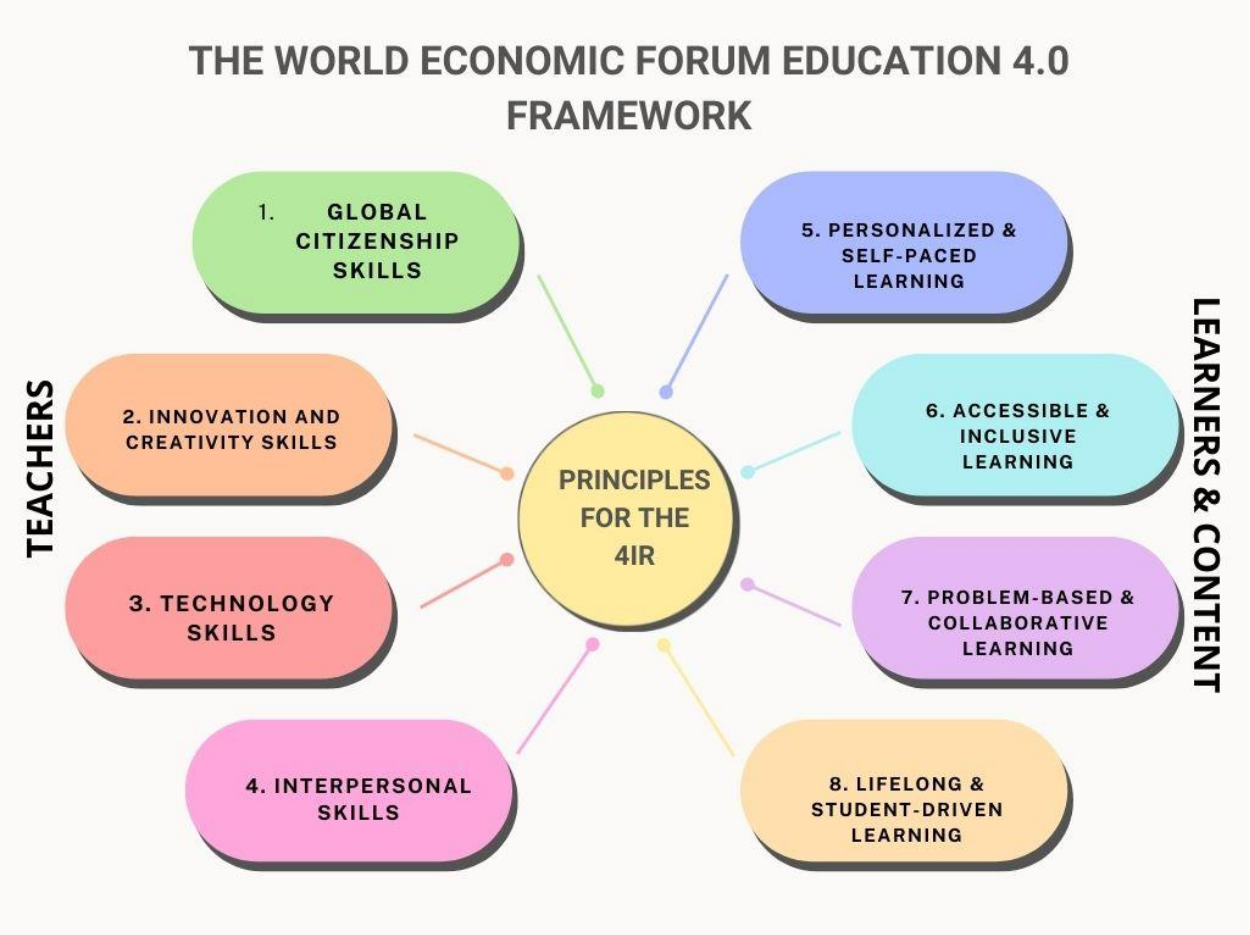
### 2.15 Conceptual Framework

When the WEF (2018) introduced the 4IR to the world, specific frameworks, and policies where designed and implemented in all sectors of the economy to make sure that every industry meets the standards and requirements for the 4IR. For the education sector, the WEF (2018) designed an educational framework labelled the World Economic Forum Education 4.0 Framework (WEFE4.0F), Schwab (2019). According to Martin (2018), the framework is responsible for defining quality education and preparing teachers and learners to meet the standards for the 4IR and beyond. The WEF (2018) decided on eight principles as the foundation to the framework. This was achieved after several consultations and research done with teachers globally, curriculum designers, policymakers, business leaders, educational technology developers, and other experts. Kehdinga & Fomunyam (2019) provides a strong statement that if education sectors and schools adhere to these standards, they have

a good chance of achieving the goals for the 4IR. Gwata (2019) on the other hand gives much attention to teachers to utilize the framework to comply with the requirements for the 4IR.

This study adopted the (WEFE4.0F) framework to serve as the theoretical framework to investigate the state of readiness of government school teachers in the introduction of the 4IR. The framework will help understand the state of readiness of teachers in compliance of the set of principles provided by the WEF (2018). The framework is discussed in greater detail below.

***Figure 2:*** *The World Economic Forum Education 4.0 Framework (WEFE4.0F) (WEF,2018)*



The above-mentioned framework serves as a guide for examining a country's educational system in terms of its compliance with the requirements of the 4IR. Given by the WEF (2018), for:

**1.Global citizenship skills** – It is necessary for learners to be exposed to cultures from other countries to comprehend how others define the world. Furthermore, this focuses on content or curriculum that fosters global awareness.

**2.Innovation and creativity skills** – Learners should be exposed to content that fosters innovation, problem solving, creativity, and analytical thinking. This will largely depend on teachers developing effective lessons to promote these skills.

**3.Technology skills** –Teachers should deliver content that focuses on the development of digital skills and technology use. This explains the critical nature of technology integration across all subjects.

**4.Interpersonal skills** –Teachers should deliver content that emphasizes leadership abilities, social awareness, cooperation, and Interpersonal Emotional Intelligence.

**5.Personalized and self-paced learning** – the WEF (2018) emphasizes the importance of expanded opportunities and the importance of no child being left behind. It also emphasizes the importance of curriculum being personalized to each child's learning goals and offering self-paced content.

**6.Accessible and Inclusive Learning** – The WEF (2018) requires that all learners, including those with disabilities, have access to new knowledge. According to the WEF (2018), the curriculum should provide sufficient opportunities and knowledge about the 4IR.

**7.Problem-based and collaborative learning** – problem-based content and peer collaboration are critical components of 4TH Industrial Education; the curriculum should provide opportunities for learners to collaborate and learn from one another, as this will prepare them to collaborate with other scientists and other global stakeholders in the future.

**8.Continuous and student-driven learning** – According to the WEF (2018), learning should be continuous and driven by existing skills and individual needs.

## 2.16 Concluding Remarks

This chapter discussed the existing knowledge on the 4IR and teacher e-readiness in schools. Furthermore, the chapter discussed the pertinent conceptual framework that serves as the foundation for the research. The following chapter will discuss the research design and methodology.

# CHAPTER THREE

# 3. RESEARCH DESIGN & METHODOLOGY

## 3.1 Chapter overview

The preceding chapter provided an extensive review of the literature on the digital skills and e-skills required in the 4IR. The chapter also gave existing knowledge on e-readiness within the education sector of South Africa, predominantly looking at teachers. The chapter lastly discussed the conceptual framework adopted from the WFE4.0F (2018). Chapter three discusses the research methodology applied in the study. The chapter gives full details on the research approach and design, the population and sampling method, the data collection method, the data analysis method used, and the quality criteria to be followed.

## 3.2 Methodology of the research.

*a. Research approach & paradigm*

The study employed a qualitative approach and an interpretive worldview to investigate and explain teachers' readiness in 4IR. Brown (2017) states that qualitative research seeks to explore and investigate; hence, the study explored and investigated the state of readiness of government school teachers in the introduction for the 4IR. Brown (2017) further adds that a qualitative approach seeks to understand people's experiences, perspectives, and concepts about a particular phenomenon. This gave the researcher the opportunity to investigate how teachers understand the 4IR and what is expected from them in the classroom in terms of digital skills. Hasnah et al. (2009) explains that in an interpretivism research, each culture, socioeconomic background, and historical situation is distinct and unique. This demonstrated that a single phenomenon could have multiple interpretations considering social, economic, political, and cultural experiences.

*b. Research methodology framework*

A research methodology framework establishes the parameters within which an investigation will be conducted, Brown (2017) explains. Rajaseker, & Chinnathambi (2017), also provision that a researcher must understand not only how to add, arrange, and describe a set of data, but also how to comprehend physical systems through mathematical modelling. Furthermore, a researcher must be aware of the following:

1. What methods will ensure the investigation's accuracy and sequence of results?
2. Which methods are most appropriate for the problem at hand?
3. How effective are the methods used to conduct the research?

As a result, the researcher explored the study using the following research methodology framework.

***Figure 3****: Structure of the research methodology framework.*



### 3.3 Sampling and target population

The general aim of the research was to investigate the state of readiness of teachers in Johannesburg central district in the introduction of the 4IR. The target population in this study was teachers in the GDE Johannesburg central district. Denscombe (2007:3) puts a strong argument that researchers cannot collect data from everyone who is in the group being researched. This means researchers always rely on finding evidence from a portion of the whole with the prospect and the belief that what is found in that portion, applies correspondingly to the rest of the population. The sample was selected purposively by paying attention to teachers in the foundation phase and intermediate phase. With such being said, ten teachers from the district participated in the study to determine the level of readiness in the 4IR, digital skills, e-skills, and knowledge of the new revolution. The reason to purposively employ teachers in the foundation phase and intermediate phase was with reasons that teachers in the senior phase have a baseline understanding of digital skills and e-learning/teaching skills as some schools have subjects such as Computer Applications Technology (CAT), computer science, Information Technology (IT), computer literacy, and engineering systems. The mentioned subjects provide teachers in the senior phase with an introductory knowledge to the 4IR, whereas teachers in the foundation phase and intermediate phase have no subjects of such calibre. Moloi (2020), emphasizes the importance of technology and computer integration in the foundation phase and intermediate phase. The more teachers are equipped with the necessary digital skills in the two phases, the better chances learners can grasp at an early age in achieving new skills for the future. Sikwebu (2020), also provides a motivating example of school children in China who are given the opportunity to start designing phones and other gadgets as early as 10 years. Such children will become highly respected citizens who will play a big role in science and technology. Therefore, South Africa should also invest in foundation phase and intermediate phase, Moloi & Marwala (2020).

### 3.4 Research Method

This research applied a case study approach seeking to investigate a problem of more real-life settings over an extended period. Denscombe (2007:3), contents that a case

study is very useful when exploring an area of which little is known, and one wants to have a holistic understanding of the phenomenon, situation, community, or group. The introduction of the 4IR came at an unprepared moment where schools and other economic sectors appeared to be struggling and catching up with recent technological transformation, Gwata (2019). It was seen significant enough by the researcher to investigate the introduction of the 4IR in schools to determine the readiness and preparations already been done to meet the requirements of the digital age.

## 3.5 Data collection tools

The study used a mixed method approach to collect data. The use of online questionnaires and face-to-face interviews was the adopted methods in this study. The two data collection methods provided the researcher with statistical results from the online questionnaires which was then quantified and in-depth results from the face-to-face interviews which results where narrated and discussed accordingly.

### *3.5.1 Online questionnaire tool (Surveys)*

The researcher designed an online questionnaire tool using Google forms to collect data at a low cost and conveniently. The Google survey tool was issued out in a form of a link so that participants can fill it in and submit it immediately when they are done. The online questionnaire tool which is also attached in (annexure C) was more intensive on questions that had to do with the participants background information, years of teaching, qualifications obtained, classroom experience with ICT, support from any stakeholders, challenges faced with in terms of ICT and knowledge on the digital skills, e-skills and the 4IR. All questions in the questionnaire tool where coded to be compulsory, therefore the participant would not be able to submit if all questions are not answered. The questionnaire tool also consisted of close ended questions and open-ended questions. At some instances, participants needed to define certain concepts arising in the study and show their understanding. After completion of the questionnaire tool, results and responses where automatically and immediately sent to the researchers Google chrome account. This gave the researcher the opportunity to see how many participants responded to the questionnaire tool. The results where

then represented statistically in a form of graphs, and charts. After the results were extracted from the Google forms, they were then used against the e-readiness criteria provided by the DBE (2018) to quantify the results and see what percentage each teacher obtained in terms of e-readiness.

### *3.5.2 Face-to-face interviews*

Janesick (2004), defines interviews as a meeting of two people or more to exchange ideas and information through questions and answers about a particular topic. The researcher developed a set of in-depth interview questions which are attached in annexure D (interview template) that was asked to the participants. The interview consisted of sixteen questions that looked at participants understanding of the WEFE4.0F, how do they teach technological skills, how do they promote creativity and innovative skills, how do they teach global citizenship skills and in-depths questions about the 4IR. When all interviews were completed, the results were analysed, and the themes and sub-themes were used in-line with the WEFE4.0F to understand and see if participants meet the requirements of the 4IR. The interviews gave the researcher the opportunity to also observe the expression of participants when answering questions. The researcher also had the chance to explain broadly and further if participants did not understand the concepts and questions. The interviews were executed at a convenient time that does not destruct teaching hours. Eight participants were interviewed after school and two participants were interviewed on a weekend.

## 3.6 Data analysis

Denscombe (2007:3), expresses that data analysis is one of the most important steps in qualitative research process. After collecting data from both the questionnaires and interviews, the data was examined using content analysis.

