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The transformation of primary and secondary education by the Fourth Industrial Revolution (4IR) technologies

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The transformation of primary and secondary education by the Fourth Industrial Revolution (4IR) technologies

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2497902

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Table of Contents

DEDICATION vii

ACKNOWLEDGEMENTS viii

SUPPLEMENTARY INFORMATION ix

ABSTRACT 1

1 INTRODUCTION 2

1.1 PURPOSE OF THE STUDY 3
1.2 PROJECT JUSTIFICATION AND BACKGROUND 3
1.3 PROBLEM STATEMENT 5
1.4 MAIN PROBLEM 6
1.4.1 SUB-PROBLEM 1 6
1.4.2 SUB-PROBLEM 2 7
1.4.3 SUB-PROBLEM 3 7
1.5 SIGNIFICANCE OF THE STUDY 7
1.6 SCOPE OF THE STUDY 8
1.7 DELIMITATIONS OF THE STUDY 8
1.8 DEFINITION OF TERMS 8
1.9 ASSUMPTIONS 10
1.9.1 CHAPTER OUTLINE 10
1.9.2 CONCLUSION 11

2 LITERATURE REVIEW 12

2.1 INTRODUCTION 12
2.2 SOUTH AFRICAN EDUCATION IN NUMBERS 15
2.3 DBE ICT PROJECTS 15
2.4 GENERATION Z LEARNING STYLES 16
2.5 THEORIES OF LEARNING AND 4IR 17
2.6 DIGITAL TRANSFORMATION AND CHANGE IN EDUCATION 18
2.7 CONNECTIVITY AS AN ALTERNATE THEORY 19
2.8 THEORETICAL FRAMEWORK 19
2.8.1 APPROACHES TO THINKING 19
2.8.2 SCIENTIFIC THINKING 19
2.8.3 DESIGN THINKING 20
2.8.4 ANALYTICAL THINKING 21
2.8.5 SYSTEMS THINKING 21
2.9 INNOVATION DIFFUSION THEORY (IDT) 24
2.10 ROGERS (1995) AND TECHNOLOGY S CURVES 24

2.11 LITERACY AND NUMERACY THEORIES 25
2.11.1 LITERACY EDUCATION THEORY 26
2.11.2 NUMERACY EDUCATION THEORY 26
2.12 HYPOTHESES 27
2.12.1 HYPOTHESIS 1 27
2.12.2 HYPOTHESIS 2 27
2.12.3 HYPOTHESIS 3 27
2.13 CONCLUSION OF LITERATURE REVIEW 27

3 RESEARCH METHODOLOGY 28

3.1 THE SURVEY 28
3.2 RESEARCH METHODOLOGY 29
3.2.1 THE QUANTITATIVE APPROACH 29
3.2.2 THE QUALITATIVE APPROACH 30
3.2.3 MIXED METHODS 30
3.2.4 PRIORITY 31
3.3 RESEARCH DESIGN 31
3.3.1 CONCEPTUAL FRAMEWORK 32
3.4 POPULATION AND SAMPLE 33
3.5 THE RESEARCH INSTRUMENT 34
3.6 PROCEDURE FOR DATA COLLECTION 35
3.7 DATA ANALYSIS AND INTERPRETATION 36
3.8 LIMITATIONS OF THE STUDY 38
3.9 VALIDITY AND RELIABILITY 38
3.10 CONCLUSION 40

4 RESULTS 41

4.1 RESPONDENTS' PROFILE 41
4.2 RESULTS FOR SUB-PROBLEM 1 44
4.2.1 DBE ROLE AND SUPPORT 44
4.2.2 LITERACY AND NUMERACY 53
4.3 RESULTS FOR SUB-PROBLEM 2 56
4.4 CONCLUSION 62

5 DISCUSSION OF THE RESULTS 63

5.1 DISCUSSION OF THE MAIN RESEARCH PROBLEM 63
5.1.1 DISCUSSION OF SUB-PROBLEM 1 63
5.1.2 DISCUSSION OF SUB-PROBLEM 2 64

6 CONCLUSION AND RECOMMENDATIONS 66

6.1 INTRODUCTION 66
6.2 SUMMARY OF THE LITERATURE 66

6.3 SUMMARY OF RESULTS 66
6.3.1 DESCRIPTIVE DATA ANALYSIS 66
6.3.2 REGRESSION ANALYSIS 67
6.4 RECOMMENDATIONS 69
6.4.1 IMPLICATIONS FOR THE DEPARTMENT OF BASIC EDUCATION (DBE) 69
6.4.2 IMPLICATIONS FOR EDUCATIONAL PROFESSIONALS AND LEARNERS 70
6.4.3 IMPLICATIONS FOR THE FOUNDATION PHASE (GRADE R-GRADE 3) EDUCATORS AND LEARNERS 71
6.5 RESEARCH LIMITATIONS 71
6.5.1 SAMPLING LOCATION 71
6.5.2 TARGET RESPONDENTS 71
6.5.3 TIME 71
6.6 SUGGESTIONS FOR FURTHER RESEARCH 72
6.7 CONCLUSION 72
REFERENCES 73

Appendix 1: The National and Provincial Quintile Breakdown 81

Appendix 2: The Percentage distribution of learners in the education system 2016 82

Appendix 3: Educators learners and schools by ratios by province 83

Appendix 4: Status of School Connectivity end of December 2017 83

Appendix 5: Schools' Connectivity in partnership with the Department of Telecommunications and Postal Services 84

Appendix 6: Accelerated Teachers ICT Training 84

Appendix 7: Research Instrument 85

Table of Figures

Figure 1: Systems Theory Variables 23

Figure 2 The S-Curve..... 25

Figure 3: Digital Needs of education professionals 46

Figure 4: of Education ICT Project Awareness by education professionals 47

DECLARATION

I, Lindiwe Setsabile Gama, declare that this project report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Lindiwe Setsabile Gama



Signed at Karenpark, Pretoria

On the 28 day of February 2023

DEDICATION

I dedicate this work to God the Saviour for the learning journey in my MBA studies.

Special thanks to my family for the encouragement and patience. Special thanks to my husband for the support as I navigated through the MBA course.

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I would like to acknowledge my supervisor; Mphekeleli Hoohlo, my former employer for giving me the chance to study and the respondents who participated in the study.

SUPPLEMENTARY INFORMATION

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ABSTRACT

Digital technologies have taken over the education sector in the Fourth Industrial Revolution. Education 4.0 necessitates the upskilling of educational professionals and learners. It also requires the Department of Basic Education (DBE) to uniformly equip all schools with digital infrastructure to prepare learners for the technology-driven work environment. The DBE must make an effort to bridge the digital divide of learners in rural, urban and remote areas as part of the National Development Plan 2030. This is necessitated by the evolving job market. Literacy and numeracy levels have been declining in South Africa despite 4IR technologies that Generation Z learn to use quickly. The interventions by the DBE and the learning styles of Generation Z require educational professionals to adjust and adapt teaching methods. Unlimited access to digital information and applications promote a customised teaching and learning environment. This study aims to investigate how digital technologies are being used by educational professionals (educators) that teach official South African languages (except for sign language) and Mathematics were sampled to solicit their views on how digital technologies can be used to increase numeracy and literacy rates. Twenty- six educators (26) conveniently sampled participated in the study. According to the 2015 Trends in International Mathematics and Science Study (TIMSS) and the 2016 Progress in International Reading Literacy Study (PIRLS). The results indicate that there is a relationship between literacy, numeracy and the digital skills of education professionals and learners. Adequate funding for the Department of Basic Education is essential for uniform digital transformation in South Africa.

Keywords: ICT, Education 4.0, Education professionals, literacy, numeracy

1 INTRODUCTION

Digital transformation due to Fourth Industrial Revolution (4IR) technologies impacts on all spheres of life, and the educational field is no exception. In the advent of digital transformation and change, major trends in evolutionary improvements in the field are being witnessed at an alarming rate because of 4IR technologies, otherwise known as Industry 4.0 (Hussin, 2018). These technologies improve the quality of education by exposing education stakeholders to endless search engines that lead to the instantaneous retrieval of information, flexible learning styles and save time. 4IR or Industry 4.0 has resulted in radical shifts from traditional methods of imparting knowledge to technology-driven means that develop quickly. These technologies are viewed to be disruptive to the educational field (Hussin, 2018; Qureshi, Khan, Raza, Imran, & Ismail, 2021).

4IR technologies bridge the learning gap from distance to door learning (Qureshi et al., 2021). For example, digital home schooling necessitates education industry professionals to acquire relevant digital skills to impart knowledge to learners to prevent the phase of “technological unemployment” (Peters, 2019). Digital technologies blend traditional teaching methods with digital forms. Examples include gaming styles, video recorded lessons that can be replayed anytime at no extra cost for missed lessons. QR codes grant instant access to websites. (Hariharasudan & Kot, 2018; Peters, 2019; Saltan & Arslan, 2016). In 2006, the Minister of Education Naledi Pandor addressed the DBE’s mandate of providing the best accessibility and use of ICT in education. Her closing remarks were as follows; “in a manner that will create better access to quality education for all, and bridge the digital divide, both within our country, between our country and other parts of the world” (Pandor, 2006).

The Covid-19 pandemic portrayed that major disparities persist in South Africa, mainly due to socio-economic inequalities (S. S. Africa, 2019) amongst learners that was more pronounced in the educational sector. The "digital divide" grew because of how 4IR technologies were instrumental in ensuring that education in South Africa continued for students from more affluent social classes in urban

areas, while regressing in remote and rural areas due to cost, a lack of digital infrastructure, and a lack of resources (Chetty et al., 2018; Gerber & Eybers, 2021).

1.1 Purpose of the study

The purpose of this research is to carry out an investigation into whether the Department of Basic Education (DBE) can improve primary school and secondary school education for South African learners through the implementation of an access to all, digital and transformational change initiative leveraging 4IR technologies. The challenge is, how the DBE can implement digital transformation countrywide, to bring about educational change in rural, remote and urban areas uniformly for all learners to have equal opportunities and access to infrastructure to be fully functional in the 4IR economy.

In so doing, this research will determine the extent of the digital divide from newly introduced 4IR technologies and their impact on primary and secondary school education. That is, to determine which of the technologies impact on education and how. The study aims to establish the innovative role of 4IR in education by use of a survey to outline the key areas of automation, new opportunities and posed threats.

1.2 Project justification and background

Education has evolved throughout the First (Education 1.0) to the Fourth Industrial Revolutions (Education 4.0). The First (Industry 1.0) and the second (Industry 2.0) Industrial Revolutions were dominated by steam engines and mass production, respectively. Fewer people were educated in Education 1.0 than in Education 2.0. Education became formalised and traditional methods of teaching placed the educator as the official source of educational information. During Education 3.0, the curriculum was formalised with some reduced rigidity through technological resources and online learning tools. Education 4.0 has seen the acceleration of technology and innovative ways of teaching and learning with more flexibility and customised digital learning tools. South Africa, like many other

countries, has experienced digital transformation and change due to 4IR technologies over this industrial revolution (George F Mukwawaya, Bruno Emwanu, & Sibusiso Mdakane, 2018; Sulaiman, Suid, & Idris, 2018).

Public ordinary schools in South Africa are classified into five groups or quintiles for the fair distribution of financial resources. Quintile one is for the poorest and quintile five for the least poor. The poverty rate and infrastructure around the school is used to determine the quintiles. Quintiles 1, 2 and 3 are no-fee schools and 4 and 5 pay school fees. The National Poverty Table 2014 in Appendix 1, indicates that 28.2% of the poorest learners in schools are from the Limpopo Province, 27.3% from the Eastern Cape and in the Western Cape 8.6%. The Western Cape led in enrolling learners from affluent schools with a value of 31.7%, Gauteng 31.4% and the Limpopo province with 8.0% leaners in schools that were classified as the least poor (Grant, 2013).

The 2015 Trends in International Mathematics and Science Study (TIMSS), highlighted Maths and Science achievement scores of grade 9 learners in which 59 participating countries were ranked, prove that East Asian countries (e.g., Singapore, South and North Korea, Tapei, Japan, Hong Kong Special Administrative Region SAR) were ranked in the top five in outstanding achievement. South Africa was second to last, ranked in the bottom five countries only ahead of Saudi Arabia (Reddy et al., 2015). The 2016 Progress in International Reading Literacy Study (PIRLS), reported that eight out of 10 Grade 4 learners could not read to deduce meaning across all languages in South Africa, with the country coming last from 50 countries that participated in the study (Howie et al., 2016).

Numeracy and literacy rates are drastically declining according to the Trends in International Mathematics and Science Study (TIMSS), where the annual Mathematics achievement improvement rate from 2003 to 2011 was 7.4 points in 2011. It declined to 4.6 points in 2019 when Grades 4/5 and Grades 8/9 were assessed cross-sectionally for proficiency in Mathematics and Science (Council, 2020). Learners are impacted adversely as they are faced with the most unequal socio-economic circumstances. If 4IR technologies are adopted fully, they can

bridge the literacy and numeracy divide in South Africa between disadvantaged and more affluent social classes as intended by the DBE.

1.3 Problem statement

South African society is amongst the most unequal in all the countries in the world with the per-capita expenditure Gini coefficient, a measure of income inequality and poverty reported as 0.67 in 2006 and declining to 0,65 in 2015. Between 2015 and 2020, the Gini co-efficient further decreased to 0.63 signalling a further increase in inequality when comparing high- and low-income levels. The Palma ratio is a measure that compares 10% of the wealthy population against 40% of the poverty- stricken population. This ratio indicates that the wealthy, 10% of the population spent 8.6 times more than the bottom 40% in 2006. In 2015, this spending reduced to 7.9 times indicating a slight decrease in inequalities between 2006 and 2015 (S. S. Africa, 2020).

On the future job skills, The World Economic Forum states that 65% of learners that are enrolling at primary school in the present day will practise in professions that have not yet been presently (Forum, 2016a). There is an urgent need to upskill present-day educators and learners on digital skills and knowledge that will be in demand in the future. The challenge is how the Department of Education implements digital transformation across the country in rural, remote and urban areas, uniformly such that all learners gain equal opportunities and access infrastructure that enables them to be fully functional in the 4IR economy.

This is set against the backdrop of the wicked problems (Niskanen, Rask, & Raisio, 2021) that are faced by the education sector in the different parts of the country, different social classes and backgrounds and in a society that is faced with inequalities and a decreasing education by -2.5% for the upcoming three years (S. S. Africa, 2019; Section27, 2022).

1.4 Main problem

In the context of the severe issues brought on by the Apartheid Legacy's inequities (Niskanen et al., 2021), South Africa finds itself with an educational state that does not promote even distribution of and equitable access to 4IR technological advancements through digital transformation. This legacy presents the challenge of a spiralling unemployment rate of 34,5% according to the Quarterly Labour Force Survey Quarter 1 2022 by Statistics South Africa (S. S. Africa, 2022). Moreover, poverty and race inequalities, compound on gender and age discrimination.

If 4IR technologies are adopted to bridge the literacy and numeracy divide in South Africa between disadvantaged and more affluent social classes as intended by the Department of Basic Education in an endeavour to uniformly equip learners through equal rights and access to education in a safe and conducive environment, why is it that the literacy rate in South Africa literacy for 2017 was 87.05%, a 7.32% decline from 2015 (Macrotrends, 2022) and the numeracy rate are drastically declining and failing many of the children in South Africa? The Multiple Overlapping Deprivation Analysis 2020 on Child Poverty in South Africa states the National Estimate at 62.1% (UNICEF, 2020).

1.4.1 Sub-problem 1

The first sub-problem is to investigate why on the one hand, literacy and numeracy rates for the affluent in South Africa, who have access to infrastructure critical for aptitude in 4IR technologies is increasing sharply. While on the other hand, (4IR) technological education is drastically failing learners with South Africa coming in last place with more than 1 in 3 having a low level of literacy and numeracy. The 2016 PIRLS reported that 80% grade 4s cannot read for meaning in the different South African languages (Howie et al., 2020). A 2015 study conducted by Trends in International Mathematics and Science (TIMMS) showed that 65% of grade 5 pupils in the country could not add and subtract whole numbers (Davids, 2019).

1.4.2 Sub-problem 2

The second sub-problem is to investigate why on the one hand, workforce and employment empowerment targets prospects by the DBE; for the affluent private education sector who are equipped with vital digital skillsets and access to resources is increasing sharply. While on the other hand, disadvantaging workforce and employment target prospects for the remainder of the educational sector, who are becoming disillusioned since the advent of 4IR technologies in education?