### *3.6.1 Content analysis*

Brown (2017) defines content analysis as a research tool used to determine the presence of certain words, themes, and concepts within any given qualitative research. Brown (2017) also adds that using content analysis provides the researcher with the opportunity to quantify and analyse the meanings of themes and concepts. The researcher saw it as appropriate to use this method to analyse data because of the mixed data collection methods used. Since the data collection methods was quantitative and qualitative, the adopted analysis method gave the researcher a great approach of discussing and presenting the results. The following table provides the steps of content analysis the researcher followed when analysing:

***Table 4:*** *Content analysis steps to following when analysing data (Denscombe,2007:3)*

| No. | Step | Activity |
|---|---|---|
| 1 | **One**<br>Identify and collect data | The data was collected from the participants in a form of online questionnaires and face-to-face interviews. |
| 2 | **Two**<br>Determine coding categories | The researcher then divided the content collected into categories so that it can be managed better. This is also known as the process of selective reduction according to Brown (2017). |
| 3 | **Three**<br>Code the content | The researcher assigned codes to the texts that had to be analysed. For example, the code “digital” would be assigned when there is a mention of any ICT concept in the text.<br><br>For the questionnaire tool, the researcher focused on the frequency on how many people responded to that question and what was their answers. Thanks to Google forms because it provided the results accordingly. |
| 4 | **Four**<br>Check validity and reliability | At this step, the researcher tested the codes that have been designed. The codes were validated for its reliability to see if the different words or phrases in the category have similar meaning or not. |

| | | |
|---|---|---|
| **5** | **Five**<br>Analyse and present results | The researcher reviewed the results, identified the patterns, arranged all the information in a sequence and presented the results. |

### 3.7 Quality criteria

Lincoln & Guba (1985) rests on four general criteria in their approach to trustworthiness in research. These criteria are credibility, dependability, transferability, and confirmability. This research obeyed to the above-mentioned ethical principles to emphasize that high-quality standard research is achieved.

#### *3.7.1 Credibility*

Ten teachers from the JHB central district participated in the study to investigate the state of readiness in government school. The data was collected through online surveys and face-to-face interviews. The sample size and response rate were sufficient to provide a conclusion to the research. The data collected was able to answer the research questions, aims and objectives.

#### *3.7.2 Transferability*

With the same size and response rate, the findings can be transferred. Moloi (2020) stated that most public school in the GDE are offered the same amount of budget and support. Therefore, this justifies that this research can be generalized to other teachers who was not part of the study because of the same budget and support.

#### *3.7.3 Dependability*

The researcher ensured that the research designs and data collection methods were effective and appropriate to ensure reliability and consistency in the findings.

#### *3.7.4 Confirmability*

The researcher ensured that the research remains neutral making it possible for the results to be confirmed and corroborated by others.

### 3.8 Ethical considerations

Before permission was granted by the Wits Ethics Committee to render this research, the researcher distributed consent forms to the participants (teachers) requesting permission to participate in the investigation. The researcher also submitted letters to the schools where research will be taking place, and the (GDE) requesting permission to conduct research at one of their schools and also applied for ethical clearance at the university. The researcher respected the anonymity, confidentiality, and privacy of the participants. There was no evidence of harm during the investigation. Participants' online responses were kept through the researcher's Google chrome account that is encrypted with a password. The information remains safe and will be destroyed after completion of the master's programme. The interview transcripts were scanned and kept in an encrypted file(folder) which is stored in the researcher's laptop. The hardcopies were destroyed, and the researcher is only in possession of soft copies (scanned copies).

### 3.9 Concluding Remarks

The third chapter discussed the target population and sampling methods, data collection methods, the data analysis and the quality criteria followed. Chapter four will discuss the research findings.

# CHAPTER FOUR

# 4. RESEARCH FINDINGS & DISCUSSION

## 4.1 Chapter Overview

Chapter three discussed the research design and methodology. The study sought to investigate the state of readiness of government school teachers in the introduction of the 4IR in terms of digital skills, e-skills and knowledge of 4IR in the JHB central district. Chapter four discusses the findings from the study. The chapter begins by describing the participants' demographics.

### 4.1.1 Demographic information

***Table 5:*** *Demographic information of participants (N=10)*

| Participant | Gender | Race | Age | Level of teaching | Years of Exp. | Qualification |
|---|---|---|---|---|---|---|
| **1** | Male | Black | 30+ | Foundation p | 11-20 years | Bachelor |
| **2** | Female | Black | 50+ | Intermediate p | 32 years | Honours |
| **3** | Male | Black | -30 | Foundation p | 4-10 years | Bachelor |
| **4** | Female | Black | 30+ | Foundation p | 4-10 years | Honours |
| **5** | Male | Black | -30 | Foundation p | 4-10 years | Honours |
| **6** | Female | Black | 50+ | Intermediate p | 21-30 years | Higher cert |
| **7** | Female | Black | 50+ | Foundation p | 4-10 years | Diploma |
| **8** | Female | Black | 50+ | Intermediate p | 21-30 years | Higher Cert |
| **9** | Female | Black | 30+ | Foundation p | 4-10 years | Honours |
| **10** | Female | Black | 40+ | Intermediate p | 10-20 years | Diploma |

The above table represents information about the participants. Ten teachers from the GDE district volunteered to participate in this study to investigate the state of readiness of teachers in the 4IR in terms of digital skills, e-skills, and knowledge on the 4IR. There were three males and seven females. All the teachers remained from the same ethnicity group, which is black (African). Two teachers are aged under 30; four teachers are over 50, one teacher over 40, and three teachers over 30. The teachers'

posses' different years of teaching experience starting from 4 years until 30 years. The highest qualification obtained from the teachers was an honours degree and the lowest was a higher certificate. All the teachers managed to complete the questionnaire tool fully. The teachers also agreed to be interviewed.

### 4.2 Discussion to the analysis

The aim of the study was to investigate the state of readiness of government school teachers in the introduction of the 4IR in terms of digital skills, e-skills, and knowledge on 4IR. The study collected data through questionnaire tools and face-to-face interviews. The collected data was analysed using the content analysis method. The data was divided into categories from both questionnaires and interviews so that it can be managed better. The researcher then assigned codes to the texts that had to be analysed. The codes were tested for reliability and reviewed. Lastly, the information was arranged in a logical sequence and results were presented.

The discussion starts by presenting the findings from the questionnaire tool, then the interviews and lastly presents the results. The questionnaire tool contained forty-one questions. Twenty questions consisted of scores while twenty-one questions looked at a general information that requires no scoring. The questionnaire tool was divided into three sections. The first section was looking at the participant's background information, the second section was observing on the participants ICT experiences such as digital literacy skills knowledge, background on ICT resources. The third section focused more on the basic knowledge in the 4IR such as the invention of the 4IR, the forum responsible for 4IR, and the characteristics for the 4IR. Individual responses were downloaded from the researchers Google chrome account to be analysed separately. The researcher looked at patterns from the individual responses and formed codes, which resulted into the creation of themes and sub-themes. The following themes and sub-themes emerged from the questionnaire tool.

***Table 4:*** *Themes and sub-themes emerging from the questionnaire tool.*

| Data collection methods | Themes | Sub-themes |
|---|---|---|
| • **Questionnaires** | Experience in ICT Education | • Years interacting with ICT<br>• Teaching ICT in the classroom<br>• Duration on using computers |
| | ICT resources in schools | • Equipment available<br>• Conditions for ICT in the classroom<br>• Teachers provided with laptops and owning a technological device. |
| | Digital skills for ICT | • Knowledge of software's (online & offline)<br>• Connecting a desktop<br>• Installing an operating system<br>• Using an (Learning management system) LMS |
| | Training and development on ICT | • Participation in ICT training<br>• ICT support at school<br>• Professional training and development on ICT<br>• Obstacles related to ICT |
| | Knowledge on 4IR | • Acronym for 4IR<br>• Year discovered<br>• Organization responsible for 4IR<br>• Characteristic for the 4IR<br>• What does the 4IR brings?<br>• Skills required in the 4IR |

Results from the Google questionnaire were quantified making it accurate to see how many participants agree or disagree to a phenomenon. This gave the researcher the ability to determine at what percentage is the teacher ready. After all the percentage

was obtained from the participants, their individual scores from the questionnaire were used in the GDE e-readiness criteria discussed in chapter two. To finalize the overall percentage, the total score of all ten teachers was added together and divided by the total score of the questionnaire, which was twenty, then multiplied by the total percentage in the criteria. This gave the researcher the total percentage of how ready teachers are in the introduction of the 4IR in terms of ICT, digital skills, e-skills, and knowledge on 4IR.  A formula from the GDE is best described below:

*Figure 4: Formula for e-readiness tool (GDE, 2018)*

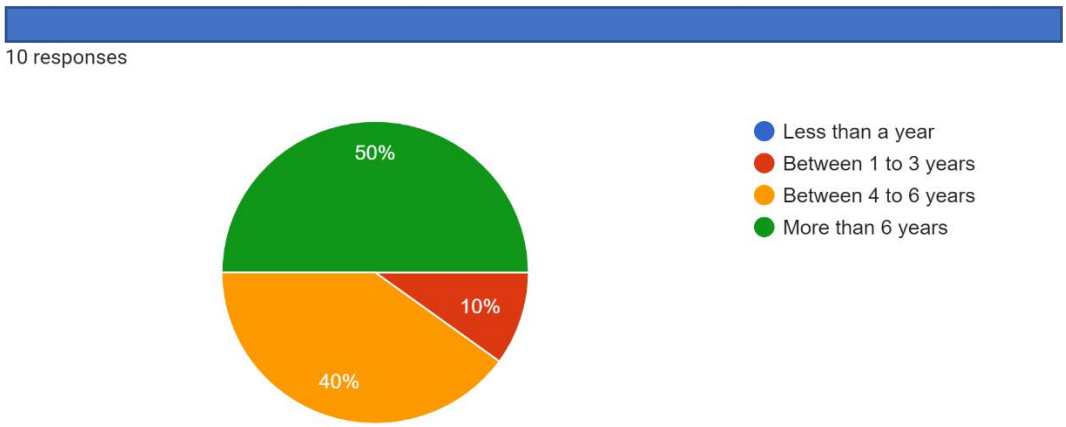
$$\frac{Teacher's\ total\ score\ from\ the\ questionnaire}{Total\ score\ of\ the\ questionnaire\ (20)}\ X\ Total\ percentage\ on\ the\ criteria\ to\ determine\ the\ level\ (90\%)$$

### 4.3 Discussion on the findings

### 4.3 1 Experience in ICT education

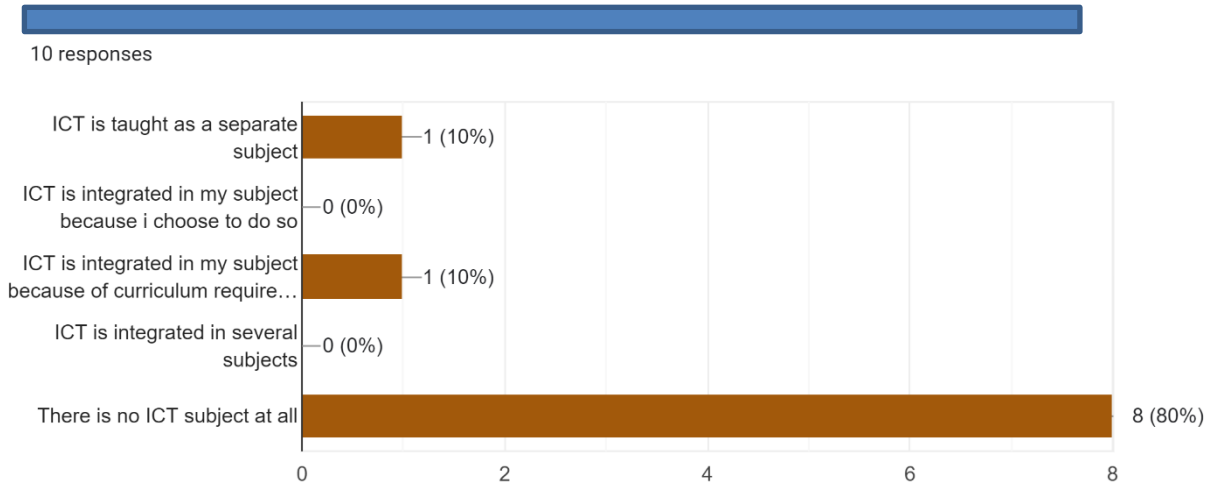
The first theme examined teachers experience in interacting with ICT, the environment within the ICT space and duration in cooperating with computers and other technological devices in the classroom.

*4.3.1.1 Figure 5: Years interacting with ICT*



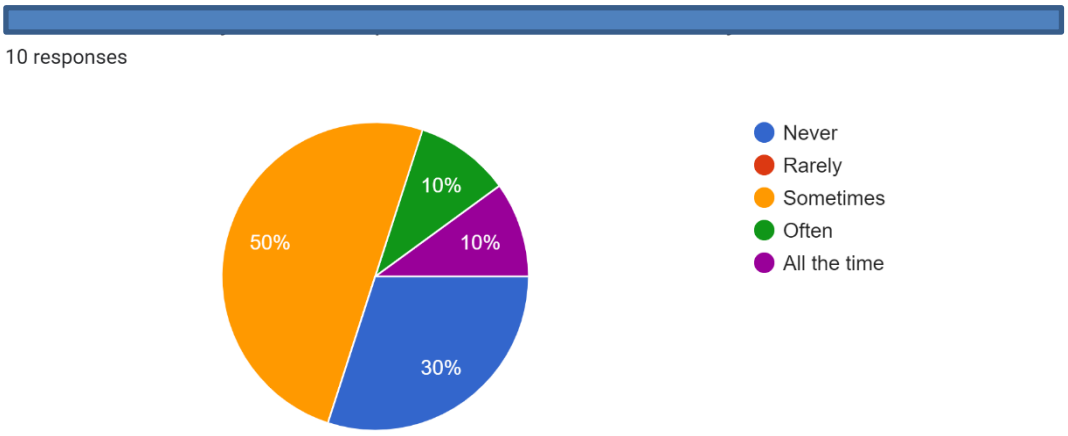
About the duration interacting with ICT, 50% indicated that they have interacted with ICT for more than 6 years. 40% where between 4 to 6 years, while 10% indicated that they were exposed to ICT for 1 to 3 years. This demonstrates that most teachers are exposed to using ICT and have been engaging with it for more than three years. This also illustrate that teachers have an adequate understanding for ICT in schools.

*4.3.1.2 Figure 6: Teaching ICT in the classroom*




On the concept of ICT in the classroom, 8 teachers which is 80% indicated that there is no ICT subject at all in the classroom, while 10 % indicated that ICT is taught as a separate subject, the other teacher indicated that ICT is integrated in their subject because of the curriculum requirement. This broadly explains that ICT is not offered in most schools more especially primary schools, and that other schools offer ICT as a supplementary curriculum or a private project to learning and teaching.

*4.3.1.3 Figure 7: Duration in using computers*



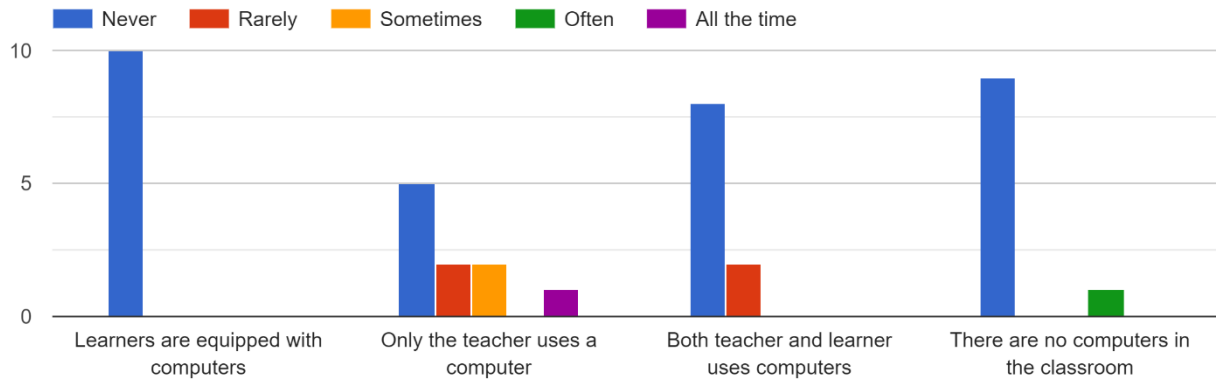

Looking at the skill of computer usage, only 10 % showed that they use their computers all the time. 50% indicated that they sometimes use their computers, when necessary, while 30 % indicated that they do not use computers at all. This should be a concern especially in the digital age where a computer is seen as a basic requirement in introducing digital learning in the classroom.

### 4.3.2 ICT resources in schools

The second theme from the questionnaire tool examined equipment and resources for ICT available for teachers, conditions for ICT in the classroom and teachers provided with laptops.

*4.3.2.1 Figure 8: Equipment and resources available*

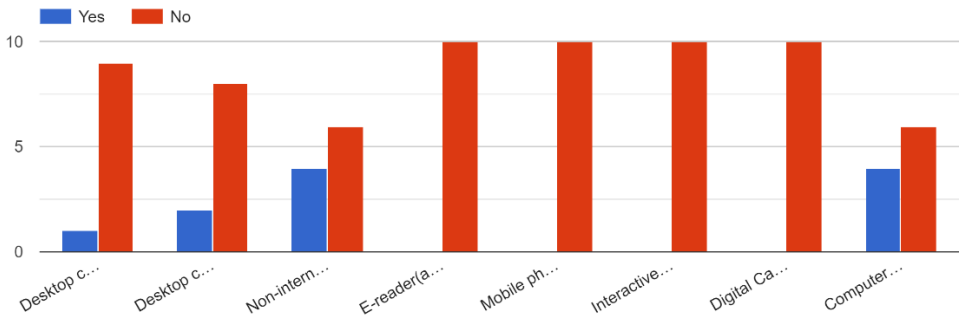





ICT can only be fully practiced if sufficient resources are available, however all participants indicated that their classrooms are not equipped with computers making it difficult for learners to meet the requirements for the 4IR. One teacher mentioned the use of a computer. On the other hand, more than seven teachers indicated that there are no computers in the classroom for introducing ICT education. It is quite clear that only the School Management Teams (SMT) are the ones provided with laptops.

*4.3.2.2 Figure 9: Conditions for ICT in the classroom*

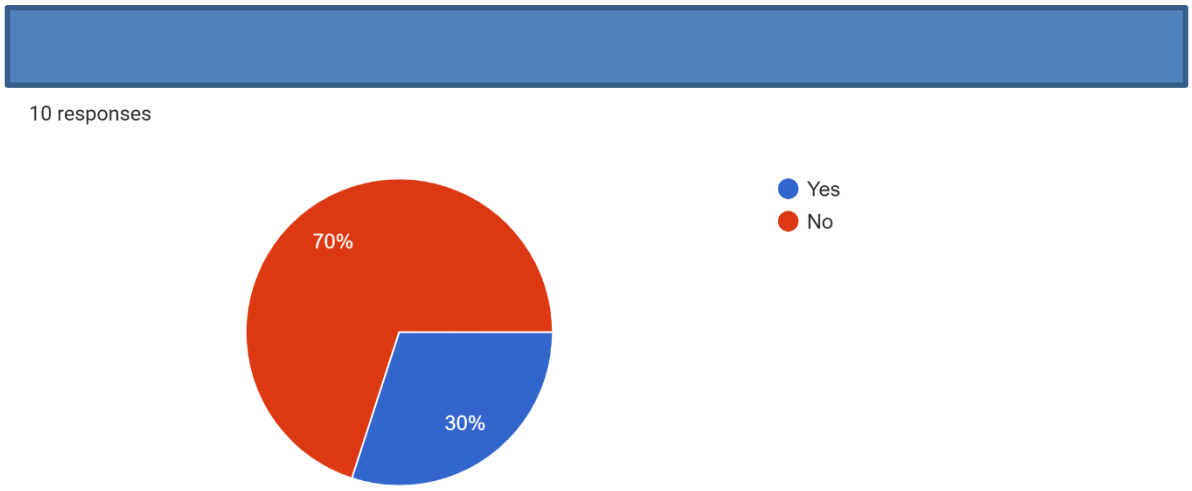





Discussing the conditions for ICT in the classroom, all teachers indicated that they do not have an e-reader (a device to read books and newspapers on the screen), no

phones provided by the school, no digital camera, and no computer laboratory. Only two teachers indicated that they have a computer laboratory with desktops without internet access. This further justifies those teachers' still lack sufficient resources to introduce ICT learning in the classrooms. This makes it difficult to introduce the 4IR.

*4.3.2.3 Figure 10: Teachers provided with a laptop and owning a technological device.*

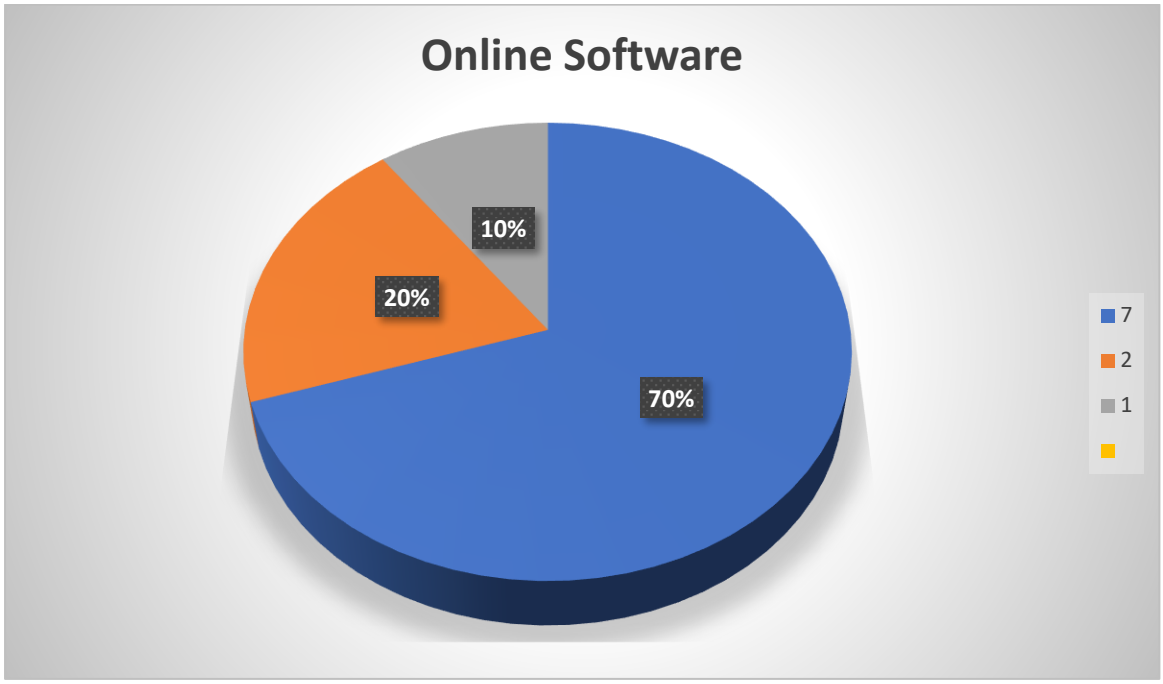



On teachers provided with laptops, only 70% indicated that they are not provided with laptops, while 30% mentioned that they are provided with laptops. Teachers provided with laptops are likely to be Head of departments (HODs), deputy principals, and principals for administration and management duties. This tells that some teachers rely on their personal laptops to design lesson plans, access online meetings. However, there is no guarantee to this. Some teachers may not have access to online and offline modes because they are not provided with laptops.

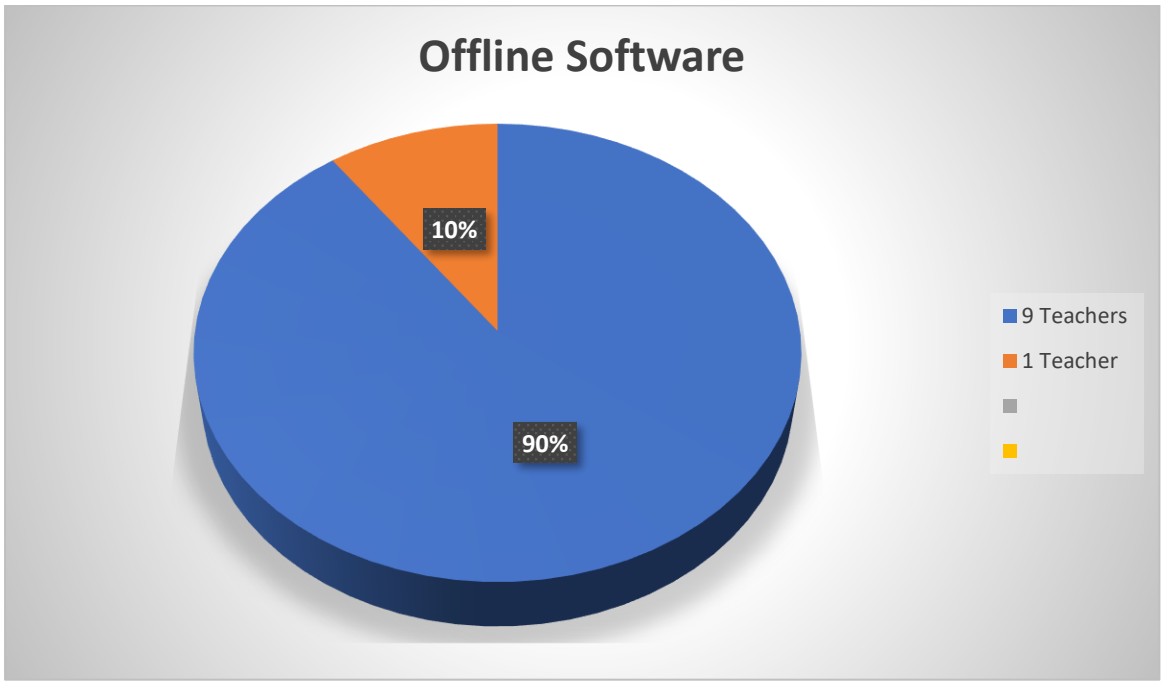
### 4.3.3 Digital skills for ICT

The third theme scrutinized teachers' digital skills in terms of knowledge on software, both online and offline, teachers' knowledge on assembling and connecting a desktop, and installing operating systems and other applications.