1.4.3 Sub-problem 3

The third sub-problem is to establish the need for educational professionals to upskill their 4IR technological prowess based on constant upgrades, new digital applications and trendy tool uses that are available to aid in advancing digital transformation and change.

1.5 Significance of the study

The study fills in the gap by studying existing quantitative and qualitative studies and focuses on the gaps highlighted in these studies to comprehend the role of 4IR in education, the quality of life that technologies provide and how they are transforming primary and secondary schooling education in South Africa. This includes digitisation costs (upskilling educators, learners and infrastructure). Costs can be prohibitive for learners in poverty-stricken communities in remote, rural and some urban areas such as townships (S. S. Africa, 2019).

The study provides guidance to the education industry stakeholders such as education professionals, online home schools, education entrepreneurs, digital entrepreneurs the Department of Education and industry players who provide 4IR technologies to schools and innovators of educational digital media and channels. It provides guidance to parents as key clients in the school system that support to their children to garner digital skills that fit in the contemporary market (Peters, 2019).

1.6 Scope of the Study

This study aims to explore the digital transformation of primary and secondary education in South Africa by 4IR technologies. The research will entail the use of a convenient sample of educators of the official languages in South Africa (except sign language) and Mathematics at primary and secondary schools. The study aims to identify the 4IR technologies that are used by education professionals and learners to improve and inculcate literacy and numeracy.

1.7 Delimitations of the study

The study is limited to educational professionals at primary, secondary schools education professionals. A convenience sample cannot be generalised to a larger population.

1.8 Definition of terms

Fourth Industrial Revolution (Industry 4.0) is the taking over from previous human brain functions by computers to technological application. 4IR technologies include the Internet of Things (IoT), Artificial Intelligence (AI), Robotics, Cloud Computing, Big Data Analytics, Autonomous Process Organisation, 3D printing, Quick Response (QR) Code and the Augmented Reality. Industry 4.0 presents more advancements in technology and the precision of digital innovations from the Third Industrial Revolution (Industry 3.0) (Hariharasudan & Kot, 2018; Salmon, 2019a).

The Internet of Things (IoT) facilitates access to internet resources and requires that users have digital skills and results in the development of future scientists. The spread of automated platforms and devices such as smartphones has made it easier for learners and academics to acquire digital skills. There is an expertise deficit in the use of automated gadgets and the IoTs that may increase if corrective measures are not established to address this skills' gap. Education plays a pivotal role in ensuring that the latest methods are incorporated for

education stakeholders to engage with machines and data effectively (Halili, 2019; Qureshi et al., 2021).

Big Data algorithms plays a crucial role in information and knowledge management. Through Big Data, education institutions process information for human resources, track personal data on learners, academic performance and attendance. Big Data facilitates quick and effective information sharing between departments (academic) and institutions for transferring learners. It is instant, quick. Data on learners can be retrieved and analysed promptly for academic or any legal purposes. Information sharing must be according to the Protection of Personal Information Act of 2013 (R. o. S. Africa, 2013; Halili, 2019; Hoosain, Paul, & Ramakrishna, 2020b; Peters, 2019).

Artificial Intelligence are the digital platforms that are performed and embedded in the human brain. Just like the human brain that is capable of storing and processing a lot of information, AI plays a crucial role in storing, processing and accessing unlimited information. It facilitates information creation, learning and sharing, the basis of the education field. AI encourages deep learning through audio-visual webs, numerous layers coupled with the actions of the human brain that are automated. Machines are used to learn and comprehend the framework to effect change (Salmon, 2019a).

Education 4.0 is the digital innovations from the Fourth Industrial Revolution (Industry 4.0) which is a digital age. Due to digitisation, the field of education has had to adjust and adapt teaching and learning using digital tools. Education 4.0 results in the change in human skills to digital skills (Huk, 2021a; Qureshi et al., 2021).

Virtual learning educators complement face-to-face learning using the internet or Web (Salmon, 2019a).

Digital Skills are the competencies that people possess to access digital channels. Students have to possess the following basic skills: computer literacy, data entry, social media, web-based communications and research, word processing, email and chat and secure information processing (News, 2021). They have to rationally assess information, organise data and media channels.

Learners must thrive in online domains and manage their digital footprint and exercise caution on privacy and security (Coldwell-Neilson, 2021).

Educators have to possess the skills outlined above for learners and the following digital skills: professional engagement, digital resources, teaching and learning, empowering learners and advance learner's digital capabilities (Hub, 2020; van der Merwe & van Heerden, 2015).

1.9 Assumptions

1. The respondents are familiar with and use 4IR technologies.

The basis of this assumption is that as the 21st Century is the Fourth Industrial Revolution (Industry 4.0), the respondents have access to and use 4IR technologies such as laptops, smartphones, applications and tablets.

2. The respondents use 4IR technologies for educational purposes.

The basis of this assumption is that the respondents use 4IR technologies to impart or gain access to educational information.

3. Access to 4IR technologies is not bound to geographical location in South Africa.

The assumption is that the whole population is connected to digital networks regardless of geographic location: rural, remote, metro or urban areas.

For the Fourth Industrial Revolution to be effective and impart knowledge and digital skills, all citizens should have access regardless of social class and geographic location.

1.9.1 Chapter Outline

This chapter introduces 4IR technologies and their transformation of education in South African primary and secondary schools. The focus of this chapter is to outline the technologies that are used to enhance the quality of education for literacy and numeracy.

Chapter 2 presents the literature review which outlines the South African education system in numbers, the ICT projects initiated by the DBE, the learning styles of Generation Z, the theories of learning and the theoretical framework which focuses on approaches to thinking.

Chapter 3 outlines the methodology used for the study. Research paradigms and methods are discussed in this chapter. A convenient sample was used to access respondents that were easily accessible and willing to participate in the study.

Chapter 4 is a presentation and analysis of the results. Descriptive statistics are used to profile the respondents. Regression analysis is used to determine the relationship identified in the hypotheses.

Chapter 5 deals with the results and draws from previous studies to substantiate current findings. Conclusions and recommendations for scholars are presented with suggestions for future research.

1.9.2 Conclusion

The education sector has to adapt and adjust to the Fourth Industrial Revolution to produce learners that are ready for the turbulent market environment. The DBE has to uniformly equip all learners and education professionals regardless of geographic location for Education 4.0.

2 LITERATURE REVIEW

2.1 Introduction

Digitisation impacts our lives at a rapid pace. All fields of study are impacted by the fast introduction and requirements of the digital world. The field of Education is faced with having to adapt and adjust rapidly to digital changes to equip students and educators with skills to acclimatise to these conditions (Huk, 2021a).

Education 4.0 facilitates the digital transformation of education and the imparting of information and knowledge between learners and educators through the Internet of Things, Big Data, Cloud Computing, Block Chain, Robotics, Augmented Reality and 3D technologies. The modern school exists in a global world and therefore, has to strive to produce learners that have embraced and immersed themselves with 4IR. The digitisation of education applies to general and practical career-oriented education as, the job market demands this knowledge and expertise. (Hoosain, Paul, & Ramakrishna, 2020a; Huk, 2021a).

4IR technologies have transformed education from the teacher as the only facilitator and source of information to a vibrant state where there are numerous sources of information through the internet and media that can be accessed by educators and learners. Education 4.0 opens the education field to a collaborative and automated environment between learners and educators. Education 4.0 facilitates versatility between educators and learners in their quest for information, knowledge and skills. Learners can source information relevant to their needs timeously and not rely heavily on educators. Learning is not bound to a bricks and mortar structure, it can take place anywhere anytime (e-Learning) as long as learners have psyched themselves and set up for it. (Huk, 2021a; Hussin, 2018).

Education 4.0 enables customised learning environment, pace, learning methods and promotes creativity. Educators have to fall in practical step with the e-learning needs of learners and customise the learning and teaching environment to suit individual learner needs. Digital media (laptops, smartphones, tablets, apps, videos, and video-conferencing) plays a pivotal role in equipping learners and

educators to flourish in the 21st Century. The concept of Bring Your Own Device (BYOD) gives learners options on how to learn. Learning is about practical application of learnt concepts and project based assessments. Learners have the freedom to select methods that suit their learning styles as per the curriculum (Hussin, 2018; Qureshi et al., 2021).

4IR technologies necessitate that traditional teaching methods undergo a transition for versatile innovative teaching and learning in live, distance and practical aspects. Education 4.0 promotes constant learning and adaptation of skills, proficiency in data and information handling for professionals in education and learners. Education 4.0 has a holistic impact on industry players at all levels to deliver quality education with a lasting practical and applicable impact on learners. This transition necessitates the upskilling of education professionals. For some educators it is not as easy (might be met with reluctance) as learners are more familiar with digital technologies and learn to use them quickly. There is an urgent need for educators to embrace digitisation and upskill to effectively impart quality education in the digital era (George F Mukwawaya et al., 2018; Qureshi et al., 2021).

Big Data Analytics facilitates the capturing and storage of all data (educational and personal) and records for effective management, research, learning organisations- attendance, learner performance, Information and Communication Technologies (ICT) skills and information sharing. It enables educational institutions to link and manage communication and information with external stakeholders (George F Mukwawaya et al., 2018; Samuel Dick, Mario, Sifiso, & Judy Van, 2019).

For teaching, learning and assessments, 4IR technologies give access to unlimited information, digital tools and platforms with vast processing and storage power (Salmon, 2019a). These technologies have modified traditional face-to face to innovative methods of teaching (Halili, 2019) whilst allowing for the customisation of education to address the needs of learners- disabled, pregnant, absent - are able to rewind recorded lessons at no additional cost and still get the same educational benefits. Digital technologies promote flexibility, as they are not bound to a location (virtual reality). Students can learn anywhere, anytime they

are ready to learn. Digital transformation promotes collaborative, project and practical learning (Huk, 2021a; Saltan & Arslan, 2016; Tsakeni, 2021).

4IR technologies are capable of reducing costs for travelling to bricks and mortar educational institutions. The quality of life for educators and learners improves with access to unlimited information and learning tools, customised dynamic teaching and learning methods for learners' educational needs whilst tailoring skills for the job and business market to avoid unemployment technology in future (Peters, 2019). Learning institutions and individuals benefit from the digital age through continual advancements catered to a varied generation of tech-savvy people. (Samuel Dick et al., 2019).

Time spent on administration and management issues reduces and focus is on education as digital technologies such as Cloud Computing, Big Data Analytics offer instant information processing on the school's management and administrative functions whilst freeing educators and the schools' management teams to focus on their key client- the learners (Huk, 2021a).

There are challenges in implementing digital technologies effectively in the South African context. These challenges are not purely South African, but are faced by other developing nations (Samuel Dick et al., 2019). These include the digital skills of educators and whether learners can take up effective learning in virtual environments (Tsakeni, 2021), schools that prohibit digital devices on their premises thus restricting the digital skills of learners and access to information. Affordability of data and digital devices, connectivity and lack of technological infrastructure such as electricity, the retention of qualified personnel in disadvantaged communities (rural, remote and townships), inadequate security and significant drop out figures. Some of these problems emanate from the socio-economic inequalities inherited from the Apartheid era and post-apartheid because of lack of service delivery (S. S. Africa, 2019; Samuel Dick et al., 2019). These factors are exacerbated by that change and innovation take longer in education and stakeholders can give up on what could be beneficial for the field (Salmon, 2019a).

2.2 South African Education in numbers

In South Africa in 2016, the distribution of the of learners, nationally was as follows: 92.7% were in public schools, 4.4% in independent schools, special schools 0.9% and Early Childhood Development sites 1.9% in Appendix 2. There was a total of 12 932 565 of leaners, 418 613 educators and 25 574 schools nationally according to the 2016 SNAP Survey in Appendix 3 (Education, 2018a). The DBE must cater for the educational needs of all these learners and professionals and bridge the digital divide created by the unequal distribution of resources and infrastructure that is historical and currently faced by the nation.

2.3 DBE ICT Projects

The socio-economic inequalities are still plaguing the nation as the DBE still struggles to level the playing field in the education sector. Operation Phakisa ensures that South African government departments including the DBE fulfil the National Development Plans 2030. Launched in 2015, Operation Phakisa ensures that the DBE ICT projects, policies and support is rolled-out nationally to urban, rural and remote communities. Operation Phakisa, focuses on the provision of infrastructure: connectivity, devices, Teacher Professional Development, Digital Content Development and Distribution and e-Administration (Kekana, 2018; Maboya, 2018).

The DBE, through Operation Phakisa has piloted and rolled out a number of ICT projects to cater for and improve the educational needs of learners and educators. Partnerships with stakeholders such as the Department of Telecommunications and Postal Services (DTPS), Independent Communications Authority of South Africa (ICASA) which also regulations telecommunications providers such as MTN, Vodacom, Cell C, Telkom and other mobile service suppliers. Mobile service providers collaborated with the DBE and its stakeholders to roll out ICT infrastructure in schools. These include but are not limited to the 2014 – 2020 School Connectivity Plan (Projections), ICT Training, School Connectivity Rural & Urban, Online Registration and Re-marking (NSC), 2015-16 (USAO) Rollout, DTPS Led Broadband Project, Virtual Learning

Solution, and Learning Anytime, Anywhere, Any Place. Other projects are the IT Services Support Hub, Research and Innovation Capacity for Teacher Education and all initiatives emanate from the Education Lab (Maboya, 2018; Services & Education, 2014).

The Rural versus Urban 2014/2015 broadband connectivity in Appendix 5 indicates that out of 11 528 (46%) non-broadband schools connected, 3 793 (33%) were in the rural areas, 6 233 (54%) in urban areas and 2 245 (19%) not stipulated pending classification of whether they were rural or urban (Maboya, 2018). For teacher training initiatives on ICT, with the exception of Gauteng and the Western Cape provinces, from 1271 schools, 1773 teachers received ICT training from the partnership between DBE, DTPS and (Integrated electronics) INTEL South Africa in Appendix 6 (Services & Education, 2014).

The DBE has made valuable strides through Operation Phakisa to fast track ICT educational projects, initiatives and infrastructure development. However, socio-economic and geo-spatial inequalities still persist. For instance, for the Rural versus Urban Connected Schools, from 2014/2015 to 2017, 16.22% (4019 out of 24775) schools had been connected by the end of December 2017 in Appendix 4 (Kekana, 2018; Maboya, 2018).

2.4 Generation Z Learning Styles

Generation-Z was born between 1997 and 2010 in the advent of the World Wide Web (WWW). They were born with unlimited access to the internet and its resources: social media and numerous online applications. They are accustomed to instant access to information and take to technological devices quickly. Generation-Z are multi-taskers and thrive in versatile collaborative work environments. They participate actively in learning and are stimulated by audio and visual tools (Demir, 2021; R Nandhakumar, 2019; Robertson, 2019).

In sharp contrast, Generation X (1965 – 1976 and Y (1980- early 2000s) who are used to the traditional set-up, education is teacher-centred. Learners relied on the teacher as the main source of information with a lot of theory based lessons. Power point presentations, tutorials and lectures were the key methods of

imparting knowledge. However, some individuals drive the innovative teaching methods in Generation X and Millennials. They are not resistant to learn and use technology to advance education. The need to upskill educators on innovative methods of teaching is urgent as, they cannot be found wanting in a Generation Z classroom setup (R Nandhakumar, 2019; Robertson, 2019).

2.5 Theories of Learning and 4IR

There are five learning theories in education: behaviourism, cognitivism, constructivism, humanism and connectivism.

Behaviourism, is a theory in psychology that encourages drill learning. Learners memorise information and regurgitate it for positive strengthening and acknowledgement by educators. Learning to take place externally using rote-learning stimuli to programme learning outcomes, (I. del Valle García Carreño, 2014; Phoenix, 2021).

Cognitivism tries to explain essence of human knowledge. Grasping new concepts is incorporated into the existing knowledge of the learner. Learning is an active individualistic process as the learner draws from prior experience. Cognitivism learning theory depicts the human brain as a computer from its conception in 1946. The brain of learners encodes information in the same manner as Cognitive Information Processing (CPIs). Learners blend in information presented by educators (Harasim, 2017).