*4.3.3.1 Figure 11: Knowledge of software (online and offline)*

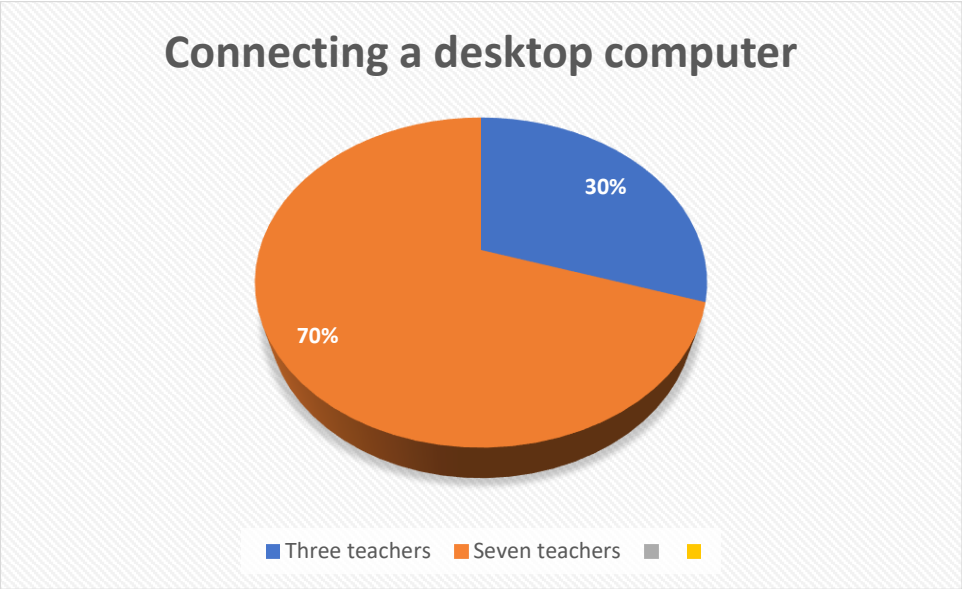



On the knowledge of online software such as Safari, google docs, internet explorer, and Firefox, 70% indicated that they are aware of online software and able to use them, while 20% are not certain of using online software. 10% showed that they do not even know what a software is.



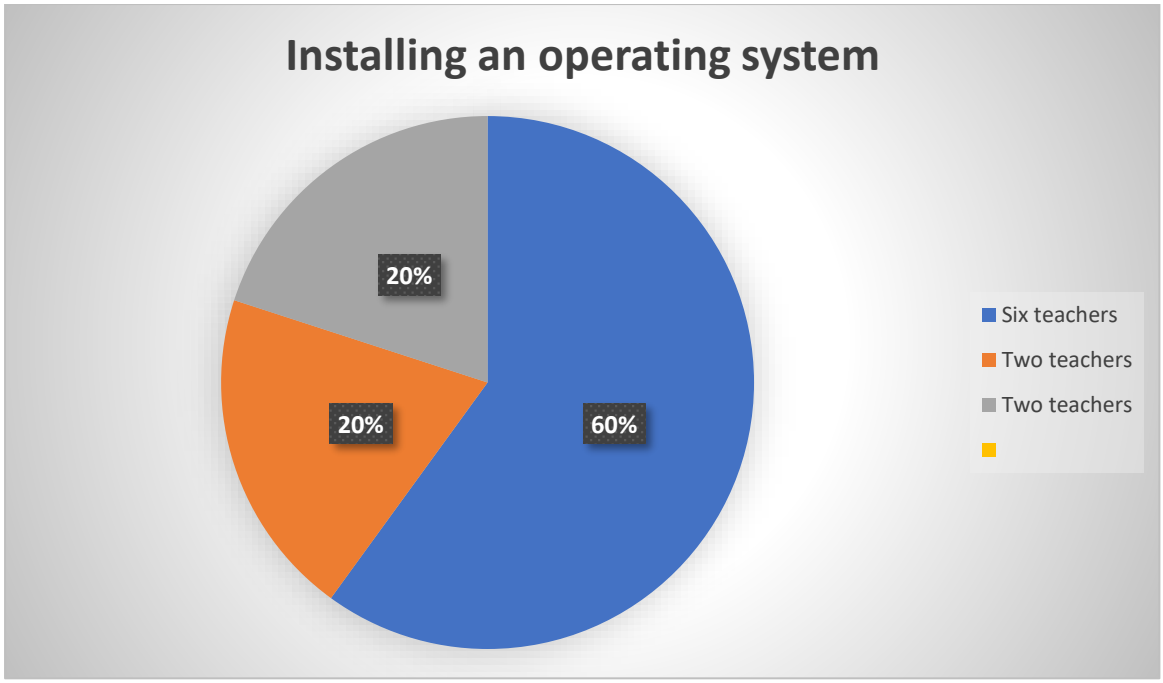
Offline software includes applications such as Microsoft, Adobe reader, Media player and Anti-virus tools that can work offline. Nine teachers indicated that they are able to use offline software and only one teacher was not sure on what the difference is between online and offline. The teacher who did not know the difference was more than 50 years old.

*4.3.3.2 Figure 12: Connecting a desktop*




Connecting a desktop computer requires the knowledge of a computer monitor, computer box, keyboard, port and LAN cables, and other peripherals. 70% of the teachers indicated that they do not know how to connect a functional desktop computer, while only three teachers mentioned that they have a basic knowledge of connecting a desktop computer. Teachers who had the basic skills where young teachers (junior teachers) below the age of 30.

*4.3.3.3 Figure 13: Installing an operating system*

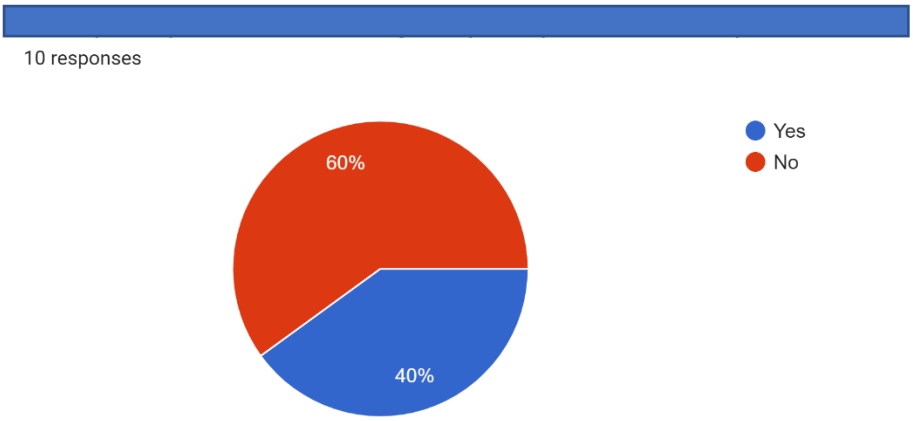



An operating system is a program that runs through any digital device to make other applications work, Microsoft (2019). An example of an operating system can be Windows, Microsoft and MacOS. On the concept of installing an operating system, 60% indicated that they have knowledge on how to install an operating system as you just follow the instructions given on the screen. 20% indicated that they are aware of operating systems but never installed any. The other 20% indicated that they do not know what an operating system is.

### 4.3.4 Training and development on ICT

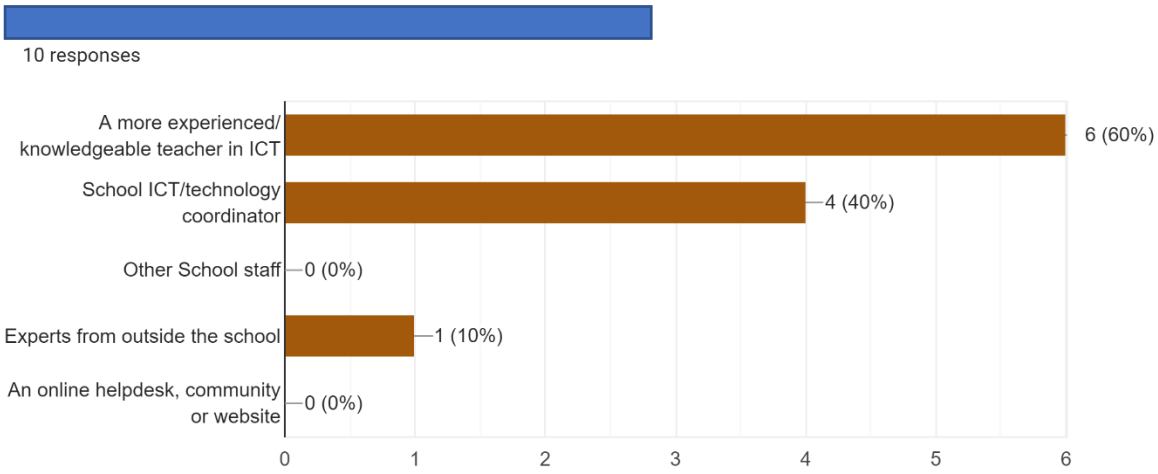
The fourth theme examined teachers' participation any ICT training, the support that they get from school and professional training and development on ICT such as a degree, diploma or certificate in ICT.

*4.3.4.1 Figure 14: Participation in ICT training*




Teachers were asked if ICT training is compulsory for them at work. 60% indicated that ICT training is not compulsory and never attended any training. 40% indicated that although ICT training is not compulsory, they have attended training to obtain digital skills in ICT.

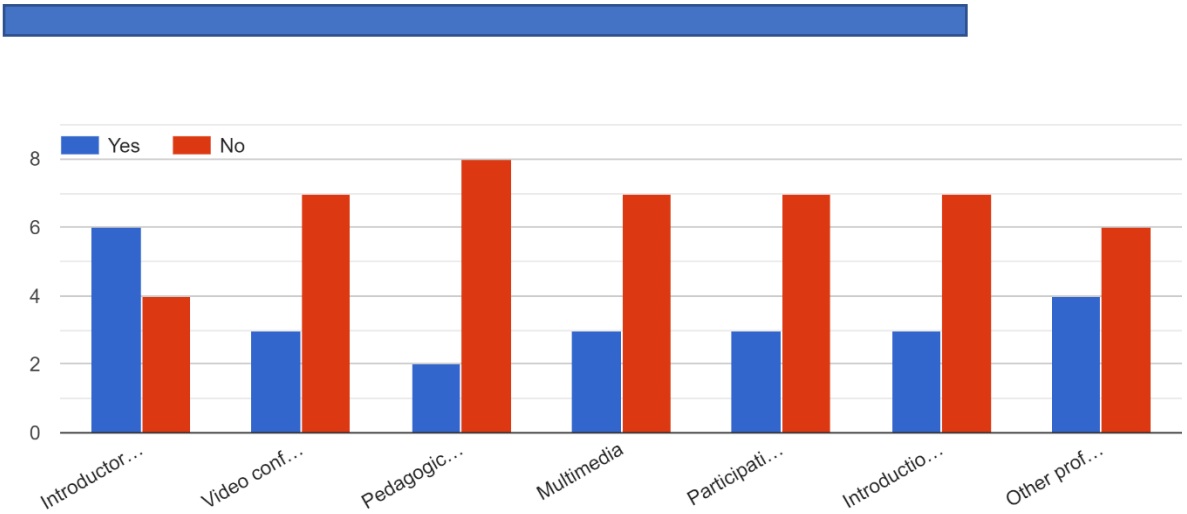
*4.3.4.2 Figure 14: ICT support at school*




ICT support is very significant in schools to provide the necessary assistance to teachers, learners and anybody that is responsible for rendering school duties. Six teachers mentioned that the support they get is from a more experienced teacher, while four indicated that they get support from the school ICT coordinator. The support

they get can be for downloading resources, installing programmes, removing viruses from their laptops and making online connections.

*4.3.4.3 Figure 15: Professional training and development on ICT*




More than six teachers indicated that they have never received professional training on ICT. Within the six teachers, none of them specialized in ICT or perusing any registered qualification in ICT. Four teachers provided that they received professional training on introductory course on internet usage, video conferencing, pedagogical use, multimedia, participation in online activities, introduction to 4IR, and other professional development opportunities related to ICT.

*4.3.4.4 Figure 16: Obstacles related to ICT in schools*

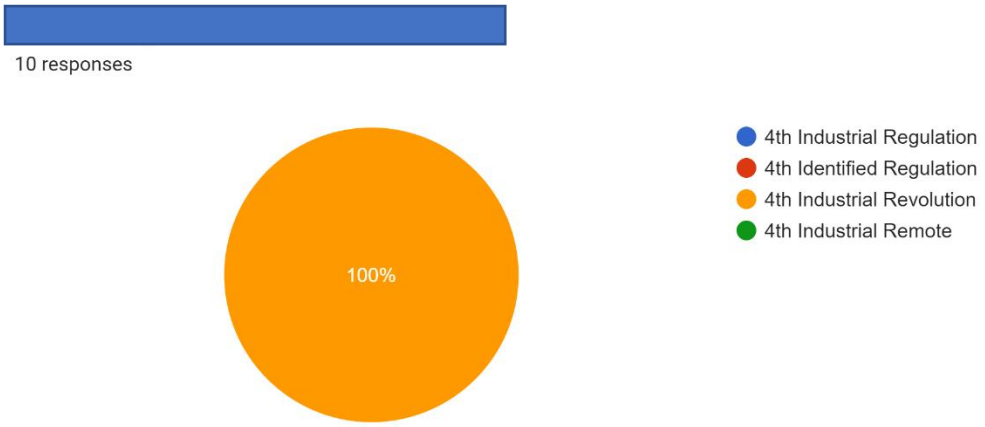



Teachers shared similar feelings in terms of the challenges they face regarding ICT in schools. Three teachers mentioned that they have insufficient number of computers, with no internet connections, and that there is a lack of ICT sponsors. The other seven teachers indicated that regardless of insufficient number of computers, a lot of concern is more on the internet connection because being online provides them with updated resources. The other major concern was lack of ICT sponsors which results in schools not having the necessary resources to meet the requirements for the 4IR.