Constructivism focuses on how individuals perceive the world. This theory emphasises that individuals have independence of thought in understanding the world. Unlike robots, people cannot be programmed and neither their reaction to stimulus be predicted in a uniform manner. Constructivism presents the learner and educator in collaboration on the learning journey with the learner as an active participant and the educator and often times peers, providing opportunities to design meaning. Sense-making is achieved by comprehending the environment coupled with experience (Ingrid del Valle García Carreño, 2014; Harasim, 2017).

Humanism centres on self-realisation of learners. Learners create an environment that promotes learning. Learners have the liberty to choose how to learn and ensure that this learning fulfils their needs and how they will use knowledge gained. The educator becomes a facilitator of learning and teaching to meet the needs of the learners.(Gandhi & Mukherji, 2022; Phoenix, 2021).

Connectivism is a learning theory for the digital age formulated by George Siemens and Stephen Downes in 2004. Connectivism draws from constructivism in that, learners are in control of how they want to learn and can control the setting where knowledge and information is shared. Computers are used to complement and increase human intelligence and not to mechanise or diminish it according to Douglas Engelbart and Ted Nelson in (Harasim, 2017) who refers to this complementary function as Augmented Human Intelligence (AHI). Connectivism concentrates on sharing networked knowledge that is outside of the individual and within the individual to think (cognitivism) in sense-making (constructivism) from an institution or a database. Learners get knowledge through networks and digital platforms, devices and applications. Educators design and organise accessible courses via intelligent networks (Ingrid del Valle García Carreño, 2014; Harasim, 2017; Turnbull et al., 2018).

2.6 Digital Transformation and Change in Education

Digital Transformation is the modification of traditional methods of executing duties and service provision because of digital technologies and innovations. Novel ways of imparting knowledge, information and skills emerge because of the technology revolution. In the education sector, digital transformation encourages new ways of interaction between educators and learners. Role players have to learn, unlearn and relearn the environment to be agile and competitive. This is necessitated by the the World Economic Forum’s declaration that 65% of learners will work in jobs that have not yet been established as they start school now (de S. Oliveira & de Souza, 2022; Forum, 2016b).

To function fully in the digital education space, learners, educators and industry role players have to be equipped with digital skills and information that they can

impart to the current generation. Schools must breed a generation that fits well in the continually digital disruptive work environment. The 21st Century requires digitally skilled employees who are on a lifelong journey to upskill, versatile and fit into any work environment globally (Balyer & Öz, 2018; de S. Oliveira & de Souza, 2022).

2.7 Connectivity as an Alternate Theory

Connectivity is based on that learners cannot control the networked environments that result from digitisation. Chaos theory focuses on irregular action in computational unpredictable multifaceted systems. Knowledge and information is shared between human beings and machines. Versatile connection networks are used to form individual and community networks for information transfer. Connectivity is an option to bridge the distance in information sharing (Andersson, Dasí, Mudambi, & Pedersen, 2016; Lyons, 2018; Turnbull et al., 2018).

For this study, constructivism, connectivity and connectivity as an alternate theory are used as they focus on the use of technology to impart knowledge in settings that the learners can control.

2.8 Theoretical framework

2.8.1 Approaches to Thinking

There are a number of approaches to thinking that assist humankind to make sense of the world. These are scientific, design, analytical and systems thinking all of which facilitate human existence and phenomena as it unfolds and evolves on Earth.

2.8.2 Scientific Thinking

The encounter between Jean Piaget and Albert Einstein is commonly regarded as the catalyst for the start of psychological study on scientific reasoning in 1928. Scientific thinking focuses on the expertise required for conducting research,

evaluating the strength of the evidence, explaining concepts, and making arguments and conversation as scientific learners and as literate in Science grownups. It is a particular kind of deliberate information or knowledge searching. However, before this intrinsic curiosity can effectively handle scientific concerns, it needs to be honed and sculpted by education through intentional activities, such exploring, asking questions, testing hypotheses, engaging in inquiry, and evaluating evidence especially in children. As a human enterprise, Science can be viewed from the perspectives of the individual, the social, and the cultural. When applied to a person, scientific reasoning and other types of problem solving and reasoning have a lot in common (Jirout, 2020; Zimmerman & Klahr, 2018).

2.8.3 Design thinking

This is an iterative process to understand the user, question presumptions, and redefine challenges in an effort to find alternate approaches and answers that might not be immediately obvious given our current level of understanding. Design thinking offers a problem-based approach to tackling issues at the same time. It consists of a variety of practical techniques as well as a way of thinking and operating. The same concepts that Herbert Simon, a 1969 Nobel Prize winner, first outlined in The Sciences of the Artificial are present in all forms of design thinking Dam &Siang “n.d.”

The five stages of design thinking are as follows according to Dam &Siang “n.d.”

- Try to understand your users.
- Define the needs, the issue, and the insights of your users.
- Ideate - by questioning presumptions and coming up with concepts for creative fixes.
- Prototype: the first step in developing a solution.
- Test – answers.

Design thinking has become the quickest organisational route to innovation and high performance over the past five years, revolutionising the relationship between creativity and business. Design used to be a phase after product development that aimed to increase the attractiveness of an already existing

product (Micheli, Wilner, Bhatti, Matteo, & Beverland, 2018; Pietro Micheli & Beverland, 2014; Serrat, 2017).

2.8.4 Analytical Thinking

The ability to examine, appraise, evaluate, compare, and contrast abstract notions is known as analytical thinking ability. Differentiating, arranging, and assigning concepts are signs of analytical thinking skills (Irwanto, Rohaeti, Widjajanti, & Suyanta, 2017).

The choice of problem sequence is crucial to improving deductive and inductive reasoning since it fosters analytical thinking and broadens one's area of interest. Analytical thinking involves the ability to (1) break a problem down into its component parts and understand the passage, (2) explain how a system works, why something happened, or how to solve a problem, (3) compare and differentiate two or more phenomena, or (4) evaluate and examine the characteristics of phenomena, is an example of analytical thinking. This ability enables students to think logically about the connections between ideas and situations they come across**.** The ability to study and separate facts and ideas based on their strengths and weaknesses is referred to as analytical thinking. It is also known as developing the capacity to think sensibly, intelligently, solve issues, analyse data, recall information, and utilise it (Yulina, Permanasari, Hernani, & Setiawan).

2.8.5 Systems Thinking

Ludwig von Bertalanffy is the proponent of the systems theory. The Systems Theory is an interdisciplinary study of systems. The General Systems Theory is an ideal that focuses on the parts of a system that are interconnected and have to be understood in the context of relatedness and not individually. Organisational environments are complicated and turbulent. Holism is a key concept that emphasises that a system's whole is greater than its individual pieces, which is an Aristotelian worldview. The goal of the logico-mathematical field known as the General Systems Theory is to formulate and derive those universal principles that

apply to all systems. By using their logical homology, notions such as completeness and sum, differentiation, progressive mechanisation, hierarchical order, finality and equifinality, which appear in all Sciences dealing with systems, may now be precisely formulated (Lai & Huili Lin, 2017; Von Bertalanffy, 1972).

Information Communication Technology (ICT) is a value creation system just like 4IR that brings numerous benefits to different fields of study. In the context of 4IR and education, the systems theory is applicable in that the quality of the technological infrastructure that is a system, determines the quality of services provided to stakeholders such as learners, educators and education professionals. The value of the system is the sum of its interdependent parts- for ICT to perform coherently; the components must be set up to function well in turbulent environments. The systems theory is used to build massive systems that enforce organisational standards globally. Systems theorists also counselled organisations on the need to have a deeper awareness of the contexts into which they were stepping to expand their organisations across national boundaries. Global inequality can have an impact on businesses' international endeavours, thus businesses need to be aware of the settings in which their target customers live, including things like voting rights, social standing, and access to facilities (Lai & Huili Lin, 2017).

For the DBE in South Africa to roll out 4IR education technologies efficiently, the systems have to be properly planned for, piloted and rolled out for all stakeholders to benefit in different provinces faced with inequalities whilst ensuring that the basic right to education is observed equally across the country. Therefore, this study aims to determine through the systems theory to what extent has the DBE prepared for and trained stakeholders for the adoption of 4IR in education whilst maintaining global standards.

Steps to investigate the Systems Theory for 4IR technologies in education:

Step 1: Start with a Problem- for the DBE the lack of uniform connectedness and infrastructure in the ICT system to rural, remote and urban areas for equal access to all primary and secondary school learners, educators and education professionals thus, affecting literacy and numeracy levels.

Step 2: Identify variables that are important to the problem (Rogers, 1995) on the variables determining the rate of adoption of innovation:

2.1 Perceived attributes of Innovation-relative advantage, compatibility, complexity, trialability and observability

2.2 Type of Innovation Decision-Optional, Collective, Authority

2.3 Communication Channels- mass media or interpersonal

2.4 Nature of the Social System- norms, degree of network interconnectedness

2.5 Extent of Change Agents' Promotion Efforts

Step 3: Linking the variables together and determine how one variable affects another.

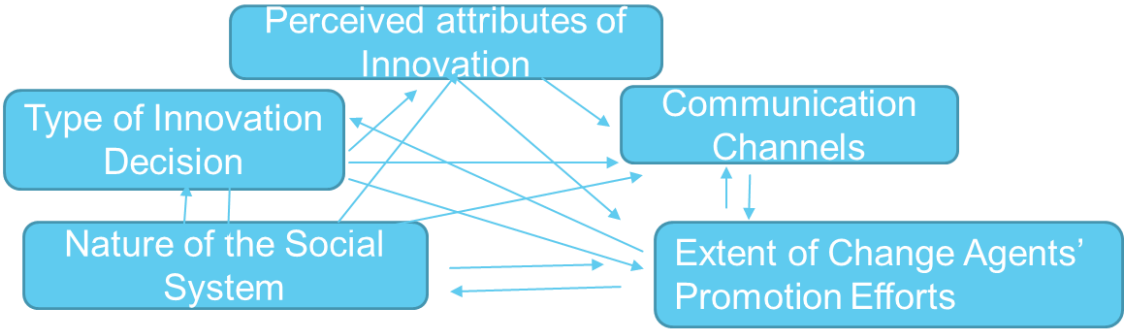


Figure 1: Systems Theory Variables

Source: L. Gama (2022) adapted from (Rogers, 1995)

Step 4: Label the loop. Show relation between cause and effect as reinforcing (+) or negative (-).

For the purpose of this study, systems thinking (theory) is used as it focuses on the parts that make a whole. The use of technology in education will be studied as part of a whole as it is a vehicle that contributes to the education of the whole person in the context of accessibility, affordability, connectivity and the ability to equip educators, learners and professionals with digital skills. The interdependences of these parts of technology are studied to understand how they contribute to the whole: using ICT effectively to achieve literacy and numeracy in South Africa.

2.9 Innovation Diffusion Theory (IDT)

Rogers (1995) posited the Innovation Diffusion Theory (IDT) (Rogers, 1995). Five key innovation characteristics are included in IDT: relative advantage, compatibility, complexity, trialability, and observability. The innovation characteristics are presented in Step 2 of the Systems Theory above in Section 2.8.5. The user adoption and decision-making process is explained using these traits. They are also used to explain how these variables interact with one another and forecast the adoption of future technical advancements. Innovation diffusion is the process through which an innovation is disseminated across members of a social system over time through certain routes. The theory covers the decision-making process for innovations, factors that affect adoption rates and the different types of adopters. The theory seeks to forecast the chance and rate at which various kinds of users accept an invention (Gaoa, Krogstiea, & Siaub, 2011; Rusek, Stárková, Chytrý, & Bílek, 2017).

2.10 Rogers (1995) and Technology S Curves

The Technology S Curve focuses on the adoption of innovation also examines leaders that are opposed to change as well as inventive opinion leaders. Some are actively promoting new ideas, while others are actively opposing them. They are therefore in the centre of interpersonal contact networks and occupy a special and powerful role within the structure of the school environment.

The term "change agent" is also introduced in this context (Kim & Baylor, 2008). Despite the fact that Rogers (1995) uses the word innovation as a synonym for technology, it can nevertheless be understood in other ways. Five groups of innovation adopters are further defined by the theory of the leaders: early adopters, late majority, late majority, laggards, and innovators (Rogers, 1995).

Although they are rejected frequently by their surroundings, they nonetheless have significance in the system because they introduce fresh perspectives into the social structure. Early respectable adopters are more assimilated into their

surroundings. They exercise the most influence over public opinion. Early adopters provide knowledge to prospective innovators. Their contribution to the decline uncertainty on the part of others to adopt new ideas. Earlier than expected, the majority (on purpose) adopts innovations the typical participants in the system. They rarely take the initiative and think carefully before applying innovation. Their place is distinctive because they serve as a bridge between members who adopt innovations quickly and members who do so more slowly in the process of diffusion. Members of the late majority (sceptical) adopt innovations just after the median members (Gaoa et al., 2011; Rusek et al., 2017). An illustration of the S-Curve is presented below in Figure 2:

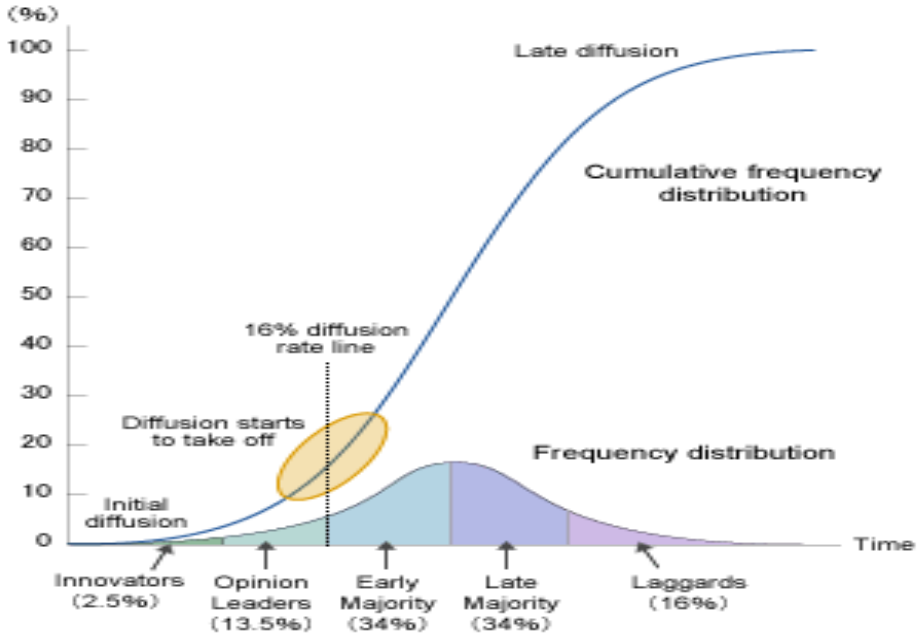


Figure 2 The S-Curve

Source: Naidoo (2022)

2.11 Literacy and Numeracy Theories

Scholars have presented a number of theories on literacy and numeracy. A discussion on the Literacy Education Theory and the Numeracy Education Theory is presented below.

2.11.1 Literacy Education Theory

In the past, in literacy education theory, the focus was on reading and writing which was a simplistic view of literacy. In the present, multiple literacies are not sorely restricted to reading and writing. Literacy is a construct used to understand economic, social and political situations. Discursive literacies transcend reading, writing, and incorporate social-cultural and sociolinguistic situations. The guide to school literacy are social and cultural assumptions and beliefs of scholars. Learning of all kinds is grounded in language and the family's position determines the extent to which literacy can be achieved. Production of knowledge depends on exposure to the channels that enable learns to produce knowledge. Literacy consists of written, oral, visual and digital literacy that are used daily in the school environment. These literacies were assessed to understand how the education system equips learners to use these literacies in academic, social and cultural contexts (Garrett-Rucks, 2013; Harasim, 2017; Purcell-Gates, 2013). Literacy skills include reading, writing, phonemic awareness, letter knowledge, phonics, decoding, fluency and comprehension (Linde, 2021; Williams, 2016).

2.11.2 Numeracy Education Theory

Numeracy entails the ability to deal with numbers. However, this is a narrow view of numeracy. Numeracy transcends the narrow view to it transferability to social and cultural contexts. Numeracy is not only mathematical but means that practical situations can be solved using mathematical knowledge. Leaners must be able to identify real-life issues and use mathematical literacy to solve these challenges. They must be equipped to deal with real-life events and form judgements based on what they have learnt in class. Learners achieve numeracy by transferring classroom knowledge of Mathematics outside of school to their home and community. The home and community has an influence in how learners grasp, perceive and use Mathematics to deal with real-life encounters (Allexsaht-Snider, 2006; Yasukawa, Rogers, Jackson, & Street, 2018).

Numeracy skills include verbal counting, one-to-one correspondence, numeral identification, cardinality, comparisons of sets and numerals, ordering numerals, story problems. Additional numeracy skills include counting, understanding of

number relationships, and number combinations (Hornburg, Schmitt, & Purpura, 2018; Kiss, Nelson, & Christ, 2019). Language skills play a vital role in learning numeracy skills (Purpura, Napoli, & King, 2019).

2.12 Hypotheses

2.12.1 Hypothesis 1

Null Hypothesis: There is no relationship between literacy and numeracy levels with affluence.

Alternative Hypothesis: There is a relationship between literacy and numeracy levels with affluence.

2.12.2 Hypothesis 2

Null Hypothesis: There is no relationship between the geo-location of education professionals and upskilling initiatives.

Alternative Hypothesis: There is a relationship between the geo-location of education professionals and upskilling initiatives.

2.12.3 Hypothesis 3

Null Hypothesis: There is no relationship between the digital skills of education professionals and literacy and numeracy levels.

Alternative Hypothesis: There is a positive relationship between the digital skills of education professionals and literacy and numeracy levels.

2.13 Conclusion of Literature Review

Digital technologies are transforming education for stakeholders in the education sector. They provide opportunities for flexible teaching and learning while equipping stakeholders in the field with digital skills and unlimited access to

information. Virtual learning, augmented reality and online learning improve the quality of life for users and reduce travel costs to bricks and mortar schools. Customising education is a benefit of the versatility of innovative 4IR technologies. The rate of literacy and numeracy of learners must be enhanced greatly because of unlimited access and applications to educational content as a basic requirement from industry stakeholders. Education practitioners are required to upskill continually to meet the educational needs of Generation Z. Theories of learning, literacy and numeracy and approaches to thinking shed light on how digital technologies are diffused to the Masses. The approaches to thinking shed light on the parts that make a whole in the rolling out of 4IR technologies in primary and secondary schools.

3 RESEARCH METHODOLOGY

3.1 The Survey

The survey method of research falls under the post-positivist worldview and is a scientific method. The formulation of assumptions is to either be approved or disproved. The post-positivist view is mainly quantitative and acknowledges that in studying human phenomenon, our assumptions on human action cannot be positive. The basis of post-positivism is determination, reductionism, empirical observation and measurement and theory verification (John W Creswell, 2014; Teddlie & Tashakkori, 2009).

Causes that determine outcomes are studied in the experiment format. The causes and effects are reduced to a manageable discrete set of variables to be tested, are part of the hypotheses, and the research question. Numbers were generated as a basis of measurement of the behavioural patterns as observed by the post-positivist. To approve or disprove a theory, the researcher gathers data to reinforce or debunk the theory whilst making the required adjustments to test the theory further (John W Creswell, 2014; Gamlen & McIntyre, 2018).

A qualitative study: the opinions, beliefs, attitudes and other information on the absorption and the state of technology-driven education in public schools

compared to private schools. A determination of whether access improves literacy, numeracy and the digital skills of learners and education professionals.

3.2 Research methodology

The methodology of the study is mixed: qualitative and quantitative. Qualitatively, the opinions, beliefs, attitudes and other information on the absorption and the state of technology-driven education in public schools compared to private schools. The aim is to determine whether access improves literacy, numeracy and the digital skills of learners and education professionals.

A convenient sample of 35 respondents/practising education professionals who received the link to online self-administered Qualtrics questionnaire and only 26 respondents participated. Quantitatively, frequencies, percentages and regression analysis was used for the presentation of the results.

3.2.1 The Quantitative Approach

The quantitative approach presents a Post-positivist perspective of thinking where the researcher assesses a theory using hypotheses. It is an experimental design. Collection of data is to reinforce or disprove hypothesis. Data collection is conducted using an apparatus to gauge viewpoints and analyse information statistically. An experimental design is pursued in this approach with a pre-test and post-test (John W Creswell, 2014).

The benefits of this design are that if a larger randomly selected sample is used, the findings can be generalised to a bigger population. Data analysis is faster by statistical software such as SPSS and Qualtrics. The disadvantages are that quantitative studies are not able to delve deeper to find and make meaning of behaviour and explanations. It cannot explain the arrangement of societal truth in terms of how humanity perceives the actions of itself and others. The variables used to study a phenomenon present a restricted view of a particular moment in time that might not present reality in context and totality. The quantitative approach omits the respondents' sense-making capabilities, meanings and experiences as it is conducted in highly supervised settings (Rahman, 2020).

3.2.2 The Qualitative approach

The qualitative approach follows the Constructivist perspective and an ethnographic design. This approach serves to explore and comprehend the meaning that society or individuals make out of societal drawbacks. Questions and data is collected from the respondents' environment; themes was drawn from the data by induction as the researcher attempts to decipher the significance of the data. Individual significance is paramount as is the intricacy of the societal drawbacks (John W Creswell, 2014).

The benefits of this design are: it details the feelings, experiences and opinions of respondents, assigns meaning to behaviour, and strives to understand behaviour based on settings. The voice, meanings and occasions are understood for the individual participants whilst also basing this on culture. The qualitative design is versatile in that it can be tailor-made by participants to suit what is in line with them. The disadvantages are that it can omit contextual responsiveness and be based on meaning and experiences, there is reduced reliability, and a small sample size prohibits generalisability and the interpretation of data is complicated (Rahman, 2020).

3.2.3 Mixed methods

The mixed method of research began in the late 1980s to 1990 in fields such as education, health Sciences, management and sociology (John W Creswell, Plano Clark, Gutmann, & Hanson, 2003). This complements the qualitative and quantitative methods of research. It blends in the qualitative and quantitative approaches together in a bid to limit prejudice that may be inherent in the two research forms in a single study. The mixed method facilitates an in-depth interpretation of the research question. The mixed method draws from the strengths of the two approaches to give a balanced view of the research question. The researcher has to carefully plan and coordinate the integration of each one of the approaches at crucial stages of the research process for there to be cohesion and to consolidate the results of the study (John W Creswell et al., 2003; Ivankova, Creswell, & Stick, 2006).

The benefits of the mixed method are that it can lead to meticulous and dependable designs. It presents an illustrative shaping of the study plan for the in-depth comprehension of the features of the plan, the sequential steps that were taken in data collection, and carefully blending in the two approaches and the data collected for the study. In the mixed method sequential explanatory design, quantitative (numeric) data is collected prior to qualitative (text) data. Qualitative data provides detailed information on the numeric data. Quantitative data and its analysis gives a broad interpretation of the research problem. Qualitative data gives a detailed perspective of the respondents using the numeric results (Ivankova et al., 2006).

3.2.4 Priority

The researcher must decide on the sequence of applying the two research approaches, that is, quantitative and qualitative. The decision on the type of data to collect first and which one last to answer the research question guided by the literature, data collection and the type of data to be collected (John W Creswell, 2014; Ivankova et al., 2006).

The benefits of the mixed methods design are that it blends in the qualitative and quantitative methods and caters for the shortcomings of either approach in data collection. This is because these approaches have shortcomings and when used together, they complement each other, counterbalance the shortcomings of any one method, and reinforce the study. In addition, social circumstances cannot be studied using one approach as they are complicated (J. W. Creswell, Clark, Gutmann, L., & Hanson, 2003).

3.3 Research Design

The convenient sample was used for this study as the methodological approach. The respondents were selected based on accessibility and convenience. This is a nonprobability sample (John W Creswell, 2014; Valerio et al., 2016). It is convenient to sample in this way, as this is an online survey. There are no restrictions by geographical location and the aim was to get access to education professionals, practitioners, and University of Witwatersrand School of Education

lecturers, final-year students, as they are practitioners in the education industry who use and have access to 4IR technologies.

A convenience sample costs less, is easier and labour saving to implement. The findings from the convenience sample cannot be generalised over a larger population and is subject to estimate bias (Andrade, 2021; Jager, Putnick, & Bornstein, 2017; Valerio et al., 2016).

3.3.1 Conceptual Framework

The literacy and numeracy rates have been declining not only in South Africa but worldwide. Literacy and numeracy skills that learners should have acquired in particular grades are lacking. The Progress in International Reading Literacy Study (PIRLS) evaluates the literacy skills of Grade 4s. The Trends in International Mathematics and Science Study (TIMSS) is used to evaluate the numeracy skills of leaners in Grade 4 and 8 with South Africa and a number of countries worldwide scoring low (Meeks, Kemp, & Stephenson, 2014) also referred to in Section 1.2. This affects the learners' academic journey as they progress from each class. The purpose of this study is to determine whether digital technologies are used to increase literacy and numeracy rates in primary and secondary schools in South Africa.

The dependent variables for this study are a high literacy rate and high numeracy rate. These are determined by the independent variables: access to technology, connectivity, income levels of educators and households, teaching methods and modes of teaching. The education level of educators, the DBE role and support in ICT are more variables that determine the effective use of ICT to improve literacy and numeracy rates (Meeks et al., 2014). These are the variables investigated in the study as part of the Learning Theory and Diffusion of Innovation Theory in Section 2.

Table 1: Conceptual Framework

Dependent Variable	Independent variables 4IR
1. High Literacy numeracy rates	Access to digital technology Teaching methods and mode (face-to-face, online, and hybrid) Connectivity/ Geographic /Spatial location Affordability/ Income levels Digital skills of educators/ Professional development Education levels of educators DBE role and support in 4IR Learner experiences/exposure to 4IR Infrastructure development
2. High Numeracy rates	Access to digital technology Teaching methods Connectivity/ Geographic /Spatial location Affordability/ Income levels Digital skills of educators/Professional development Education levels of educators DBE role and support in 4IR Learner experiences/ exposure to 4IR Infrastructure development

3.4 Population and sample

Professionals and practitioners in the education sector are the target population. These are from primary, secondary and tertiary institutions. The sampling method for the study is a convenience sample of Languages (official South African languages except for sign language) and Mathematics educational practitioners at public and private, online and bricks and mortar schools. Professionals in these sectors of education were sampled as they practise in the field, use and

implement ICT in South African schools and professionals (lecturers) and final-year students from the Faculty of Education at the University of Witwatersrand. A sample size of forty was chosen as the number of respondents to cater for non-response.

A convenience sample of educators in public and private schools was drawn and an online survey was administered through a Qualtrics link. The sample includes educators at different professional levels and provinces (Gauteng, Western Cape and Kwa-Zulu Natal).

Table 2: Profile of respondents

Description of respondent type, e.g. Manager, Union representative, student	**Number sampled**
Online school educators	11
Private school educators	6
Educators from public schools	9
Higher Education Faculty professionals (University of Witwatersrand)	0
Student/ Intern Teachers (University of Witwatersrand)	0

3.5 The research instrument

Data was collected by using a closed self-administered online questionnaire that was designed through Qualtrics. This was meant to enable the researcher to design the online questionnaire and email it to the respondents quickly. Qualtrics facilitates the collection of data, generation and processing of results by the researcher through an Excel spreadsheet. Objective questions for the quantitative approach were used (John W Creswell, 2014; Varela, Ruiz, Andrés, Roy, & Fusté, 2016).

The advantages of the online self-administered questionnaire are that it can be emailed quickly to save time and costs, reduces errors in data coding and entry, versatile ways of processing and a reduction of human inaccuracy in statistical interpretation. On the other hand, the disadvantages include a low response rate of online surveys, the rate of familiarity with the internet by respondents and internet access for remote areas and survey saturation for respondents who receive online questionnaires often (Carmen Varela et al., 2016).

Semantic Differential Scale

A seven (7) point Semantic Differential Scale was used for the online self-administered questionnaire to rate the extent to which the respondents felt about the questions from one extreme to another. The Semantic Differential Scale will facilitate the inclusion of subjective questions for the qualitative approach (Taherdoost, 2019).

3.6 Procedure for data collection

Data collection was conducted from 18 January 2023 to 11 February 2023 with the Qualtrics electronic survey questionnaire circulated via email and social media (Facebook Messenger, WhatsApp and LinkedIn) from educators in the public and private sector. The respondents were contacted via email and WhatsApp to send the link to the self- administered questionnaire. To mitigate against non-response, the researcher targeted and contacted forty-eight (48) educators in different provinces. Two educators did not respond to the emailed request to participate in the study, two had agreed to participate in the study but did not give final consent to receive the link. Six educators (6) did not respond to the request (sent via WhatsApp and follow-up calls) to participate in the study. Three (3) educators who were called to recommend South African official languages and Maths educators did not supply any respondents. One respondent received the link but did not complete the survey as he was a temporary educator who started teaching in January 2023.

Thirty-five (35) respondents received the Qualtrics link in total. Of the 35 respondents, 4 (11.4%) accessed Qualtrics but did not answer any questions

which is the non-response rate for Qualtrics. The respondent rate is 74.29% as 26 answered the online survey. Incomplete survey responses account for 20% as seven of the respondents did not attempt all questions. There are twenty-six (26) respondents for the study with with three (3) primary school educators (11.5%) and 23 secondary school educators (88.5%).

Despite being targeted as respondents for the study, the Witwatersrand School of Education lecturers and final-year students did not participate in the study. This is despite email requests sent to the Deputy Academic Registrar, two academics and an administrator in the School of Education.

3.7 Data analysis and interpretation

Data processing and analysis was conducted through the Statistical Package for the Social Sciences (SPSS) and Qualtrics. Editing, cleaning of data was first conducted in SPSS for non-responses and imported directly to SPSS. Data was be downloaded to Microsoft Excel to clean and edit and compare the SPSS version with the Microsoft Excel version.

Regression enables the researcher to make connections between variables to determine how one (dependent) relies on others (independent variables). Regression is based on four key components; association, variables, explanation and prediction. This is linear regression. Multiple regression studies the effect of a number of variables (dependent) on a number of independent variables (G. J. Lee).

Descriptive statistics for (descriptive questions) these are the measures of central tendency (mean median and mode), spread and the distribution of variables. Spread, standard deviation and inter-quartile range variable distribution statistics were used with descriptive SPSS tables (John W Creswell, 2014; G. J. Lee).

Data Analysis

Step 1: Descriptive statistics

The descriptive statistics used for the continuous data are: (1) frequencies, (2) percentage (%), and (3) the mean.

The Cronbach Alpha was used for multi-item scale in internal reliability. Internal reliability measures the items that group together to assess a construct. The lowest value of Cronbach alpha must be 0.65 and 0.80 the highest value (G.J. Lee, 2021).

Step 2: Determine sample error in relation to confidence intervals

A convenience sample was drawn therefore, sampling error is not applicable as the confidence levels for such a sample cannot be determined.

Step 3: Data transformation for analysis

Each multi-selection variable was recoded by combining the selection options into a new variable where each instance of selection was represented by a value=1. The combined variable was used to generate frequencies, cross-tabulations and regression analysis. For regression analysis, the combined variable was a sum of each respondents' selections across the different options.

Step 4: Linear Regression for continuous data with two variables that are dependent and independent.

Dependent and independent variables were used for the continuous data as extremely dissatisfied= (1) and extremely satisfied= (7). Linear regression was conducted on the specified variables and R–square which is a value between -1 and 1. An R–square value of -1 signifies a perfectly negative correlation between variables, 1 a perfectly positive relation and 0 that there is no relationship between the variables (G.J. Lee, 2021).

F-values:

The ANOVA F-figure is an official statistical significance assessment of fit. It is used to assess the precision of The R–square. It is used to asses data fit to the straight line: 0.05 or 0.01.

p-values

A p-value lower than 0.05 indicates that the data fits the straight line or is significant. If the p-value is less than 0.05 or 0.01, we often attribute statistical significance to the result. If the p-value is 0.05 then the null hypothesis (H0) can be rejected.

Step 5: Treatment of missing data from online survey responses

On Qualtrics, for four (4) respondents that accessed the online survey questionnaire but did not attempt any questions, the responses were deleted and treated as non-responses. No imputation was effected on missing data values.

3.8 Limitations of the study

- The study is limited to educational professionals at primary and secondary school.
- Educators were sampled conveniently from different provinces based on consent and availability.
- The views, opinions and attitudes of educational professionals might be different provincially or nationally.
- A convenience sample cannot be generalised to a larger population.