### 4.3.5 Knowledge on 4IR

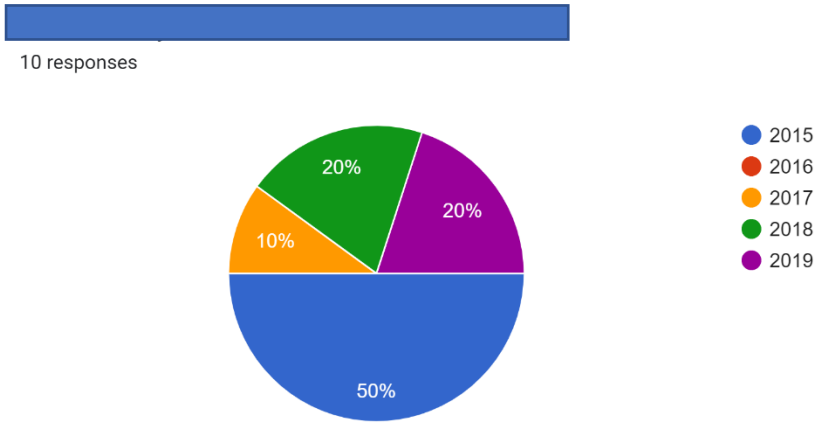
The fifth theme tested the teachers' knowledge on the 4IR. The theme rested much focus on understanding the acronym for 4IR, defining 4IR, and background knowledge on the new revolution, characteristics for the 4IR, what it brings, and skills required. The theme further investigated teachers understanding on artificial intelligence (AI) and three-dimensional printing (3D).

*4.3.5.1 Figure 17: Acronym for 4IR*



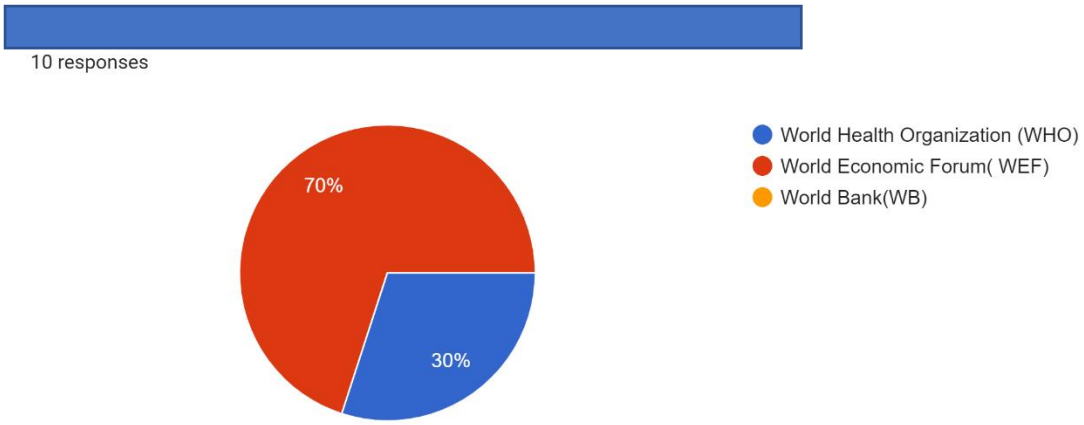

All teachers provided correct answers by understanding that 4IR stands for the fourth industrial revolution.

*4.3.5.2 Figure 18: Year discovered*



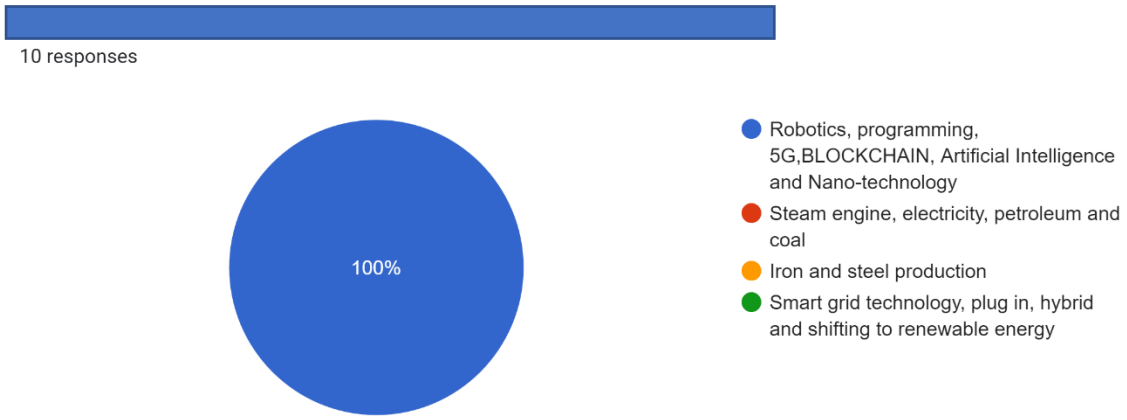

All the teachers got the answer wrong. They did not know in which year 4IR was discovered. The 4IR was discovered and introduced by the WEF in 2016, WEF (2018).

*4.3.5.3 Figure 19: Organization responsible for 4IR*



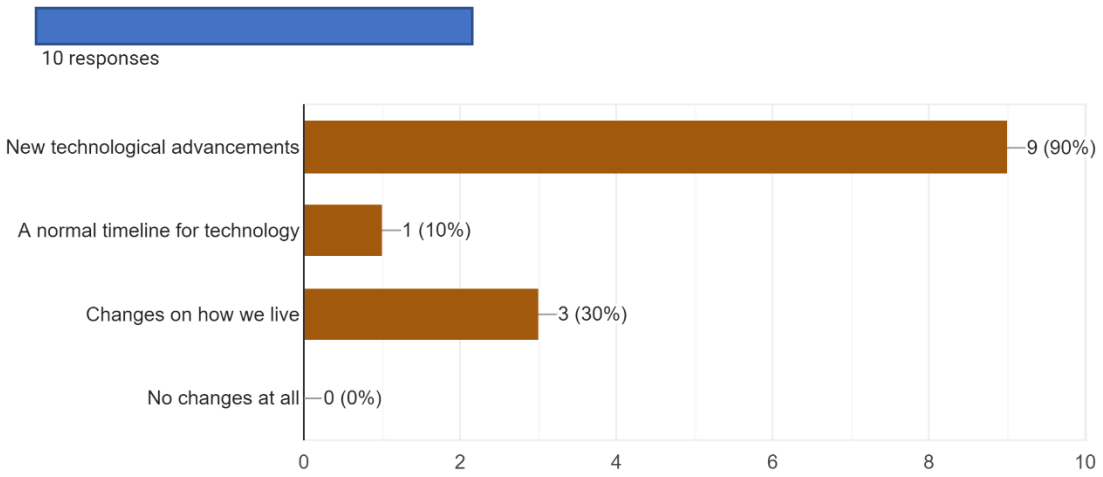

Seven teachers were able to identify that the organization responsible for the 4IR is the WEF. Three teachers indicated that the World Health Organization (WHO) is responsible for the 4IR.

*4.3.5.4 Figure 20: Characteristics for the 4IR*



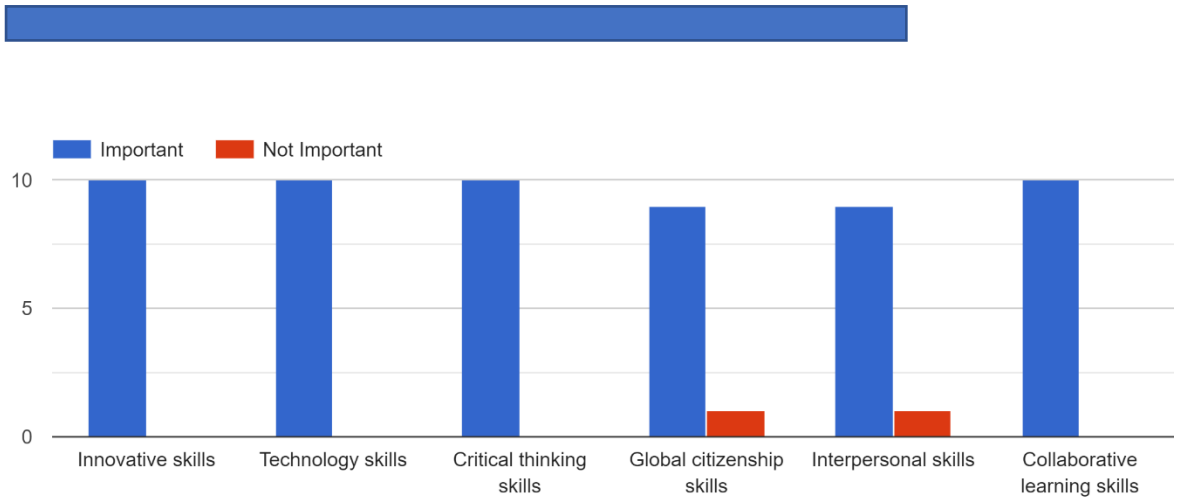

All the teachers got the correct answer. They were able to identify that the features or characteristics for the 4IR are artificial intelligence, nano-technology, blockchain, 5G, programming and robotics.

*4.3.5.5 Figure 21: What does the 4IR brings?*




Looking at what to expect in the 4IR. 90% indicated that 4IR is all about new technological advancements, while 30% mentioned that the 4IR would change how we live.

*4.3.5.6 Figure 22: Required skills in the 4IR*




The required skills identified by the WEF (2028) in the 4IR are technology skills, innovative skills, global citizenship skills, interpersonal skills and collaborative skills. Teachers indicated that all the skills are required for the 4IR. Only two teachers expressed that global citizenship skills and interpersonal skills are not important for the 4IR.

## 4.4 Individual scores according to the questionnaire tool

After the findings was primarily analysed, teachers scores from the questionnaire were collected and tabled in the e-readiness score tool to obtain at what percentage are teachers ready in terms of the 4IR, digital skills, e-skills, and knowledge on ICT and 4IR. The scores are presented below.

***Table 6:*** *e-readiness questionnaire and score tool (adopted from e-ready ICT maturity assessment tool, DBE (2018)*

| Teacher | E-readiness Score<br><br>Total: 90% | Acronym for 4IR | In which year 4IR was discovered. | What are the characteristics for the 4IR? | Organization responsible for 4IR | Skills required in the 4IR | Do you own a laptop? | Assembling a desktop computer | Knowledge of a computer software | Any classroom ICT resources? | Attended any ICT training & development? | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Score | 1 | 1 | 5 | 1 | 5 | 1 | 2 | 1 | 1 | 2 | 20 |
| 1 | 81% | 1 | 0 | 5 | 1 | 5 | 1 | 2 | 1 | 0 | 1 | 18 |
| 2 | 54% | 1 | 0 | 5 | 0 | 4 | 1 | 0 | 0 | 0 | 1 | 12 |
| 3 | 76,5% | 1 | 0 | 5 | 1 | 5 | 1 | 2 | 1 | 0 | 1 | 17 |
| 4 | 58,5% | 1 | 0 | 5 | 0 | 4 | 1 | 0 | 1 | 0 | 1 | 13 |
| 5 | 72% | 1 | 0 | 5 | 1 | 5 | 1 | 2 | 1 | 0 | 0 | 16 |
| 6 | 72% | 1 | 0 | 5 | 1 | 5 | 1 | 2 | 1 | 0 | 0 | 16 |
| 7 | 72% | 1 | 0 | 5 | 1 | 5 | 1 | 2 | 1 | 0 | 0 | 16 |
| 8 | 67,5% | 1 | 0 | 5 | 1 | 5 | 0 | 2 | 0 | 0 | 0 | 15 |
| 9 | 72% | 1 | 0 | 5 | 1 | 5 | 1 | 1 | 1 | 1 | 0 | 16 |
| 10 | 67,5% | 1 | 0 | 5 | 1 | 5 | 1 | 1 | 1 | 1 | 0 | 15 |

The percentage obtained from the scores was then used in the GDE e-readiness criteria to determine the final percentage of the participants validate which level they have obtained. The GDE e-readiness criteria is presented below:

***Table 7**: GDE e-readiness criteria for teachers (DBE, 2018)*

| Level | | Applied to the teacher |
|---|---|---|
| **Entry** *(Starting point)* ***(10%-29%)*** | 1 | The teacher is computer literate. He/she can use a computer. However, the teacher also lack confidence in ICT. Insecurities and frustrations are common in the introduction of ICT. |
| **Adoption** *(The process of accepting something)* ***(30%-49%)*** | 2 | The teacher can use a variety of ICTs including computers to support teaching and learning in the classroom. The teacher is also able to teach learners on how to use ICT. |
| **Adaptation** *(The state of change to fit a new environment)* ***(50%-69%)*** | 3 | The teacher can use ICT to support everyday learning at an appropriate CAPS level, assess learners online and ensures progression. The teacher can reflect critically on how ICT resources can enable him/her to re-design the teaching and learning processes and use ICT learning management systems. |
| **Appropriation** *(Taking something for your own use)* ***(70%-90%)*** | 4 | The teacher has an inclusive understanding of the ways in which ICT can contribute to teaching and learning. The teacher has the confidence and experience to reflect on how ICT can influence teaching and learning approaches. The teacher can develop new learning environments that use ICT as a flexible tool so that learning can become interactive and collaborative. |

Based on the results acquired, Teacher 1 obtained 81% in terms of e-readiness, which is level 4 in the criteria. This means the teacher has an inclusive understanding of the ways in which ICT can contribute to teaching and learning. The teacher has the confidence and experience to reflect on how ICT can influence teaching and learning approaches. The teacher can develop new learning environments that use ICT as a flexible tool so that learning can become interactive and collaborative.

Teacher 2 obtained 54%, which is level 3 in the criteria. This tells that the teacher can use ICT to support everyday learning at an appropriate CAPS level, assess learners online and ensures progression. The teacher can reflect critically on how ICT resources can enable him/her to re-design the teaching and learning processes and use ICT learning management systems.