3.9 Validity and reliability

Validity consists of the following elements; content, predictive and concurrent and construct. Content validity assesses if the content from the items on the questionnaire fulfil their intended purpose. Predictive and concurrent validity assesses the scores to ascertain if the scores are in agreement with the criterion measure and to determine if there is a correlation with the results and construct

validity focusses on the measurement of hypothetical constructs or concepts (John W Creswell, 2014).

The Semantic Differential Scale is the most reliable measure as it it easy to develop and user friendly for the respondents. However, it lacks validity because respondents tend to avoid responses that can present them in a negative light. Validity for Semantic Differential scales is achieved by using scales that have six or more response categories. (Taherdoost, 2019).

3.9.1 External validity

Using Semantic Differential Scale ensures validity even though it can be compromised if respondents do not select responses that may present them negatively. There can be an element of bias in the selection of responses (Taherdoost, 2019).

3.9.2 Internal validity

Internal validity refers to the risks involved pertaining to the procedures of conducting the experiment. These include the treatments, incidents in the lives of the respondents, the history, selection, maturation, mortality and regression of respondents, as they are not static but dynamic individuals who can undergo changes during the course of the experiment. The researcher can also influence the experiment by interfering with the processes through diffusion, being receptive or dismissive towards respondents and interference with the testing tool (John W Creswell, 2014). For the purpose of this study these threats to validity will be minimised by interacting with the respondents via email to send the link to the self- administered questionnaire and collecting data within a month and only calling respondents minimally for follow up calls if really necessary.

3.9.3 Reliability

This is a measure of internal consistency; that is to assess if the responses are compatible with constructs and if the questionnaire would yield the same scores if re-administered and to assess the cause of errors which can be based on

administration and scoring (John W Creswell, 2014; Johnson, Yang, & Reed, 2019).

The seven (7) point Semantic Differential scale enables the researcher to device the most reliable scale as it is easy to develop and user friendly for the respondents (Taherdoost, 2019).

3.10 Conclusion

The mixed method (qualitative and quantitative) approach was used for the study as the opinions beliefs, attitudes and other relevant information were sought from respondents on the effective use of 4IR technologies for literacy and numeracy in primary and secondary education. The positivist approach was used as the internal and external views of survey participants were sought by the researcher. The education professionals experience these behavioural patterns as they use digital technologies for literacy and numeracy. A seven (7) point Semantic Differential scale was used assess the exactness of the Qualtrics online survey responses of 26 education professionals that were analysed in frequencies, percentages, means and regression.

4 RESULTS

This section is a presentation of the results as set according to the research questions and the sub-problems. A narrative of the highlights of the research results is presented without interpretation from the online Qualtrics survey.

4.1 Respondents' profile

The tables and information below are a presentation of the respondents' demographics. In Table 3, twenty respondents are female which accounts for 76.92% and 6 male respondents that is 23.08%.

Table 3: Sex

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	6	23.08	23.08	23.08
	Female	20	76.92	76.92	100.00
	Total	26	100.00	100.00	

In Table 4, the age of the respondents ranges 25-34 and 65- 74. 38.46% of the respondents are in the age range 35-44, 30.77% from 25-34 and 3.85% respondents in the 65-74 age range.

Table 4: Age

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25 - 34	8	30.77	30.77	30.77
	35 - 44	10	38.46	38.46	69.23
	45 - 54	5	19.23	19.23	88.46
	55 - 64	2	7.69	7.69	96.15
	65 - 74	1	3.85	3.85	100.00
	Total	26	100.00	100.00	

Table 5 is a presentation of the levels of education of the respondents. Honours Degree respondents make up 50%, Undergraduate Degree 19.23% and Masters' Degree 7.96%.

Table 5: Highest Level of education

Highest level of education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Diploma	2	7.69	7.69	7.7
	Undergraduate Degree	5	19.23	19.23	26.9
	Post Graduate Diploma/Certificate	4	15.38	15.38	42.3
	Honours Degree	13	50.00	50.00	92.3
	Master's Degree	2	7.69	7.69	100.0
	Total	26	100.00	100.00	

In Table 6, the annual income levels of the respondents are as follows: 26.92% earn between R 153 601- R 307 200, 15.38% earn between 307 201-614 400 and 3.85% between 4801- R 9 600 per annum.

Table 6: Annual Income Levels

Annual Income Levels

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	R 4801-R 9600	1	3.85	3.85	3.85
	R 9601-R19 200	4	15.38	15.38	19.23
	R 19 201- R 38 400	7	26.92	26.92	46.15
	R76 801- R153 600	3	11.54	11.54	57.69
	R 153 601- R 307 200	7	26.92	26.92	84.62
	R 307 201- R 614 400	4	15.38	15.38	100.00
	Total	26	100.00	100.00	

In Table 7, secondary/ high school educators account for 84.62%, primary school educators 11.54% and other 3.85% for occupation as presented.

Table: 7 Occupation

Occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secondary/ High School Educator	22	84.62	84.62	84.62
	Primary School Educator	3	11.54	11.54	96.15
	Other	1	3.85	3.85	100.00
	Total	26	100.00	100.00	

Table 8 presents the mode of teaching by the education professionals. Respondents that use face-to-face as a mode of teaching have a value of 53.85%, Online 30.77%, and 15.38% did not make a selection (other modes were hybrid and other).

Table 8: Mode of Teaching

Mode of education

	N	%
Face-to-face	14	53.85%
Online	8	30.77%
Missing System	4	15.38%

4.2 Results for Sub-problem 1

4.2.1 DBE role and support

In Table 9, four questions/ items on satisfaction with Rollout of 4IR Technologies by the DBE, Policies on the rollout of 4IR Technology by the DBE, Technical support on 4IR Technologies by the DBE and the Development of e-resources by the DBE were converted to a construct called DBE Role for implementing digital technologies in education. The measure of reliability, the Cronbach Alpha of 0.95 for the questions indicates that they are closely related in assessing the role of the DBE in ensuring and facilitating the rollout of 4IR nationally. The construct DBE_Role was added as a variable in the data.

Table 9: DBE Role Reliability

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.95	.95	4

In Table 10, the construct was scored using an average (Item Means) which recommended in for the Semantic Differential Scale of 1-7 (G.J. Lee, 2021) to determine the overall outcome as shown below. The mean of 3.57 on a Semantic Differential Scale of 1-7 corresponds to an overall score of 4= neither satisfied nor dissatisfied with the role of the DBE in rolling out 4IR, policies on the rollout, technical support on, the development of e-resources for 4IR.

Table 10 DBE Role Item Statistics

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.57	3.27	3.73	.45	1.14	.04	4

In Table 11, four questions/ items on the rating of training, connectivity, interactive media for literacy and numeracy were converted to a construct called DBE Support for implementing digital technologies in education. The measure of reliability, the Cronbach Alpha of 0.89 for the questions indicates that they are closely related in assessing the Support Services of the DBE in ensuring and facilitating the rollout of 4IR nationally. The construct DBE_Support_Services was added as a variable in the data.

Table 11 DBE Support Reliability

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.89	.90	4

In Table 12, the construct was scored using an average (Item Means) which recommended in for the Semantic Differential Scale of 1-7 (G.J. Lee, 2021) to determine the overall outcome as shown below. The mean of 4.18 on a Semantic Differential Scale of 1-7 corresponds to an overall score of 4= neither satisfied nor dissatisfied with the Support Services of the DBE in providing training, connectivity and interactive media for literacy and numeracy for 4IR.

Table 12: DBE Support Item Statistics

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.18	3.95	4.65	.70	1.18	.103	4

Figure 3, on the services that the DBE should offer to improve the digital needs of education, 15.87% of the respondents opted for the offering of Free Online Training Packages, 14.29% for the provision of digital devices and 14.29% for Teacher Development Centres within schools. The respondents also cited Subsidised Online Packages by 7.94% and Other Services at 4.76%.

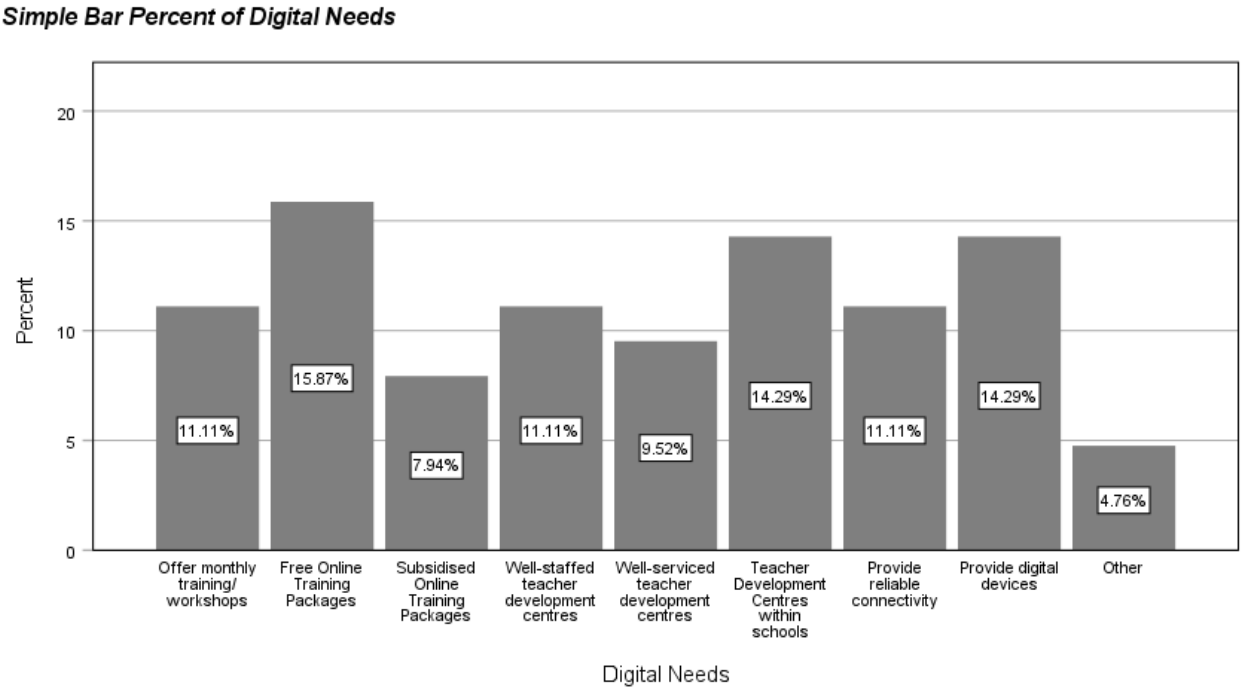


Figure 3: Digital Needs of education professionals

In Figure 4, on the respondents' awareness of DBE ICT Projects, 28.75% of the respondents were aware of the Resourced Teacher Centres and Professional Development, School Connectivity-Rural versus Urban 21.43%, Operation Phakisa and the Universal Service and Access Obligation (USAO) 7.14%. None

of the respondents were aware of the Broadband Project and 28.57% were aware of other ICT projects.

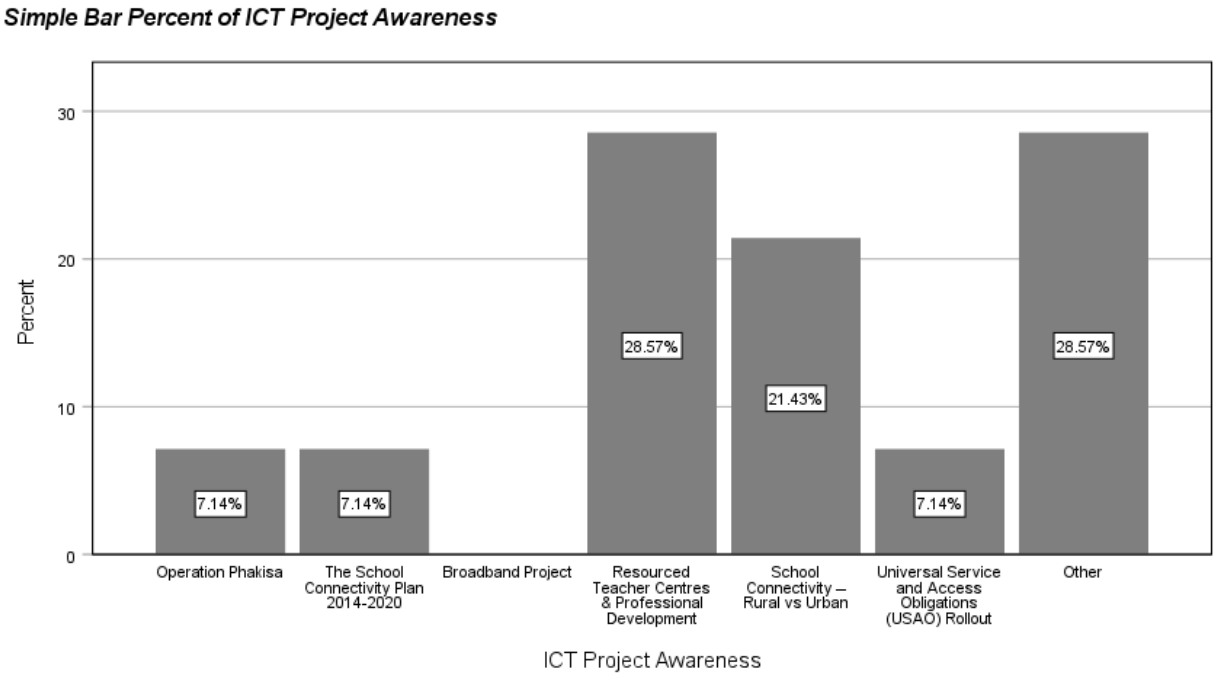


Figure 4: of Education ICT Project Awareness by education professionals

Table 13 shows correlations on whether the respondents had read the DBE Draft White Paper 2004 with DBE Role and Support. There is a weak inverse relationship of -0.29 and 0.26 between the respondents reading of the DBE White Paper 2004 and their views on the role of the DBE and its support of educational professionals respectively. There is a moderate and positive correlation of 0.63 between the DBE's role and its provision of support to educational professionals.

Table 13 DBE Draft White 2004 correlations with DBE Role and DBE Support

Correlations

		Draft White Paper on e-Education of 2004	DBE role	DBE support
Draft White Paper on e-Education of 2004	Pearson Correlation	1.00	-.29	-.26
	Sig. (2-tailed)		.19	.24
	N	22.00	22.00	22.00
DBE role	Pearson Correlation	-.29	1.00	.63**
	Sig. (2-tailed)	.19		.00
	N	22.00	23.00	22.00
DBE support	Pearson Correlation	-.26	.63**	1.00
	Sig. (2-tailed)	.24	.00	
	N	22.00	22.00	22.00

**. Correlation is significant at the 0.01 level (2-tailed).

In Table 14, Computer Laboratories, Connectivity, Teacher Development Centres and Maintenance of 4IR infrastructure were considered to be the most crucial infrastructure development areas for 4IR by the respondents with a value of 14.74% respectively. The Security of 4IR infrastructure and Educators' digital skills scored a value of 13. 68%. Other infrastructure development areas had a value of 2.11%.

Table 14: Infrastructure Development Areas for Public Schools

$Development Areas Public Frequencies

		Responses		Percent of Cases
		N	Percent	
Infrastructure Development Areas[a]	Computer Laboratories	14	14.74%	77.8%
	Connectivity	14	14.74%	77.78%
	Teacher Development Centres	14	14.74%	77.78%
	Maintenance of 4IR infrastructure	14	14.74%	77.78%
	Security of 4IR infrastructure	13	13.68%	72.22%
	Educator's digital skills	13	13.68%	72.22%
	Reliable Electricity Supply	11	11.58%	61.11%
	Other	2	2.11%	11.11%
Total		95	100.00%	527.78%

a. Dichotomy group tabulated at value 1.

Table 15 on what the respondents consider to be the most crucial infrastructure development areas in private schools for 4IR, the most crucial are Computer Laboratories and Reliable Electricity Supply with a value of 16.67% of all responses, Connectivity 15% of all responses, Teacher Development Centres 10% of all responses. Other infrastructure development areas are considered the most crucial with a value of 3.33%.

Table 15: Infrastructure Development Areas for Private Schools

$Development Areas Private Frequencies

		Responses		
		N	Percent	Percent of Cases
Development Areas Private[a]	Computer Laboratories	10	16.67%	71.43%
	Connectivity	9	15.00%	64.29%
	Teacher Development Centres	6	10.00%	42.86%
	Maintenance of 4IR infrastructure	8	13.33%	57.14%
	Security of 4IR infrastructure	8	13.33%	57.14%
	Educator's digital skills	7	11.67%	50.00%
	Reliable Electricity Supply	10	16.67%	71.43%
	Other	2	3.33%	14.29%
Total		60	100.00 %	428.57%

a. Dichotomy group tabulated at value 1.

Table 16 on what the respondents consider to be the most crucial the human resource development areas in public and private schools for digital technologies, the most crucial are Workforce and employment empowerment targets, Digital Training Fees/ Sponsors and Job satisfaction with a value of 15.12% of all responses respectively. Incentives are considered to be the most crucial at 10.47%. Other human resource development areas at 4.65% and none at 1.16%.

Table 16: Human Resource Development Areas for Public and Private Schools

Human Resource Development Frequencies

		Responses		Percent
		N	Percent	of Cases
Human Resource Development[a]	Workforce and employment empowerment targets	13	15.12%	68.42%
	Digital skills	12	13.95%	63.16%
	Digital Training Fees/ Sponsors	13	15.12%	68.42%
	Talent management/career progression/succession plan	10	11.63%	52.63%
	Incentives/ rewards	9	10.47%	47.37%
	Staff turnover	11	12.79%	57.89%
	Job satisfaction	13	15.12%	68.42%
	Other	4	4.65%	21.05%
	None	1	1.16%	5.26%
Total		86	100.00%	452.63%

a. Dichotomy group tabulated at value 1.

Table 17 indicates that the most dominant factor is Cost of Technology at 23.08% followed by Policies in ICT at 19.23% and Funding from National Treasury at 15.38%. Other factors have the lowest rating of 3.85%.

Table 17: Factors of Digital Transformation

Factors of digital transformation in primary

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Income	1	3.85	4.76	4.76
	Cost of education	3	11.54	14.29	19.05
	Cost of technology	6	23.08	28.57	47.62
	Feeder areas	1	3.85	4.76	52.38
	Policies in ICT Education	5	19.23	23.81	76.19
	Funding from National Treasury	4	15.38	19.05	95.24
	Other	1	3.85	4.76	100.00
	Total	21	80.77	100.00	
Missing	System				
Total					

Table 18, 19 and 20 show whether the dependent variable, that is, the most crucial Factors of digital transformation in primary and secondary schools, is explained by the independent variables Access to technological devices, Annual Income Levels, Sex, Occupation, Age, Highest level of education. The regression model has an R–square of 0.29 which indicates that 29% of the variance of the dependent variable is explained by the regression line. The F–statistic of 0.90 and the p-value of 0.52 (greater than 0.05) show lack of statistical significance and that the straight line does not fit the data sufficiently. The regression coefficient (Beta) for sex is 0.45 with a p-value of 0.10 and sex is more correlated with the factors of digital transformation. The Highest level of education has the smallest regression coefficient of 0.06 and a p–value of 0.87. Removing the less significant predictor variables may improve the model's p–value but does not guarantee that it will fall below 0.05.

Table 18: Model Summary of Factors of Digital Transformation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.54[a]	.29	-.03	1.74

a. Predictors: (Constant), Access to technological devices, Annual Income Levels, Sex, Occupation, Age, Highest level of education

Table 19: F-Statistic of Factors of Digital Transformation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.38	6.00	2.73	.90	.52[b]
	Residual	39.42	13.00	3.03		
	Total	55.80	19.00			

a. Dependent Variable: Factors of digital transformation in primary and secondary schools

b. Predictors: (Constant), Access to technological devices, Annual Income Levels, Sex, Occupation, Age, Highest level of education

Table 20: Regression Coefficients of Factors of Digital Transformation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.09	6.74		.16	.87
	Sex	1.89	1.08	.45	1.76	.10
	Age	-.29	.45	-.19	-.64	.53
	Highest level of education	.09	.53	.06	.16	.87
	Annual Income Levels	-.11	.22	-.12	-.50	.62
	Occupation	1.30	1.85	.23	.70	.50
	Access to technological devices	-.48	.57	-.26	-.84	.42

a. Dependent Variable: Factors of digital transformation in primary

4.2.2 Literacy and numeracy

Table 21, 22 and 23, on the dependent variable, OutputsLanguages (educational outputs in which interactive media improves literacy) in primary and secondary schools, is explained by the constructed independent variables AppsLanguages (Applications used to teach languages) and LiteracyInteractiveMedia (Interactive Media for literacy). The R–square of 0.27, indicates that 27% of the variance of the dependent variable is explained by the regression line. The F–statistic of 3.18 and the p-value of 0.07 (greater than 0.05) show lack of statistical significance and that the straight line does not fit the data sufficiently. The regression coefficient (Beta) for AppsLanguages is 0.37 with a p-value of 0.11 and it is more correlated with the OutputsLanguages. LiteracyInteractiveMedia has the smallest regression coefficient of 0.27 and a p–value of 0.23.

Table 21: Model Summary of Literacy and digital technologies

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.52[a]	.27	.19	2.64

a. Predictors: (Constant), AppsLanguages, LiteracyInteractiveMedia

Table 22: F-Statistic of Literacy and digital technologies

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	44.15	2	22.07	3.18	.07[b]
	Residual	118.05	17	6.94		
	Total	162.20	19			

a. Dependent Variable: OutputsLanguages

b. Predictors: (Constant), AppsLanguages, LiteracyInteractiveMedia

Table 23: Coefficients for Literacy and digital technologies

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.19	1.19		1.84	.08
	LiteracyInteractiveMedia	.29	.23	.27	1.26	.23
	AppsLanguages	.87	.51	.37	1.68	.11

a. Dependent Variable: OutputsLanguages

Table 24, 25 and 26 on the dependent variable OutputsMaths (educational outputs in which interactive media improves numeracy) is explained by the constructed independent variables AppsMaths (Applications used to teach Maths) and NumeracyInteractiveMedia (Interactive Media for numeracy). In

Table 24, the R–square of 0.11, indicates that 11% of the variance of the dependent variable is explained by the regression line. The F–statistic of 0.64 and the p-value of 0.55 (greater than 0.05) show lack of statistical significance and that the straight line does not fit the data sufficiently. The regression coefficient (Beta) for NumeracyInteractiveMedia is 0.24 with a p-value of 0.56 and it is more correlated with the OutputsMaths. AppsMaths has the smallest regression coefficient of 0.13 and a p–value of 0.75.

Table 24: Model Summary of Numeracy and digital technologies

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.34[a]	.11	-.06	2.90

a. Predictors: (Constant), AppsMaths, NumeracyInteractiveMedia

Table 25: F-Statistic of Numeracy and digital technologies

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.82	2	5.41	.64	.55[b]
	Residual	84.10	10	8.41		
	Total	94.92	12			

a. Dependent Variable: OutputsMaths

b. Predictors: (Constant), AppsMaths, NumeracyInteractiveMedia

Table 26 Coefficients for Numeracy and digital technologies

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.79	1.40		1.99	.07
	NumeracyInteractiveMedia	.28	.47	.24	.60	.56
	AppsMaths	.26	.81	.13	.32	.75

a. Dependent Variable: OutputsMaths

4.3 Results for Sub-problem 2

Table 27 on the frequency of training of education professionals on digital technologies shows that 53.85% of the respondents received training sometimes, 15.38% about half the time and 7.69% never received training.

Table 27: Training Frequency of Education Professionals

Training frequency

	N	%
Never	2	7.69%
Sometimes	14	53.85%
About half the time	4	15.38%
Most of the time	2	7.69%
Always	1	3.85%
Missing System	3	11.54%

Hypothesis 1

Table 28, 29 and 30, on the dependent variable GeoLocation (the GPS location of the respondents as captured on Qualtrics which will also be used as a proxy for affluence), is explained by the constructed independent variables OutputsLanguages (educational outputs in which interactive media improves literacy), OutputsMaths (educational outputs in which interactive media improves numeracy). The R–square of 0.27, which indicates that 27% of the variance of

the dependent variable is explained by the regression line. The F–statistic of 0.76 and the p-value of 0.56 (greater than 0.05) show lack of statistical significance and that the straight line does not fit the data sufficiently. The regression coefficient (Beta) for TechLearnerBehaviour (technologies influencing learners' behaviour) is -0.59 with a p-value of 0.24 and it is most correlated with the GeoLocation. OutputsLanguages has the smallest regression coefficient of -0.10 and a p–value of 0.82. The model's p-value of 0.56 is greater than 0.05, therefore, we fail to reject the null hypothesis.

Table 28: Model Summary GeoLocation, Literacy and Numeracy Levels

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.52[a]	.27	-.09	.59

a. Predictors: (Constant), TechLearnerBehaviour, OutputsLanguages, OutputsMaths

Table 29: F- Statistic for GeoLocation, Literacy and Numeracy Levels

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.80	3	.27	.76	.56[b]
	Residual	2.11	6	.35		
	Total					

a. Dependent Variable: GeoLocation

b. Predictors: (Constant), TechLearnerBehaviour, OutputsLanguages, OutputsMaths

Table 30: Coefficients GeoLocation, Literacy and Numeracy Levels

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.27	.46		4.90	.00
	OutputsLanguages	-.02	.09	-.10	-.24	.82
	OutputsMaths	.05	.12	.20	.41	.70
	TechLearnerBehaviour	-.12	.09	-.59	-1.29	.24

a. Dependent Variable: GeoLocation

Hypothesis 2

Table 31, 32 and 33, on the dependent variable GeoLocation (the GPS location of the respondents as captured on Qualtrics), is explained by the constructed independent variables SkillsTraining (digital skills received from digital training), TechMaths (digital technologies training for Maths), TechLanguages (digital technologies training for Languages) and TechTraining (additional digital training on overall school digital technologies). The R–square of 0.94, which indicates that 94% of the variance of the dependent variable is explained by the regression line. The F–statistic of 3.70 and the p-value of 0.37 (greater than 0.05) show lack of statistical significance and that the straight line does not fit the data sufficiently. The regression coefficient (Beta) for TechMaths is 0.69 with a p-value of 0.29 and it is most correlated with the GeoLocation. TechTraining has the second highest Beta of -0.64 and a p–value of 0.48. TechLanguages has the smallest regression coefficient of 0.27 and a p–value of 0.58. The model's p-value is 0.37 is greater than 0.05, therefore, we fail to reject the null hypothesis.

Table 31: Model Summary on the GeoLocation and Upskilling of Education Professionals

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.97[a]	.94	.68	3.92

a. Predictors: (Constant), SkillsTraining, TechMaths, TechLanguages, TechTraining

Table 32: F-Statistic on the GeoLocation and Upskilling of Education Professionals

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	227.86	4	56.96	3.70	.37[b]
	Residual	15.39	1	15.39		
	Total					

a. Dependent Variable: GeoLocation

b. Predictors: (Constant), SkillsTraining, TechMaths, TechLanguages, TechTraining

Table 33: Coefficients for the GeoLocation and Upskilling of Education Professionals

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-6.35	5.83		-1.09	.47
	SkillsTraining	-1.52	1.96	-.49	-.78	.58
	TechTraining	-1.89	1.76	-.64	-1.07	.48
	TechMaths	9.34	4.64	.69	2.01	.29
	TechLanguages	4.67	6.10	.27	.77	.58

a. Dependent Variable: GeoLocation

Hypothesis 3

Table 34, 35 and 36, on the dependent variable SkillsTraining (digital skills received from digital training), is explained by the constructed independent variables OutputsLanguages (educational outputs in which interactive media improves literacy), OutputsMaths (educational outputs in which interactive media improves numeracy). The R–square of 0.82, which indicates that 82% of the variance of the dependent variable is explained by the regression line. The F–statistic of 10.30 and the p-value of 0.01 (less than 0.05) shows statistical significance and that the straight line fits the data sufficiently. The regression coefficient (Beta) for TechLearnerBehaviour is 0.84 with a p-value of 0.01 and it is most correlated with the SkillsTraining. OutputsLanguages has the smallest regression coefficient of -0.08 and a p–value of 0.71. The model's p-value is 0.01 is less than 0.05, therefore, we reject the null hypothesis and accept the alternative hypothesis.

Table 34: Model Education professionals' digital skills and literacy and numeracy

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.90[a]	.82	.74	1.10

a. Predictors: (Constant), TechLearnerBehaviour, OutputsLanguages, OutputsMaths

Table 35: F-Statistic Education professionals' digital skills and literacy and numeracy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	37.66	3	12.55	10.30	.01[b]
	Residual	8.53	7	1.22		
	Total					

a. Dependent Variable: SkillsTraining

b. Predictors: (Constant), TechLearnerBehaviour, OutputsLanguages, OutputsMaths

Table 36: Coefficients Education professionals' digital skills and literacy and numeracy

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.31	.85		.36	.73
	OutputsLanguages	-.06	.16	-.08	-.38	.71
	OutputsMaths	.14	.22	.15	.64	.54
	TechLearnerBehaviour	.65	.17	.84	3.87	.01

a. Dependent Variable: SkillsTraining

4.4 Conclusion

The results of the regression analysis indicate that the small sample may be responsible for high R–square values with p–values that are not statistically significant. The respondents are neither satisfied nor dissatisfied with the DBE role and support in crafting and implanting ICT policies and providing technical support to educational professionals. There is no relationship between GeoLocation, Literacy and Numeracy Levels and there is also no relationship between GeoLocation and upskilling of educational professionals. There is a relationship between digital skills training, literacy, numeracy and technological learner behaviour.

5 DISCUSSION OF THE RESULTS

5.1 Discussion of the main research problem

The main problem statement centres on the inequalities that exist in South Africa that perpetuate the digital divide in the use of 4IR technologies which must be used to enhance the literacy and numeracy rates in the country. The main problem will be answered through a discussion of the results for sub-problem 1 and 2.

5.1.1 Discussion of sub-problem 1

The results indicate that education professionals are neither satisfied nor dissatisfied with the role and technical support provided by the DBE in rolling out digital technologies nationally. The three most dominant factors of digital transformation are Cost of Technology, DBE Policies in ICT and Funding from National Treasury. The applications for teaching languages are more correlated to the literacy levels than the interactive media while, for teaching Mathematics the interactive media is more correlated to the numeracy levels than the applications. The top three digital needs identified by education professionals are Free Online Training Packages, Teacher Development Centres and the provision of digital devices. The respondents are aware of Resourced Teacher Centres and Professional Development and Other respectively, School Connectivity. None of the respondents are aware of the Broadband Project. The high cost of technology, obscure ICT policies in education and inadequate funding make it difficult for the digital needs of education professionals and learners to be met. Inadequate resources and ICT infrastructure have a negative effect on literacy and numeracy levels which may explain the declining rates presented in the PIRLS (Howie et al., 2016) reports on literacy and TIMMS (Davids, 2019) reports on numeracy .

The Systems Theory(Von Bertalanffy, 1972) clarifies how parts of a whole work together for overall achievement. For the DBE it is evident that there are parts of

the ICT in education initiative that have to be aligned for maximum effectiveness (Kekana, 2018).

5.1.2 Discussion of sub-problem 2

The sample does not provide enough evidence to conclude on the absence of a relationship between literacy, numeracy levels and GeoLocation (used as a proxy for affluence). The sample also does not provide enough evidence to conclude on the absence of a relationship between upskilling initiatives and GeoLocation (used as a proxy for affluence). There is enough evidence in the data to conclude that there is a relationship between literacy, numeracy levels and the digital skills of education professionals. The frequency of training for education professionals on digital technologies is inadequate as most do not receive regular training. The results suggest that there is a gap in the frequency of training which has a negative effect on the digital skills of education professionals. This may be linked to the declining literacy and numeracy levels which are reflected in the PIRLS (Howie et al., 2020) reports on literacy and TIMMS (Davids, 2019) reports on numeracy. Operation Phakisa as an ICT education initiative needs to be fast tracked as the education professionals and learners in the schools that are waiting to be connected digitally lag behind (Kekana, 2018; Maboya, 2018).

It is evident from the results that the experience and access to digital technologies influences the views of education professionals on the role of the DBE and its provision of technical support. It can be deduced that the experiences and views of the education professionals mirror those of the learners taking into account affluence which is reflected through geographical location. Upskilling educators for digital technologies is important for imparting knowledge and information (G.F. Mukwawaya, B. Emwanu, & S. Mdakane, 2018; Salmon, 2019b).