Teacher 3 obtained 76, 5%, which is level 4. The teacher has an inclusive understanding of the ways in which ICT can contribute to teaching and learning. The teacher has the confidence and experience to reflect on how ICT can influence teaching and learning approaches. The teacher can develop new learning

environments that use ICT as a flexible tool so that learning can become interactive and collaborative.

Teacher 4 obtained 58.5%, which is level 3. The teacher can use ICT to support everyday learning at an appropriate CAPS level, assess learners online and ensures progression. The teacher can reflect critically on how ICT resources can enable him/her to re-design the teaching and learning processes and use ICT learning management systems.

Teacher 5, 6, 7 and 9 obtained 72%, which is level 4. The teachers have an inclusive understanding of the ways in which ICT can contribute to teaching and learning. The teachers have the confidence and experience to reflect on how ICT can influence teaching and learning approaches. The teachers can develop new learning environments that use ICT as a flexible tool so that learning can become interactive and collaborative.

Teacher 10 obtained 67.5%, which is level 3. This means the teacher can use ICT to support everyday learning at an appropriate CAPS level, assess learners online and ensures progression. The teacher can reflect critically on how ICT resources can enable him/her to re-design the teaching and learning processes and use ICT learning management systems.

The final step was to add the total scores of all teachers to determine the state of readiness of teachers in the introduction of the 4IR based on the questionnaire tool. The below formula from the GDE (2018) was used to get the total percentage.

*Figure 5: Formula for e-readiness tool (GDE, 2018)*

$$\frac{Teacher's\ total\ score\ from\ the\ questionnaire}{Total\ score\ of\ the\ questionnair\ (20)}\ X\ Total\ percentage\ on\ the\ criteria\ to\ determine\ the\ level\ (90\%)$$

$$\frac{\mathbf{18+12+17+13+16+16+16+15+16+15=154}}{\mathbf{20x10=200}}\ X\ (90\%)$$

$$\boldsymbol{Total = 69\%}$$

The formula determined that teachers are 69% ready in terms of meeting the standards of the 4IR in digital skills and e-skills. The total percentage acquired rests in level 3, which is adaptation. This means that teachers can use ICT to support everyday learning at an appropriate CAPS level, assess learners online and ensures progression. The teachers can reflect critically on how ICT resources can enable him/her to re-design the teaching and learning processes and use ICT learning management systems.

### 4.5 Findings from the Interviews

Face-to –face interviews were also used to accurately screen information from the participants. The interviews provided in-depth answers from the participants in terms of discussing the 4IR and giving their understanding of ICT from a verbal approach. This gave the researcher the ability to monitor the emotions and behaviour of the participants when answering questions. This also allowed the researcher to see if the participants were not copying when they completed the questionnaire tool.

The use of content analysis was used to divide the content into categories to be managed better. The researcher then assigned codes to the texts that were being analysed. The codes were tested arranged and reviewed until results were achieved.

The interviews significantly focused much to the WEF4.0F (WEF, 2017). The goal of the investigation was to determine the state of readiness in the 4IR. Therefore, the education framework from the world economic forum was used as a guiding principle in determining the entire objective of the research and answering the research question. The following themes and sub-themes emerged from the interview responses:

***Table 8:*** *Themes and sub-themes emerging from the interview responses*

| Data collection methods | Themes | Sub-themes |
|---|---|---|
| Face-to-face interviews | Teachers' familiarity with 4IR | • Define 4IR<br>• Inadequate knowledge of 4IR characteristics.<br>• Familiarity with the 4IR Education Framework 4.0. |
| | A working knowledge of the 4IR technology application tools | • The deployment of 5G<br>• Robotics<br>• Computing at a quantum level<br>• Nanotechnology<br>• Blockchain technology<br>• Internet of Things (IoT) |
| | Teaching & learning content for the 4IR | • STEM subjects and their content. |

### 4.5 1 Teachers familiarity with 4IR

The first theme examined teachers' familiarity with the 4IR. According to Schwab (2017), teachers are the primary individuals responsible for implementing 4IR in schools; it is critical for them to gain sufficient knowledge and understanding of 4IR. Schwab (2017) further explains that education sectors and higher academic institutions should provide a range of training and development opportunities in the new digital world because they are centres of innovation and research. The majority of participants indicated a lack of knowledge about 4IR and a desire for training and development.

*4.5.1.1 Defining 4IR*

Some participants expressed difficulty in defining the 4IR, while others stated that 4IR is a new technology. Five respondents to the interview struggled to define the 4IR. Participants indicated that:

[PARTICIPANT 6]: "To be honest, I'm not sure what 4IR is all about; I've heard it's a new technology."

[PARTICIPANT 7]: "4IR is about world changes and new technology."

[PARTICIPANT 8]: "4IR is a novel concept in the world."

[PARTICIPANT 2]: "4IR ushers in a new technological era."

Following such responses, it became clear that participants lack a solid definition for 4IR. Rather than that, they used the terms 'new' and 'changes'. They recognize that 4IR is a new era but overlook its unique characteristics.

*4.5.1.2 Inadequate Knowledge of 4IR Characteristics.*

Eight participants correctly identified characteristics of 4IR using the questionnaire tool. Two were incorrect. However, when interviewed in-depth, participants were unable to fully define the characteristics. This indicates that participants are unfamiliar with concepts such as artificial intelligence, nanotechnology, big data, blockchain, the Internet of Things (IoT), 3D printing, quantum computing, and coding.

[PARTICIPANT 6]: "I've never heard of such things; I'm assuming they're a new technology."

[PARTICIPANT 1]: "I am unable to define these characteristics because I am unaware of them."

*4.5.1.3 Familiarity with the World Economic Forum's 4.0 Education Framework*

The World Economic Forum (2018) established a new education framework to assist all sectors of education in meeting the standards and requirements of the 4IR. Technology skills, interpersonal skills, innovation and creativity, global citizenship skills, personalized and self-paced learning, accessibility and inclusive learning, problem-based and collaborative learning, and lifelong and student-driven learning are all included in the framework. All participants, however, were unaware of this framework. They were all unaware of this framework during the interview. Additionally, they have no idea when the framework was published. The only thing they could deduce about the forum from the questionnaire tool was that it is in charge of the 4IR.

"I am unfamiliar with this framework; I have never heard of it," [PARTICIPANT 4] stated.

[PARTICIPANT 8]: "I'm not going to lie; I'm not sure".

### 4.5.2 A working knowledge of the 4IR technology tools

The 4IR introduced new digital technologies that are expected to revolutionize the way we live (WEF, 2018). Among these digital innovations are 5th generation networking, or 5G, the Internet of things (IoT), big data, artificial intelligence (AI), nanotechnology, quantum computing, Blockchain, robotics, and coding, to name a few. This theme examined teachers' knowledge of the characteristics of the 4IR.

*4.5.2.1 The deployment of 5G*

5G is the fifth generation of telecommunications technology, according to Microsoft (2019). 5G enables high-speed networking and frequency. When asked about this new technology, participants one and three explained that they had previously read about it, while eight indicated that they were unfamiliar with it.

*4.5.2.2 Robotics*

Robotics is the study and development of machines capable of performing tasks normally performed by humans (Microsoft, 2019). Robots are primarily used in mechanical engineering, electrical engineering, mechatronics, and bioengineering fields. When asked about this, participant five answered that he occasionally read about it, while nine others stated that they had never read about it.

*4.5.2.3 Computing at the quantum level*

Quantum computation, as defined by Microsoft (2019), is a subset of computer engineering that utilizes the computer to perform calculations. Superposition, interference, and entanglement are all examples of this. All participants answered that they were unfamiliar with this new technology and had never read about it.

*4.5.2.4 Nanotechnology*

Nanotechnology is a relatively new field of science and engineering that focuses on the application of scientific phenomena to manufacturing, structures, electronic devices, and systems. All participants indicated that they were unfamiliar with this novel technology for this sub-theme.

*4.5.2.5 Blockchain technology*

Blockchain is a scientific strategy for capturing and recording data in a way that makes it difficult to breach, hack, or alter, Microsoft Security (2019). Simply put, Blockchain is an online security system that guards against cybercrime. Only two respondents stated that they had read about this novel technology, while the remainder stated that they had never heard of it.

*4.5.2.5 Internet of Things (IoT)*

The Internet of things refers to electronic objects equipped with sensors, software, and other systems capable of connecting to and exchanging data with other devices via

the internet, Schwab (2017). All participants answered that they have never read about or are unaware of this new technology.

### 4.5.3 Teaching and learning for the 4IR

The third theme examined teachers' approaches in the classroom in terms of providing 4IR learning and content taught to ensure that learners meet the standards for the 4R.

#### *4.5.3.1 STEM subjects and their content*

The WEF (2017) argues that new curricular content is required. With the introduction of new skills, it is necessary to redesign learning content to conform to the standards of the 4IR. The forum recommends content that emphasizes global citizenship, creativity, technology, and interpersonal skills. Additionally, the forum advocates for technology integration across all subjects. This last theme looks at the type of curricular teachers deliver in the classroom in public schools.

***Table 8: content taught in the classroom by government school teachers for introducing 4IR.***

| Participant | Home Language | English Additional language | Life Skills | Maths | Science and Technology | Creative Arts |
|---|---|---|---|---|---|---|
| **1** | Reading & Writing | Reading & Writing | Different cultures | Counting | N/A | Drawing and Design |
| **2** | Reading & Writing | Reading & Writing | Different cultures | Problem solving | N/A | Drawing |
| **3** | Reading & Writing | Reading & Writing | N/A | Problem Solving | N/A | Drawing |
| **4** | Reading & Writing | Reading & Writing | N/A | Problem Solving | Planet earth | Drawing |
| **5** | Reading & Writing | Reading & Writing | Different cultures | Problem Solving | Structures | Drawing |
| **6** | Reading & Writing | Reading & Writing | N/A | Problem Solving | Structures | Drawing |

| | | | | | | |
|---|---|---|---|---|---|---|
| **7** | Reading & Writing | Reading & Writing | Different cultures | Problem Solving | N/A | Drawing |
| **8** | Reading & Writing | Reading & Writing | N/A | Problem Solving | Production | Drawing |
| **9** | Reading & Writing | Reading & Writing | N/A | Problem Solving | Manufacturing | Drawing |
| **10** | Reading & Writing | Reading & Writing | N/A | Problem Solving | Production | Drawing |

The preceding table summarizes the content that teachers teach in the classroom. Teachers responded that reading and writing are critical in language subjects. They believe that through reading and writing, students can develop new terms and positively respond to them. Participants indicated that teaching different cultures is critical for developing global citizenship skills. Participants believe that understanding diverse cultures enables them to gain insight into how other cultures view the world. In mathematics, participants indicated that they teach content related to problem solving. They believe that this will aid learners in developing their problem-solving and critical thinking abilities. Participants in the intermediate phase of science and technology teach production, manufacturing, structures, and the planet earth. They believe that understanding our planet enables learners to define new digital transformations and the issues confronting our universe. Participants in creative arts teach drawing. They believe that drawing can assist learners in developing skills related to architecture and design, engineering, and planning. This demonstrates that the (CAPS) satisfies certain standards set forth in the fourth industrial education. Additionally, teachers use appropriate, relevant teaching methods as defined in the policy document.

## 4.6 Discussion of the findings in accordance with the World Economic Forum Education Framework

### *4.6.1 Global Citizenship skills*

The first principle of the framework focused on exposing learners to cultures from other countries to understand how others define the world. Additionally, the focus is on curriculum that fosters global awareness. From the interviews, the teachers expressed

that the curriculum only focus on cultures within the South African perimeter. They mentioned subjects like Life Skills, and History as the ones paying attention to cultures in South Africa. This principle was not achieved because teachers only teach South African cultures and do not go beyond boarders.

### *4.6.2 Innovation and creativity skills*

The second principle focused on content that fosters innovation, problem solving, creativity and analytical thinking. This requires teachers to develop effective lessons to promote the above-mentioned skills. The collected data indicated that teachers rely on STEM subjects to provide content that fosters innovation and problem-solving skills. These skills can be found in subjects such as mathematics, natural sciences and technology and social sciences. This principle was achieved in public schools.

### *4.6.3 Technology skills*

The third principle of the framework requires that teachers need to deliver content that focuses on the development of digital skills and technology use. Unfortunately, schools are facing insufficient ICT resources. Teachers in the interview and questionnaire tool expressed that there is no technology integration in their teaching and that with the lack of resources, it is difficult to implement digital learning in the classroom. This principle was not met accordingly.

### *4.6.4 Interpersonal skills*

The fourth principle alludes that teachers must deliver content that emphasize on digital leadership skills, social awareness, interpersonal and emotional intelligence. Unfortunately, with no ICT resources in the classroom, teachers cannot plan lessons that can be presented digitally to promote online skills and other social media content. This principle was also not achieved.

### *4.6.5 Personalized and self-paced learning*

The WEF (2018) emphasized the importance of expanded opportunities and of no child being left behind in terms of digital opportunities in the classroom. With the teachers having problems with the ICT resources and other related issues on digital literacy, this principle could not be met to its full potential. There is a decline for digital learning in the classrooms.

### *4.6.6 Assessable and inclusive learning*

This principle recommends that all learners including those with disabilities should have access to new knowledge. The principle further elaborates that the curriculum must provide sufficient opportunities and knowledge on 4IR. Regrettably, in the interviews teachers expressed that the curriculum only offers opportunities in STEM subjects. Learning on robotics, coding and programming is not achieved in public schools.

### *4.6.7 Problem based and collaborative learning*

The seventh principle in the framework focused on problem-based content and peer collaboration, when teachers were asked about teaching methods in the digital age together with the content taught, thy expressed that problem solving activities are significant in introducing 4IR. Teachers also expressed that giving learners the opportunity to learn in peers sets great skills in defining the world through their views. This principle was well achieved,

### *4.6.8 Continuous and student driven learning.*

The last principle in the framework focuses on continuous development from both teachers and learners in the 4IR. Unfortunately, in the questionnaire tool, teachers expressed that they have never received any training in 4IR or ICT. They added that even if the district provides mini trainings on digital literacy, those trainings are not

compulsory. Such habit jeopardises learners' development in ICT and other digital development opportunities. This last principle was not achieved by the teachers.

## 4.7 Concluding Remarks

This chapter discussed the findings from both the questionnaire tool and face-to-face interviews. Themes and sub-themes were generated using content analysis. Findings from both questionnaires and interviews were discussed separately to show order of results. Chapter five will summarize the major findings, make conclusions, and recommendations.

# CHAPTER FIVE

# 5. MAIN FINDINGS, CONCLUSION AND RECOMMENDATIONS

## 5.1 Chapter Overview

The preceding chapter discussed the pertinent findings from the data collection processes. Data collection methods included a questionnaire tool and face-to-face interviews. The collected data was used to generate themes and sub-themes. The data was analysed using content analysis. This chapter summarizes the major findings and make conclusions, and recommendations to the study.

## 5.2 Significant findings in accordance with the aims and objective of the study

The aim of the research was to investigate the state or readiness of government school teachers in the introduction of the 4IR in terms of digital skills, e-skills, and the knowledge on the 4IR in the classroom.

### 5.2.1 Objective one: To determine what digital skills do public school teachers possess in the JHB district.

The first objective was to determine what digital skills teachers possess in the JHB central district. Based on the results obtained from the questionnaire tool in relation to the themes and sub-themes emerged, On the knowledge of online software such as Safari, Google docs, internet explorer, and Firefox, 70% indicated that they are aware of online software and able to use them, while 20% are not certain of using online software. 10% showed that they do not even know what a software is. Offline software includes applications such as Microsoft, Adobe reader, Media player and Anti-virus tools that can work offline. Nine teachers indicated that they could use offline software and only one teacher was not sure on what the difference is between online and offline. The teacher who did not know the difference was more than 50 years old.

The other skill was connecting a desktop computer. Connecting a desktop computer requires the knowledge of a computer monitor, computer box, keyboard, port and LAN cables, and other peripherals. 70% of the teachers indicated that they do not know how to connect a functional desktop computer, while only three teachers mentioned that they have a basic knowledge of connecting a desktop computer. Teachers who had the basic skills where young teachers (junior teachers) below the age of 30.

The last skill was installing an operating system. An operating system is a program that runs through any digital device to make other applications work, Microsoft (2019). An example of an operating system can be Windows, Microsoft and MacOS. On the concept of installing an operating system, 60% indicated that they have knowledge on how to install an operating system as you just follow the instructions given on the screen. 20% indicated that they are aware of operating systems but never installed any. The other 20% indicated that they do not know what an operating system is. Other skills that teachers possess according to the data collected includes the use of Microsoft, social media sites, and being able to organize online meetings.

However, this objective is partially achieved because teachers have a limited background of skills in terms of going digital. With the digital skills discussed in the literature review, it is evidently clear that teachers need to acquire more digital skills to meet the requirements for 4IR.

### 5.2.2 Objective two: Determine what are the skills required and digital knowledge needed from public school teachers for the 4IR.

The second objective was to determine what skills and digital knowledge is required from teachers for the 4IR. Chapter two provides a discussion on the skills required from teachers. Jones & Pimdee (2017) positions that digital competence, digital literacy, and digital skills are mostly featured in policy documents for the 4IR and are

sometimes used interchangeably. Jama (2019) also elucidates that with immense technological transformations taking place, teachers are required to keep up with the pace. Jones & Pimdee precisely enlightens that teachers in the 4IR need to have access to a mobile phone, tablet, laptop and be able to use them to their full specifications. Understanding online applications and being able to share online content is very pivotal in the 4IR, Jama (2019). Lankshear (2016), also identified the following fundamentals that institute digital literacy: information content evaluation, knowledge assembly, navigation of hypermedia content and internet searching. The other digital skill required from teachers is the ability to know and understand concepts arising in the 4IR such as data analysis, cloud computing, virtual reality in the classroom, machine learning and online learning, Staunton (2017).

Since technology is the fundamental pillar and denominator of the 4IR, Gary (2016), proposes that teachers need to upgrade from digital skills to e-skills for them to achieve the 4IR. This then confirms that for e-skills, teachers need to understand online teaching from an advanced level and be able to use appropriate online tools and resources that can meet the learners needs, Stauton (2017). On the other hand, e-skills comprises the skills needed to create and develop ICT products such as designing a learning content through an approved learning management system (LMS) platform, Martine (2018). This objective was achieved by being able to determine the skills required in the 4IR through existing knowledge and from the data collected from the teachers.

### 5.2.3 Objective three: Determine how ready are public school teachers with the introduction of the 4IR.

The last objective was to determine how ready are public school teachers with the introduction of the 4IR. To achieve this objective, an e-readiness tool and formula from the GDE (2018) comprising with the questionnaire tool was used to provide a quantified response. According to the e-readiness tool, it indicated that teachers are 69% e-ready in terms of meeting the standards of the 4IR in digital skills and e-skills. The total percentage acquired rests in level 3 in the e-readiness criteria for teachers, which is adaptation. This means that teachers can use ICT to support everyday

learning at an appropriate CAPS level, assess learners online and ensures progression. The teachers can reflect critically on how ICT resources can enable him/her to re-design the teaching and learning processes and use ICT learning management systems. This objective was fully achieved.

### 5.3 Significant findings to the primary research question.

The general question of the study was to investigate the state of readiness of government school teachers in the introduction of the 4IR in terms of digital skills, e-skills, and knowledge on 4IR in the JHB central district.

#### 5.3.1 Research question: What is the state of readiness of government school teachers in the introduction of the 4IR in terms of digital skills, e-skills, and knowledge on 4IR in the JHB central district?

Denscombe (2007:3), makes a strong point that in a mixed methods of data collection, to answer the research question, it is imperative that findings from both qualitative and quantitative methods are discussed separately before giving a collaborative statement for answering the research question. From the questionnaire tool the results indicated that teachers are 69% e-ready in terms of meeting the standards of the 4IR in digital skills and e-skills. The total percentage acquired rests in level 3 in the e-readiness criteria for teachers, which is adaptation. In the interviews, teachers indicated that they are aware of the 4IR, but also expressed that they do not know what the WEFE4.0 is all about. The teachers further mentioned that they have never read about the characteristics for the 4IR. This tells that teachers still lack the necessary knowledge and skills in the 4IR. To answer this question collaboratively from both the qualitative and quantitative approach, teachers are 69% ready in terms on the introduction of the 4IR, this means teachers can use ICT to support everyday learning at an appropriate CAPS level, assess learners online and ensures progression. The teachers can reflect critically on how ICT resources can enable him/her to re-design the teaching and learning processes and use ICT learning management systems, however, teachers have inadequate knowledge on the 4IR. They do not understand its aims and objectives and they cannot provide sufficient clarity on the features of the 4IR.

Teachers also don't have the necessary resources to promote 4IR learning which puts their state of readiness in meeting the standards of the new digital revolution at a very unpleasant level.

### 5.4 Conclusion to the study

All teachers are required to use ICT for teaching and learning. In the digital age. Regardless of any geographic location, gender, age and socio-economic background, the 4IR demands teachers to integrate ICT into their pedagogic activities in order to prepare learners for the 4IR and beyond. The WEF framework and GDE e-readiness criteria provide a clear approach for embedding digital skills and ICT for teaching and learning. This study revealed that digital skills and e-skills (advanced skills) are critical as a foundation of introducing 4IR in the classrooms. The literature review also provided knowledge on the set of skills required from teachers in the 21st century. The reviewed literature also gave a paramount understanding of the principles stipulated by the education framework from the WEF (2018). It is significant for teachers to understand each industrial revolution from an education approach to be able to recognize their aims and objectives. The 4IR also requires teachers to always become digitally literate and integrate technology in all learning areas. Understanding features of the 4IR is also crucial from the teachers. This allows teachers to create lessons that are associated with these new characteristics that will contribute to the job market. Having lessons associated with robotics, coding, and programming prepares learners to meet the requirements for the future.

The study highlighted a myriad of reasons that contribute to the state of readiness of public-school teachers in the introduction of the 4IR. Above all reasons, digital skills, e-skills, and knowledge on 4IR takes centre stage. The results showed that teachers stand at an average of 69% in the e-readiness criteria, however it is still concerning based on the education framework by the WEF that teachers do not know how to use the framework, they do not know its mandate and cannot elaborate on its characteristics. It is required that teachers start investing in the 4IR education by obtaining professional development so that the implementation of 4IR in schools can be successfully achieved. The study also identified issues in the curriculum in accordance with the education framework. The education policy document, which is

CAPS cannot be changed anytime soon, therefore teachers need to design supplementary programmes that will complement the CAPS curriculum to offer specific subjects such as robotics and coding to provide learners with the opportunity to engage with digital learning.

### 5.5 Recommendations

After gathering the research results and conclusions, it was determined that the national education government, provincial education governments, regional education governments, district offices, school governing bodies, and school management teams are all required to develop a thoughtful implementation plan for executing the 4IR. The following recommendations were believed to be the most critical in assisting public schools' teachers in attaining the 4IR.

a. *Collaborative platforms*

   Teachers must engage in online collaborative platforms from different locations together with other teachers to share how to teach in the 4IR. In the United State, Netflix has developed a series of curriculum-based science and maths shows to specifically support teachers in terms of introducing 4IR learning in the classrooms, Microsoft (2019)

b. *Supplementary programmes*

   Instead of waiting for the government to fulfil their hesitant promises in implementing 4IR, teachers need to design lessons that will give learners the opportunity to engage with 4IR. These lessons can include videos about the digital age, games to be considered in 4IR and quizzes, Moloi (2020).

c. *Engagement in STEM programmes*

Organizations such as Council for Scientific and Industrial Research (CSIR), Sci-Bono science centre and Eskom expo for young scientists are implementing programmes in science, engineering, and technology. The idea behind these programmes is to expose new innovations designed by learners. Regrettably, teachers are not attending these programmes (Moloi & Marwala, 2020). Only one teacher per school would attend to accompany that single learner. It is for such reasons that there is a gap between learners and teachers in terms of technology. It is recommend that teachers participate in such programmes to be exposed in environments of innovation and critical thinking. This will allow teachers to have a solid background of what is expected in the classroom more especially in the digital age.

d. *Investing in 4IR advanced resources*

Technology has taken centre stage and the relevant resources are required to keep up with the pace. Knowing very well that these resources can come up with a heavy price, it is recommended that teachers must start investing in these resources. The 4IR recommends cell phones with a faster network known as 5G (fifth generation), Lego building blocks, virtual reality headset, and at least an I5 laptop (WEF, 2018). These are just minimum requirements that teachers need to have.

e. *Implementing an ICT structure*

The DBE (2018) under the directorate of the e-education white paper reaccommodate that each school must have a functional ICT structure. The structure must consist of the ICT committee, the activities to be accomplished and the timeframe. This will help teachers to consistently engage with ICT in their schools.

*f. Access to social media related platforms*

The share of information has been made faster through social media platforms recently. This is defined as big data according to Schwab (2017). Large amount of information can be accessed in a short space of time. Social media technology sites such as Google news, Nasa info, National geographic, Edmodo, Khan Academy and Kahoot offers information in recent technology trends which can help teachers to analyse the state of education from a technology approach to make informed decisions and plans in the classrooms.

## 5.6 Limitations to the study

This study was conducted to 10 teachers in the JHB central district and therefore it cannot be generalized. To ensure accurate results, a group of enough participants was needed. Since data was also collected through online surveys without the supervision of the researcher when participants answered the questions, it may be that participants requested help from friends and families to complete the survey which may have jeopardized the results.

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## Annexure A: Information sheet

**INFORMATION SHEET**

**Dear Sir/Madam**

My name is **SEREMA EDWARD NKOANA** and I am a Masters student in Education at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the **STATE OF READINESS OF GOVERNMENT SCHOOL TEACHERS ON THE INTRODUCTION OF THE 4TH INDUSTRIAL REVOLUTION** under the supervision of Dr Piet Bothma. The aim of the research is to find out what is the state of readiness of teachers towards new technology transformations labelled as the 4IR in schools.

As part of this project, I would like to invite you to take part in an interview and questionnaire. This activity will involve asking you questions and answering them in a form of verbal and written form. This will take 45 minutes f your time. With your permission, the interview transcripts will be stored in a safe place and be destroyed after the research has been completed.