The findings of this study are in accordance to research conducted by other authors (Howie, Combrinck, Mokoena, Tshele, & Roux, 2022; Huk, 2021b; G.F. Mukwawaya et al., 2018; Salmon, 2019b) that in the advent of Education 4.0, the DBE ICT policies and initiatives have to be in line with the demands of the technological advancing world to meet the needs of educators ad learners.

The DBE requires support from other government departments to implement ICT policies and initiatives efficiently, especially funding. The cost of ICT infrastructure as a determinant for the successful implementation and use of digital technologies in education and to bridge the digital divide (Chetty et al., 2018; Gerber & Eybers, 2021; Mwapwele, Marais, Dlamini, & Van Biljon, 2019).

The digital skills and the teaching methods of educators have to adapt to the changing educational landscape. The upskilling of education professionals to meet the requirements and technological abilities of Generation Z and the job market. Upskilling educators for Education 4.0 can have positive influence on the literacy and numeracy rates according to other authors. (Aziz Hussin, 2018; de S. Oliveira & de Souza, 2022; Gerber & Eybers, 2021; R. Nandhakumar, 2019).

6 CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents conclusions on the research investigation on the role of digital technologies in the rate of literacy and numeracy. Potential implications for education scholars and practitioners are explained with suggestions for future research.

6.2 Summary of the Literature

Digital technologies have the potential to advance the education sector in the 21st Century. Applications, interactive media and virtual learning enables educators to transition from traditional, face-to-face geographically bound classes to versatile classrooms. Education professionals and students must embrace Education 4.0 as it facilitates customised learning anytime and anyplace. For digital technologies to succeed, the digital skills of education professionals and learners have to be improved through training and practical application. Educators have to be equipped to teach Generation-Z learners who adopt technological devices quickly. Content based lessons where the teacher is the only source of information do not fit this generation of technologically inclined multi-taskers. The inclination to use digital technologies by Generation-Z can be used to improve the literacy and numeracy rates.

6.3 Summary of Results

Collected data was analysed using descriptive statistics. Convenience sampling is subjective and the results cannot be generalised to a larger population.

6.3.1 Descriptive Data Analysis

A sample of 26 respondents was drawn from conveniently available educators. Twenty, 76.92% of the respondents are females and six, 23.08% are males.

Females have a figure of 76.92 % compared to 23.08% males. Respondents between the age of 35-44 have a figure of 38.46% which is the highest age group and the average age of a teacher in South Africa is 43 years which is dominated by Generation X who are still youthful to adopt digital technologies though there can be some resistance (Development, 2019; R. Nandhakumar, 2019).

6.3.2 Regression Analysis

The regression model's p-value of 0.52 (greater than 0.05) shows lack of statistical significance in the relationship between selected factors of digital transformation in primary and secondary schools. This indicates that the independent variables Access to technological devices, Annual Income Levels, Sex, Occupation, Age, Highest level of education are not good predictors of the factors of digital transformation.

The regression model's p-value of 0.07 (greater than 0.05) shows lack of statistical significance in the relationship between OutputsLanguages (educational outputs in which interactive media improves literacy) in primary and secondary schools. This indicates that the independent variables AppsLanguages (Applications used to teach languages) and LiteracyInteractiveMedia (Interactive Media for literacy) are not good predictors of the OutputsLanguages (educational outputs in which interactive media improves literacy).

The regression model's p-value of 0.55 (greater than 0.05) shows lack of statistical significance in the relationship between OutputsMaths (educational outputs in which interactive media improves numeracy) in primary and secondary schools. This indicates that the independent variables AppsMaths (Applications used to teach Maths) and NumeracyInteractiveMedia (Interactive Media for numeracy) are not good predictors of the OutputsMaths (educational outputs in which interactive media improves numeracy).

Hypothesis 1

The regression model's p-value of 0.56 (greater than 0.05) shows lack of statistical significance in the relationship between GeoLocation (the GPS location of the respondents as captured on Qualtrics which will also be used as a proxy for affluence) in primary and secondary schools. This indicates that the independent variables OutputsLanguages (educational outputs in which interactive media improves literacy), OutputsMaths (educational outputs in which interactive media improves numeracy) are not good predictors of the GeoLocation (the GPS location of the respondents as captured on Qualtrics which will also be used as a proxy for affluence). There is no relationship between literacy and numeracy levels with affluence.

Hypothesis 2

The regression model's p-value of 0.56 (greater than 0.05) shows lack of statistical significance in the relationship between GeoLocation (the GPS location of the respondents as captured on Qualtrics which will also be used as a proxy for affluence) in primary and secondary schools. This indicates that the independent variables SkillsTraining (digital skills received from digital training), TechMaths (digital technologies training for Maths), TechLanguages (digital technologies training for Languages) and TechTraining (additional digital training on overall school digital technologies) are not good predictors of the GeoLocation (the GPS location of the respondents as captured on Qualtrics which will also be used as a proxy for affluence). There is no relationship between the geo-location of education professionals and upskilling initiatives.

Hypothesis 3

The regression model's p-value of 0.01 (less than 0.05) shows statistical significance in the relationship between SkillsTraining (digital skills received from digital training). This indicates that the independent variables OutputsLanguages (educational outputs in which interactive media improves literacy), OutputsMaths (educational outputs in which interactive media improves numeracy) are good predictors of SkillsTraining (digital skills received from digital training). There is a

relationship between the digital skills of education professionals and literacy and numeracy levels.

6.4 Recommendations

6.4.1 Implications for the Department of Basic Education (DBE)

The DBE must continue to be strategic and systematic in ensuring that education practitioners are empowered to implement digital technologies in education regardless of geographic location, cost and affluence evident in Sections 2.2 and 2.3. The DBE should provide training programs on digital skills, bursaries and scholarships for education professionals who enrol in tertiary institutions for further training on digital skills. The DBE should improve the incentives on the recognition of further training as part of remuneration for education professionals who upgrade their digital skills. Partnerships with tertiary institutions through the Department of Higher Education and Training (DHET) should be ongoing to ensure that teacher training institutions produce new educators who are fully functional to implement Education 4.0. Data science skills for educators to interpret dashboards for monitoring academic and administrative information have to be pursued actively by the DBE.

The DBE policies on ICT must be rolled out effectively and uniformly for all educators and be reviewed to cater for the post-Covid 19 environment and the fast-paced evolution of digital technologies.

Infrastructure development for education professionals and learners through telecommunications stakeholders such as MTN, Vodacom, Telkom and other mobile operators. Off-the-shelf software for standardisation purposes in schools for learners and education professionals through proper governance to bridge the digital divide should be enforced by the DBE. School administration infrastructure should be upgraded to be compatible with Education 4.0 for professionals and learners uniformly countrywide. Digitising regional and provincial offices of the DBE should be prioritised for compatibility, remote monitoring and evaluation of schools. A holistic digital transformation of the education system (digitise the

learning, classroom, school and offices) for proactive decision making by the DBE.

The DBE should introduce compulsory computer literacy from the Foundation Phase (Grade R-Grade 3) to the FET Phase (Grade 10-12) to equip learners with lifelong 4IR skills for the technology driven work environment and economy.

Education 4.0 geared towards the National Development Plan 2030 for education should be funded by Department of National Treasury and rolled out with support equally across the country.

6.4.2 Implications for Educational Professionals and Learners

The human resource, that is, education practitioners must embrace digital technologies. They should enrol for digital skills training, empowerment initiatives initiated by the DBE and tertiary institutions, use applications and interactive media intentionally to improve the literacy and numeracy rate. The educational professionals should be equipped with digital management skills to troubleshoot devices and general use to cut costs on ICT technicians and pressure. Education professionals should use innovative teaching methods for Generation Z which responds well to technology. Innovative teaching methods should not re-enforce traditional pedagogy but educators as facilitators who understand and support Generation Z learning styles.

Learners should enrol for compulsory computer literacy programs initiated by the DBE, download and use applications and digital technologies that are geared towards improving literacy and numeracy. Learners must be encouraged to sign up for additional digital technologies that they explore online and are found to be satisfactory in improving literacy and numeracy skills. Learners should be equipped with skills to care for and troubleshoot devices to reduce pressure on ICT technicians and costs to the schools and the DBE.

6.4.3 Implications for the Foundation Phase (Grade R-Grade 3) educators and learners

The 2016 Progress in International Reading Literacy Study (PIRLS) presents that 8 out 10 Grade 4s cannot read for meaning and understanding in all South African official languages. It is imperative that literacy and numeracy are actively addressed in the Foundation Phase as this phase determines the success of learners throughout their school life. This in turn has a bearing on career choices in Grade 9 which is the Senior Phase (D. o. B. E. o. S. Africa, 2023).

6.5 Research limitations

6.5.1 Sampling location

The study is not random enough to generalise on a larger population as it is based on conveniently available educators. There are more educators nationally and in rural and remote areas who can shed more light on ICT and education practises.

6.5.2 Target respondents

- The distribution of the online survey was not fairly distributed to rural and remote areas that can shed light into the use of digital technologies for literacy and numeracy.
- The Witwatersrand School of Education lecturers and final-year students did not participate in the study. As respondents, they might have shed light into teacher training pedagogy, 4IR and practise.

6.5.3 Time

Time restrictions resulted in an online survey approach yet in-depth interviews with practitioners in the education field- DBE ICT education officials, educators, learners and other education stakeholders tasked with the roll out of ICT projects in education can shed more light.

6.6 Suggestions for further research

Studies on digital technologies in education give valuable information on the benefits and detail the challenges that are faced by learners, education practitioners and policy makers in implementing Education 4.0 effectively and uniformly across the country (Mhlanga, 2020). Additional studies are necessary in the following aspects:

- There is a need for a longitudinal study on Foundation Phase (Grade R-3) and Intermediate Phase (Grade 4-6) educators and learners on the training and use of 4IR technologies for literacy and numeracy as, the Foundation Phase determines the performance of learners in their whole school life.

- A school based longitudinal study involving languages and Mathematics educational professionals and leaners to determine if and how digital technologies are utilised for literacy and numeracy skills.

- A larger sample size on the use of digital technologies for literacy and numeracy that explores how the education system prepares current learners for the digital world of work.

6.7 Conclusion

The digital technologies brought by Education 4.0 are transforming the experiences of educational practitioners and learners. For digital transformation to succeed, the Department of Basic Education (DBE) must mitigate against inequalities in rural, urban and remote areas by providing digital access to all and digital skills training initiatives. Literacy and numeracy promote digital skills acquisition through the use of digital applications and interactive media that transform the traditional teacher-centred classroom to a learner-centred classroom. Digital technologies must be incorporated actively in schools to avoid the digital divide and technology unemployment in future. Adequate funding, curriculum design and infrastructure development are necessary for learners and educational professionals to be fully functional in the digital economy.

REFERENCES

Africa, D. o. B. E. o. S. (2023). Curriculum Assessment Policy Statements (CAPS)/ CAPS for Foundation Phase.

Africa, R. o. S. (2013). *Protection of Personal Information Act, 2013*. Cape Town

Africa, S. S. (2019). *Inequality Trends in South Africa*

A multidimensional diagnostic of inequality. Pretoria

Africa, S. S. (2020). How Unequal Is South Africa?

Africa, S. S. (2022). *Quarterly Labour Force Survey (QLFS) Q1:2022*. Pretoria

Allexsaht-Snider, M. (2006). Editorial: Urban Parents' Perspectives on Children's Mathematics Learning and Issues of Equity in Mathematics Education. *An International Journal of Mathematical Thinking and Learning, Volume 8, Number 3*, 187-192.

Andersson, U., Dasí, À., Mudambi, R., & Pedersen, T. (2016). Technology, innovation and knowledge: The importance of ideas and international connectivity. *Journal of World Business, 51*(1), 153-162. doi:10.1016/j.jwb.2015.08.017

Andrade, C. (2021). The Inconvenient Truth About Convenience and Purposive Samples. *Indian J Psychol Med, 43*(1), 86-88. doi:10.1177/0253717620977000

Aziz Hussin, A. (2018). Education 4.0 Made Simple: Ideas For Teaching. *International Journal of Education and Literacy Studies, 6*(3). doi:10.7575/aiac.ijels.v.6n.3p.92

Balyer, A., & Öz, O. (2018). Academicians' Views On Digital Transformation In Education. *International Online Journal of Education and Teaching (IOJET), 5*(4), 809-830.

Chetty, K., Qigui, L., Gcora, N., Josie, J., Wenwei, L., & Fang, C. (2018). Bridging the digital divide: measuring digital literacy. *Economics: The Open-Access, Open-Assessment E-Journal, 12*(1), 1-21. doi:10.5018/economics-ejournal.ja.2018-23

Coldwell-Neilson, J. (2021). Developing students' digital skills through online learning [The times Higher Education: Resources for Academics and University Staff].

Council, H. S. R. (2020). *Highlights of South African Grade 5 and 9 Results in Mathematics and Science*.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed methods Approaches* (F. Edition Ed.): SAGE Publications, Inc.

Creswell, J. W., Clark, P., Gutmann, V. L., L., M., & Hanson, W. E. (2003). An Expanded Typology for

Classifying Mixed Methods

Research Into Designs. In *Handbook of mixed methods in social and behavioral research* (pp. 209-240): Thousand Oaks, CA: Sage.

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., & Hanson, W. E. (2003). Advanced mixed methods research designs. *Handbook of mixed methods in social and behavioral research, 209*(240), 209-240.

Davids, N. (2019). Solving SA's literacy crisis. Retrieved from https://www.news.uct.ac.za/features/highlights2019/-article/2019-01-11-solving-sas-literacy-crisis

de S. Oliveira, K. K., & de Souza, R. A. C. (2022). Digital Transformation towards Education 4.0. *Informatics in Education,, 21*(No 2), 283-309.

del Valle García Carreño, I. (2014). Theory of Connectivity as an Emergent Solution to Innovative Learning Strategies. *American Journal of Educational Research, 2*(2), 107-116. doi:10.12691/education-2-2-7

del Valle García Carreño, I. (2014). Theory of Connectivity as an Emergent Solution to Innovative Learning Strategies. *American Journal of Educational ResearchScience and Education Publishing, Vol. 2*(No. 2), 107-116. doi:DOI:10.12691/education-2-2-7

Demir, K. A. (2021). Smart education framework. *Smart Learning Environments, 8*(1). doi:10.1186/s40561-021-00170-x

Development, O. O. f. E. C.-o. a. (2019). *TALIS 2018 Results: Teachers and school lifelong learners*. Retrieved from

Education, D. o. B. (2018a). *Education Statistic SA 2016* Pretoria: Department of Basic Education

Education, D. o. B. (2018b). *Education Statistics in South Africa 2016*. Pretoria

Forum, W. E. (2016a). Preparing for the Work Force of the Fourth Industrial Revolution The Future of Jobs and Skills.

Forum, W. E. (2016b). *Work Force of the Fourth Industrial Revolution The Future of Jobs and Skills Executive Summary*. Retrieved from Switzerland:

Gamlen, A., & McIntyre, C. (2018). Mixing methods to explain emigration policies: A post-positivist perspective. *Journal of Mixed Methods Research, 12*(4), 374-393.

Gandhi, M. H., & Mukherji, P. (2022). Learning Theories. *National Library of Medicine- National Center for Biotechnology Information*.

Gaoa, S., Krogstiea, J., & Siaub, K. (2011). Developing an instrument to measure the adoption of mobile services. *Mobile Information Systems 7*, 45-67. doi:DOI 10.3233/MIS20110110

Garrett-Rucks, P. (2013). Problematisizin the Role of Cultural Instruction in Foreign Language Learning. In *Intercultural Competence in Instructed Language Learning: Bridging Theory and Practise*: Information Age Publishing.

Gerber, A., & Eybers, S. (2021). Converting to inclusive online flipped classrooms in response to Covid-19 lockdown. *South African Journal of Higher Education, 35*(4). doi:10.20853/35-4-4285

Grant, D. (2013). *Background to the national quintile system*. Western Cape

Halili, S. H. (2019). Technological advancements in education 4.0. *The Online Journal of Distance Education and e-Learning, 7*(1), 63-69.

Harasim, L. (2017). Learning Theory and Online Technologies

In (Second ed., pp. 31). New York: Routledge Taylor and Francis Group.

Hariharasudan, A., & Kot, S. (2018). A scoping review on Digital English and Education 4.0 for Industry 4.0. *Social sciences, 7*(11), 227.

Hoosain, M. S., Paul, B. S., & Ramakrishna, S. (2020a). The impact of 4IR digital technologies and circular thinking on the United Nations sustainable development goals. *Sustainability, 12*(23), 10143.