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 noy want to. The interview will be completely confidential and anonymous as I will not be asking 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) to represent your participation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me on 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. The data collected from this project will be stored On ICLOUD and will be kept for 3 years. With your permission the data collected from this research project may be used by other researchers in an anonymized format. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee( Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,
Serema Edward Nkoana

Researcher :

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Dr Piet Bothma, piet.bothma@wits.ac.za, 011 717 3276

## Annexure B: Consent form

**CONSENT FORM**

**TITLE**

**THE STATE OF READINESS OF GOVERNMENT SCHOOL TEACHERS ON THE INTRODUCTION OF THE 4TH INDUSTRIAL REVOLUTION**

**NAME OF RESEARCHER :** SEREMA EDWARD NKOANA

**DEGREE :** MASTERS OF EDUCATION BY COURSEWORK AND RESEARCH REPORT

**SUPERVISOR:** DR. PIET BOTHMA

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 tick the relevant options below)

| Consent | Yes | No |
|---|---|---|
| I agree that my participation will remain anonymous | | |
| I agree that the researcher may use anonymous quotes in his/her research report. | | |
| I agree that the interview may be audio recorded | | |
| I agree that the information I provided may be used in an anonymized format after this project has ended, for academic purposes by the other researchers, subject to their own ethics clearance being obtained. | | |

Signature:……

Name of participant:……..

Date:……

Signature:……..

Name of person seeking consent:…….

Date:……

## Annexure C: Questionnaire template



# Teacher questionnaire on the use of ICT and knowledge of the 4th IR /Education.

All responses are anonymous ,treated in strict confidence and remain private.

Questionnaire compiled by : Serema Edward Nkoana

*Required

### Personal Background Information

1. 1. Age *

*Mark only one oval.*

- ◯ Under 30
- ◯ From 30 to 39
- ◯ From 40 to 49
- ◯ 50 or more

2. 2. Gender *

*Mark only one oval.*

- ◯ Female
- ◯ Male

3. 3. Subject(s) Area: *

*Mark only one oval.*

- Mathematics
- Social Sciences
- Languages
- Special needs
- Natural Sciences & Technology
- Foundation phase subjects
- Life skills
- Physical Education
- Other

4. 4. Highest Qualification Obtained *

*Mark only one oval.*

- Higher Certificate
- Diploma
- National Diploma
- Bachelors Degree
- Honours Degree
- Masters Degree
- Doctorate Degree
- Other

5. 5. School Level of teaching *

*Mark only one oval.*

- Foundation Phase
- Intermediate Phase
- Other

6. 6. Average number of learners per class *

*Mark only one oval.*

- Fewer than 10
- 10-15
- 16-20
- 21-25
- More than 25

7. 7. Teaching hours per week *

*Mark only one oval.*

- Fewer than 10
- 10-15 hours
- 16-20 hours
- 21-25 hours
- More than 25 hours

8. 8. Teaching experience (years of teaching) *

*Mark only one oval.*

- Less than 1 year
- 1-3 years
- 4-10 years
- 11-20 years
- 21-30 years
- More than 30 years

## Experience on ICT Education

9. 9. How is ICT taught to classes in your school? *

*Tick all that apply.*

- [ ] ICT is taught as a separate subject
- [ ] ICT is integrated in my subject because i choose to do so
- [ ] ICT is integrated in my subject because of curriculum requirements
- [ ] ICT is integrated in several subjects
- [ ] There is no ICT subject at all

10. 10. Do you use computers and/or the internet for the following activities? *

*Mark only one oval per row.*

| | Yes | No | Sometimes |
|---|---|---|---|
| Preparing lessons | ◯ | ◯ | ◯ |
| Teaching the class | ◯ | ◯ | ◯ |
| Downloading resources | ◯ | ◯ | ◯ |
| Watching Videos | ◯ | ◯ | ◯ |

11. 11. For how many years have you been using a computer or the internet at your school? *

*Mark only one oval.*

- ◯ Less than a year
- ◯ Between 1 to 3 years
- ◯ Between 4 to 6 years
- ◯ More than 6 years

12. 12. How often do you use computers and/or the internet in your classes? *

*Mark only one oval.*

- Never
- Rarely
- Sometimes
- Often
- All the time

13. 13. When you use computers and/or Internet during class teaching in front of the learners, which equipment is available? *

*Mark only one oval per row.*

| | Never | Rarely | Sometimes | Often | All the time |
|---|---|---|---|---|---|
| Learners are equipped with computers | | | | | |
| Only the teacher uses a computer | | | | | |
| Both teacher and learner uses computers | | | | | |
| There are no computers in the classroom | | | | | |

14. 14. Which conditions do you have access in your class? *

*Mark only one oval per row.*

| | Yes | No |
|---|---|---|
| Desktop computer without internet access | ◯ | ◯ |
| Desktop computer with internet access | ◯ | ◯ |
| Non-internet-connected laptop, tablet PC, netbook or notebook computer | ◯ | ◯ |
| E-reader(a device to read books and newspapers on a screen) | ◯ | ◯ |
| Mobile phone provided by the school | ◯ | ◯ |
| Interactive whiteboard | ◯ | ◯ |
| Digital Camera | ◯ | ◯ |
| Computer Laboratory | ◯ | ◯ |

15. 15. Does your school provide teachers with Laptops (or tablet PC, desktop computers) for their own use? *

*Mark only one oval.*

◯ Yes
◯ No

16. 16. Do you own the following devices? *

*Mark only one oval per row.*

| | Yes | No |
|---|---|---|
| Laptop | ◯ | ◯ |
| Smart Cellphone | ◯ | ◯ |
| Smart Watch | ◯ | ◯ |
| Tablet | ◯ | ◯ |
| WiFi Router | ◯ | ◯ |

17. 17. Is participation in ICT training compulsory for teachers in your school? *

*Mark only one oval.*

◯ Yes
◯ No

18. 18. Have you ever undertaken professional development in the following areas? *

*Mark only one oval per row.*

| | Yes | No |
|---|---|---|
| Introductory courses on Internet use and general applications(Word, Powerpoint & Excel) | ◯ | ◯ |
| Video conferencing | ◯ | ◯ |
| Pedagogical Use | ◯ | ◯ |
| Multimedia | ◯ | ◯ |
| Participation in online communities | ◯ | ◯ |
| Introduction to 4th Industrial Revolution | ◯ | ◯ |
| Other professional development opportunities related to ICT | ◯ | ◯ |

19. 19. Who provides the ICT support at your school? *

*Tick all that apply.*

- [ ] A more experienced/knowledgeable teacher in ICT
- [ ] School ICT/technology coordinator
- [ ] Other School staff
- [ ] Experts from outside the school
- [ ] An online helpdesk, community or website

20. 20. How often do you do the following activities *

*Mark only one oval per row.*

| | Never | Rarely | Sometimes | Often | All the time |
|---|---|---|---|---|---|
| Browse/search the internet | | | | | |
| Create your own digital teaching materials | | | | | |
| Post homework for students on the school website | | | | | |
| Evaluate digital learning resources in subjects you teach | | | | | |
| Communicate online with parents | | | | | |
| Download/upload materials | | | | | |
| Look for online professional development opportunities | | | | | |

21. 21. What obstacles have you come across to the use of ICT in teaching and learning *

*Mark only one oval per row.*

| | Not at all | A little | Partially | A lot |
|---|---|---|---|---|
| Insufficient number Computers | ◯ | ◯ | ◯ | ◯ |
| No Internet Connections | ◯ | ◯ | ◯ | ◯ |
| Training and Development in ICT | ◯ | ◯ | ◯ | ◯ |
| Lack of ICT Sponsors | ◯ | ◯ | ◯ | ◯ |

## TEACHERS KNOWLEDGE ON 4IR (AN INTRODUCTION TO DIGITAL TRANSFORMATION)

The world is declared to be in the 4IR, meaning, we have entered the digital world.

22. 1. What do you think the 4IR stands for? *

*Mark only one oval.*

- ◯ 4th Industrial Regulation
- ◯ 4th Identified Regulation
- ◯ 4th Industrial Revolution
- ◯ 4th Industrial Remote

23. 2. When do you think the 4IR was discovered? *

*Mark only one oval.*

- ◯ 2015
- ◯ 2016
- ◯ 2017
- ◯ 2018
- ◯ 2019

24. 3. Which Organization is best described to play a role in the 4IR? *

*Mark only one oval.*

- ◯ World Health Organization (WHO)
- ◯ World Economic Forum( WEF)
- ◯ World Bank(WB)

25. 4. What do you think the 4IR brings? *

*Tick all that apply.*

- ☐ New technological advancements
- ☐ A normal timeline for technology
- ☐ Changes on how we live
- ☐ No changes at all

26. 5.What are the key factors for the 4th Industrial Revolution? *

*Mark only one oval.*

- ◯ Technology, economy and social development
- ◯ Natural resources and climate
- ◯ Natural disasters
- ◯ Steam engines

27. 6. What are the characteristics of the 4th Industrial Revolution? *

*Mark only one oval.*

- ◯ Robotics, programming, 5G,BLOCKCHAIN, Artificial Intelligence and Nano-technology
- ◯ Steam engine, electricity, petroleum and coal
- ◯ Iron and steel production
- ◯ Smart grid technology, plug in, hybrid and shifting to renewable energy

THANK YOU FOR YOUR PARTICIPATION




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Google Forms

## Annexure D: Interview template

**TEACHER INTERVIEW ON THE 4TH INDUSTRIAL REVOLUTION/EDUCATION IN SCHOOLS**

**DATE: _____.** **PARTICIPANT NO: _____**

**GRADE: _____.** **YEARS OF TEACHING: _____**

**SUBJECT(S) TEACHING: _____**

| NO. | QUESTIONS | ANSWERS |
|---|---|---|
| 1 | Can you tell me anything about the World Economic Forum Education 4.0 Framework? What are the general aims and objectives of this framework? | |
| 2 | What preparations has your school already made to the 4IR Education? For example, technology resources, lessons on 4IR, teacher development training? | |
| 3 | How do you teach lessons that promote technological skills? | |
| 4 | How do you teach lessons that promote Innovate and Creativity skills? | |
| 5 | How do you teach lessons that promote Global Citizenship skills? | |
| 6 | In your subject(s), can you give examples of learning content that aims at technological skills, Innovative and Creativity skills and Global Citizenship skills (example Global Citizenship skills may be: Different Cultures found in the world-Life skills subject) | |

| | | |
|---|---|---|
| **7** | Have you or do you integrate technology in your subject(s)? If yes, how do you do it? If no, why not integrate? | |
| **8** | What is your understanding on the concept of the 4th Industrial Revolution in schools? | |
| **9** | What type of teaching methods do you think are required in the new digital generation? | |
| **10** | Blooms taxonomy is one of the teaching and learning theory used worldwide by teachers, which level(s) and example of questions do you think is most necessary to introduce the 4IR in schools and why? | |
| **11** | What kind of non-curriculum lessons (lessons out of the curriculum) would you design for learners to expose them to the new digital world? (Exposing them to robots, Cars that can operate themselves without human intervention, gamification and using Google for online learning? | |
| **12** | As a teacher, what is your responsibility in the 4th Industrial Revolution? | |
| **13** | How can you use old traditional teaching methods to implement and introduce the 4th Industrial Education in the classroom? | |
| **14** | What opportunities do you think the 4th Industrial Education brings? | |
| **15** | What Challenges do you think the 4th Industrial Education brings? | |
| **16** | Have you ever introduced any digital games in your classroom? Which game and how did it go? | |

**THANK YOU FOR YOUR PARTICIPATION**

WSoE
Wits School of Education

## Annexure E: Ethics Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | WSoE Wits School of Education

**SCHOOL OF EDUCATION ETHICS COMMITTEE**

**CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)**

| | |
|---|---|
| **CLEARANCE CERTIFICATE** | **PROTOCOL NUMBER: 2021ECE102M** |
| **PROJECT TITLE** | The state of readiness of government school teachers on the introduction of the 4th industrial revolution |
| **INVESTIGATOR** | **SEREMA EDWARD NKOANA** |
| **SCHOOL/DEPARTMENT OF INVESTIGATOR** | |
| **DATE CONSIDERED** | 15 November 2021 |
| **DECISION OF THE COMMITTEE** | Approved unconditionally |
| **RISK LEVEL** | **MINIMAL RISK** |
| **EXPIRY DATE** | Date of submission of the Research Report |

**ISSUE DATE OF CERTIFICATE** 22 November 2021 **CHAIRPERSON** _____
Dr. Paul Goldschagg

cc: Dr. Piet Bothma

**DECLARATION OF INVESTIGATOR**

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are 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/we undertake to resubmit the protocol to the Committee.

_____ **Signature**

_____/_____/_____ **Date**

## Annexure F: GDE Approval Letter

**GAUTENG PROVINCE**
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

**GDE RESEARCH APPROVAL LETTER**

| | |
|---|---|
| **Date:** | **14 September 2021** |
| **Validity of Research Approval:** | **08 February 2021– 30 September 2021**<br>**2021/284** |
| **Name of Researcher:** | **NKOANA S.E** |
| **Address of Researcher:** | **UNIT 162 COTTONWOOD ESTATE** |
| | **6TH INVICTA ROAD** |
| | **MIDRAND** |
| **Telephone Number:** | **067 050 6549** |
| **Email address:** | **764036@students.wits.ac.za** |
| **Research Topic:** | **THE STATE OF READINESS OF GOVERNMENT SCHOOL TEACHERS ON THE INTRODUCTION OF THE 4TH INDUSTRIAL REVOLUTION.** |
| **Type of qualification** | **MASTER OF EDUCATION BY COURSEWORK & RESEARCH REPORT** |
| **Number and type of schools:** | **1 PRIMARY SCHOOL** |
| **District/s/HO** | **JOHANNESBURG CENTRAL** |

***Re: Approval in Respect of Request to Conduct Research***

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

21/09/2021

**The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:**





**Office of the Director: Education Research and Knowledge Management**
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of COVID 19 pandemic researchers can ONLY collect data online, telephonically or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate. The approval letter will then indicate the type of arrangements that have been made with the school.***
4. ***The Researchers are advised to make arrangements with the schools via Fax, email or telephonically with the Principal.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
14. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

.....
Mr Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 21/09/2021





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