Hoosain, M. S., Paul, B. S., & Ramakrishna, S. (2020b). The Impact of 4IR Digital Technologies and Circular Thinking on the United Nations Sustainable Development Goals. *Sustainability, 12*(23). doi:10.3390/su122310143

Hornburg, C. B., Schmitt, S. A., & Purpura, D. J. (2018). Relations between preschoolers' mathematical language understanding and specific numeracy skills. *Journal of Experimental Child Psychology*.

Howie, S., Combrinck, C., Mokoena, G., McLeod, D., Tshele, M., & Roux, K. (2020). Ten-year study shows South African school reading literacy is slow to improve: Research Matters.

Howie, S., Combrinck, C., Mokoena, G., Tshele, M., & Roux, K. (2022). Ten-year study shows South African school reading literacy is slow to improve. *Research Matters*.

Howie, S., Combrinck, C., Roux, K., Tshele, M., Mokoena, G. M., & McLeod, P. N. (2016). *PIRLS Literacy 2016 : South African highlights report.* Retrieved from Pretoria:

Hub, E. C. S. (2020). Digital Competence Framework for Educators (DigCompEdu).

Huk, T. (2021a). From Education 1.0 to Education 4.0 – Challenges

for the Contemporary School. *The New Educational Review*, 36-47.

Huk, T. (2021b). From Education 1.0 to_Education 4.0-Challenges

for the Contemporary School. *The New Educational Review*, 36-45. doi:10.15804/tner.2021.66.4.03

Hussin, A. A. (2018). Education 4.0 made simple: Ideas for teaching. *International Journal of Education and Literacy Studies, 6*(3), 92-98.

Irwanto, Rohaeti, E., Widjajanti, E., & Suyanta. (2017). *Students' Science Process Skill and Analytical Thinking Ability in Chemistry Learning*. Paper presented at the AIP Conference Proceedings 1868, 030001 (2017); https://doi.org/10.1063/1.4995100.

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed-methods sequential explanatory design: From theory to practice. *Field methods, 18*(1), 3-20.

Jager, J., Putnick, D. L., & Bornstein, M. H. (2017). II. More than just convenient: The scientific merits of homogeneous convenience samples. *Monographs of the Society for Research in Child Development, 82*(2), 13-30.

Jirout, J. J. (2020). Supporting Early Scientific Thinking Through Curiosity. *Frontiers in Psychology, 11*(1717), 7. doi:doi: 10.3389/fpsyg.2020.01717

Johnson, F. R., Yang, J.-C., & Reed, S. D. (2019). The internal validity of discrete choice experiment data: a testing tool for quantitative assessments. *Value in Health, 22*(2), 157-160.

Kekana, M. (2018). *Operation Phakisa Report 2018*. Cape Town: Parliament of The Republic of South Africa Research Unit

Kim, C., & Baylor, A. L. (2008). A virtual change agent: motivating pre-service teachers to integrate technology in their future classrooms. *Educational Technology and Society, 2*(11), 309-321.

Kiss, A. J., Nelson, G., & Christ, T. J. (2019). Predicting Third-Grade Mathematics Achievement: A Longitudinal Investigation of the Role of Early Numeracy Skills. *Learning Disability Quarterly, 42(3)*, 161-174.

Lai, C. H., & Huili Lin, S. (2017). Systems Theory. *The International Encyclopedia of Organizational Communication*, 1-18. doi:10.1002/9781118955567.wbieoc203

Lee, G. J. Calculating the Net Value of a Selection Procedure. In (pp. 1-178).

Lee, G. J. (2021). Calculating the value of the net procedure. In (pp. 42-74). Johannesburg: University of Witwatersrand.

Linde, S. (2021). Determining Students' Literacy Levels Through Screening Assessments.

Lyons, G. (2018). Getting smart about urban mobility – aligning the paradigms of smart and sustainable.

. *Centre for Transport & Society, Faculty of Environment and Technology.*, 1-18. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0965856416311028

Maboya, M. J. (2018). *Portfolio Committee Meeting on Operation Phakisa ICT Rollout In Basic Education*. Pretoria: Department of Basic Education

Macrotrends. (2022). South Africa Literacy Rate 1980-2022.

Meeks, L., Kemp, C., & Stephenson, J. (2014). Standards in Literacy and Numeracy: Contributing Factors. *Australian Journal of Teacher Education, 39*(7). doi:10.14221/ajte.2014v39n7.3

Mhlanga, D. (2020). Industry 4.0: The challenges associated with the digital transformation of education in South Africa. . *ResearchGate*, 12-25.

Micheli, P., Wilner, S. J. S., Bhatti, S. H., Matteo, M., & Beverland, M. B. (2018). Doing Design Thinking: Conceptual Review, Synthesis, and Research Agenda. *Journal of Product Innovation Management, 0(0)*, 1-25. doi:DOI: 10.1111/jpim.12466

Mukwawaya, G. F., Emwanu, B., & Mdakane, S. (2018). *Assessing the readiness of South Africa for Industry 4.0-analsysis of government policy, skills and education.* Paper presented at the International Conference on Industrial Engineering and Operations Management.

Mukwawaya, G. F., Emwanu, B., & Mdakane, S. (2018). *"Assessing the readiness of South Africa for Industry 4.0-analysis of government policy, skills and education.* Paper presented at the Proceedings of the International Conference on Industrial Engineering and Operations Management.

Mwapwele, S. D., Marais, M., Dlamini, S., & Van Biljon, J. (2019). Teachers' ICT Adoption in South African Rural Schools: A Study of Technology Readiness and Implications for the South Africa Connect Broadband Policy. *The African Journal of Information and Communication*(24), 1-21. doi:10.23962/10539/28658

Nandhakumar, R. (2019). *A Study on the Learning Pattern of Generation-Z (Gen-Z) & their Perception on Curriculum, Course Deliverance and Infrastructure.* Paper presented at the National Conference On Technology Enabled Teaching and Learning in Higher Education, School of Management Studies, VISTAS, Chennai, India.

Nandhakumar, R. (2019). *A study on the learning pattern of Generation-Z (GenZ) and their perception on the curriculum, course deliverance and infrastructure.pdf*. Paper presented at the National Conference On Technology Enabled Teaching And Learning

In Higher Education, Chennai, india.

News, S. (2021). Why Digital Skills Are the Foundation of Our Future Workforce [News and Insights].

Niskanen, V.-P., Rask, M., & Raisio, H. (2021). Wicked Problems in Africa: A Systematic Literature Review. *SAGE Open, 11*(3). doi:10.1177/21582440211032163

Pandor, N. (2006). *Address at the opening of a multi-media centre at Langa High School, 13 March 2006 , Minister Naledi Pandor speeches*.

Peters, M. A. (2019). Technological unemployment: Educating for the fourth industrial revolution. In *The Chinese Dream: Educating the Future* (pp. 99-107): Routledge.

Phoenix, U. o. (2021). Five Educational Learning Theories and how to apply them. Retrieved from https://www.phoenix.edu/blog/educational-learning-theories.html

Pietro Micheli , S. J. S. W., Sabeen Hussain Bhatti, Matteo Mura, and, & Beverland, M. B. (2014). The Scientific Method. Retrieved from https://getrevising.co.uk/grids/the_scientific_method

Purcell-Gates, V. (2013). Complicating the Complex. In V. Purcell-Gates (Ed.), *Cultural Practises of Literacy: Case Studies of Language, Literacy, Social Powe*: Routledge Taylor and Francis Group.

Purpura, D. J., Napoli, A. R., & King, Y. (2019). Chapter 7 - Development of Mathematical Language in Preschool and Its Role in Learning Numeracy Skills. *Cognitive Foundations for Improving Mathematical Learning, Volume 5*, 175-193.

Qureshi, M. I., Khan, N., Raza, H., Imran, A., & Ismail, F. (2021). Digital Technologies in Education 4.0. Does it Enhance the Effectiveness of Learning? A Systematic Literature Review. *International Journal of Interactive Mobile Technologies (iJIM), 15*(04). doi:10.3991/ijim.v15i04.20291

Rahman, M. S. (2020). The advantages and disadvantages of using qualitative and quantitative approaches and methods in language “testing and assessment” research: A literature review.

Reddy, V., Visser, M., Winnaar, L., Arends, F., Juan, A., Prinsloo, C., & Isdale, K. (2015). *Trends in International Mathematics and Science Study (TIMSS) 2015 Highlights of Mathematics and Science Achievement of Grade 9 South African Learners*. Retrieved from

Robertson, A. (2019). *Preparing for Generation Z: How can technology enhanced learning be firmly embedded in our students' learning experience? A case study from Abertay University.* Paper presented at the 13th International Technology, Education and Development Conference.

Rogers, E. M. (1995). Diffusion of innovations. In *Diffusion of Innovations* (Fourth ed., pp. 204-250). New York: Free Press.

Rusek, M., Stárková, D., Chytrý, V., & Bílek, M. (2017). Adoption of ICT Innovations by Secondary School Teachers and Pre-Service Teachers Within Chemistry Education. *Journal of Baltic Science Education Vol. 16*(No. 4). doi:10.33225/jbse/17.16.510

Salmon, G. (2019a). May the Fourth Be with You: Creating Education 4.0. *Journal of Learning for Development, Volume 6, No. 2*, 95-115.

Salmon, G. (2019b). May the Fourth Be with You_Creating Education 4.0. *Journal of Learning for Development, 6*(2), 95-115.

Saltan, F., & Arslan, Ö. (2016). The use of augmented reality in formal education: A scoping review. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(2), 503-520.

Samuel Dick, M., Mario, M., Sifiso, D., & Judy Van, B. (2019). Teachers' ICT Adoption in South African Rural Schools: A Study of Technology Readiness and Implications for the South Africa Connect Broadband Policy. *The African Journal of Information and Communication (AJIC)*(24). doi:10.23962/10539/28658

Section27. (2022). BUDGET-2022-ANALYSIS Fails to equip Basic Education or Health Sectors Post-Pandemic Recovery. Retrieved from https://section27.org.za/2022/02/2022-budget-statement-and-analysis/

Serrat, O. (2017). Knowledge SolutionsProposition 18 Design Thinking. doi:DOI 10.1007/978-981-10-0983-9_18

Services, D. o. T. a. P., & Education, D. o. B. (2014). *The Department of Telecommunication and Postal Services & the Department of Basic Education's provision of ICT and e-Education in Schools with a focus on Connectivity*.

Sulaiman, H., Suid, N., & Idris, M. A. B. (2018). *Usability evaluation of confirm-a learning tool towards education 4.0.* Paper presented at the 2018 IEEE Conference on e-Learning, e-Management and e-Services (IC3e).

Taherdoost, H. (2019). What is the best response scale for survey and questionnaire design; review of different lengths of rating scale/attitude scale/Likert scale. *Hamed Taherdoost*, 1-10.

Teddlie, C., & Tashakkori, A. (2009). *Foundations of Mixed Methods Research: Integrating Quantitative and .Qualitative Approaches in the Social and Behavioral Sciences*(pp. 1-54).

Tsakeni, M. (2021). Transition to Online Learning by a Teacher Education Program with Limited 4IR Affordances. *Research in Social Sciences and Technology, 6*(2), 129-147.

Turnbull, L., Hütt, M. T., Ioannides, A. A., Kininmonth, S., Poeppl, R., Tockner, K., . . . Parsons, A. J. (2018). Connectivity and complex systems: learning from a multi-disciplinary perspective. *Applied Network Science, 3*(1). doi:10.1007/s41109-018-0067-2

UNICEF, U. N. C. s. F. (2020). *Child Poverty in South Africa: A multiple overlapping deprivation analysis summary*. Retrieved from Pretoria:

Valerio, M. A., Rodriguez, N., Winkler, P., Lopez, J., Dennison, M., Liang, Y., & Turner, B. J. (2016). Comparing two sampling methods to engage hard-to-reach communities in research priority setting. *BMC Medical Research Methodology, 16*(1). doi:10.1186/s12874-016-0242-z

van der Merwe, R., & van Heerden, D. (2015). Using technology to gain knowledge: Development, implementation and evaluation of a mobile digital skills curriculum for educators. 1-11. doi:DOI: 10.1145/2815782.28157

Varela, C., Ruiz, J., Andrés, A., Roy, R., & Fusté, A. (2016). Advantages and Disadvantages of using the website SurveyMonkey in a real study: Psychopathological profile in people with normal-weight, overweight and …e-methodology

The International Scientific Journal

1-138.

Varela, C., Ruiz, J., Andrés, A., Roy, R., Fusté, A., & Saldaña, C. (2016). Advantages and Disadvantages of using the website SurveyMonkey in a real study: Psychopathological profile in people with normal-weight, overweight and obesity in a community sample. *E-methodology, 2016*(3), 77-89.

Von Bertalanffy, L. (1972). The history and status of General Systems Theory. *The Academy of Management Journal, 15*(4), 407-426.

Williams, G. (2016). Reflection Literacy in the First Years of Schooling: Questions of Theory and Practice. *Society in Language, Language in Society*.

Yasukawa, K., Rogers, A., Jackson, K., & Street, B. V. (2018). *Numeracy as a Social Practise Global and Local Perspectives*. Retrieved from New York:

Yulina, I. K., Permanasari, A., Hernani, H., & Setiawan, W. *Analytical thinking skill profile and perception of pre service chemistry teachers in analytical chemistry learning*. Paper presented at the International Conference on Mathematics and Science Education (ICMScE 2018).

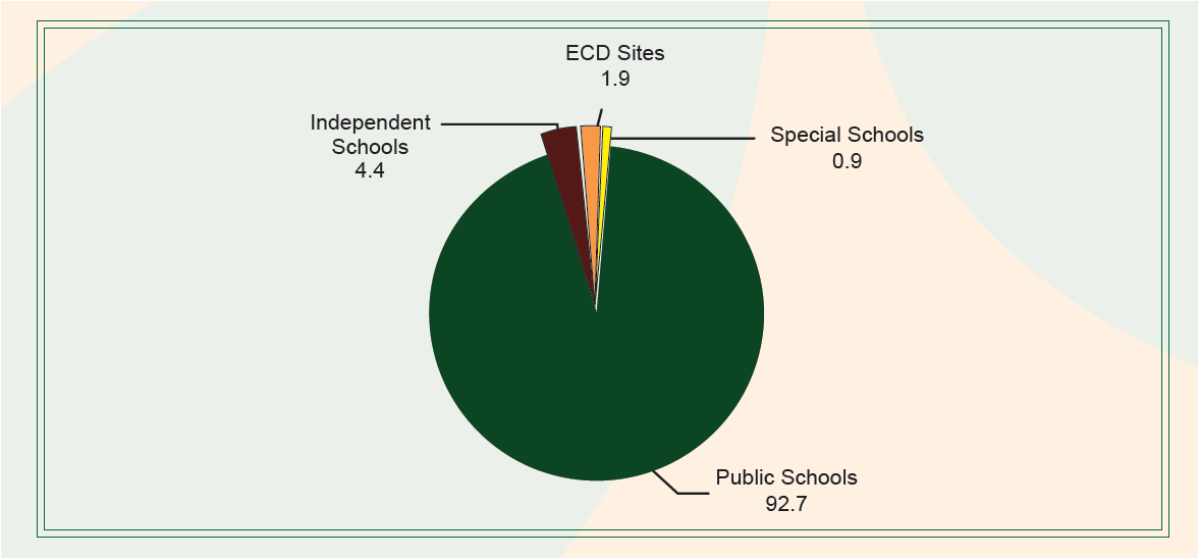
Zimmerman, C., & Klahr, D. (2018). Stevens' handbook of experimental psychology and cognitive neuroscience 4 (2018): 1-25. Development of Scientific Thinking. In (Vol. 4, pp. 1-25). doi:DOI: 10.1002/9781119170174.epcn407

Appendix 1: The National and Provincial Quintile Breakdown

National Poverty table for 2014					
	National Quintiles				
	1	2	3	4	5
EC	27.3%	24.7%	19.6%	17.0%	11.4%
FC	20.5%	20.9%	22.4%	20.8%	15.4%
GP	14.1%	14.7%	17.9%	21.9%	31.4
KN	22.1%	23.2%	20.2%	18.7%	15.8%
LP	28.2%	24.6%	24.2%	14.9%	8.0%
MP	23.1%	24.1%	21.5%	17.7%	13.5%
NC	21.5%	19.3%	20.7%	21.4%	17.1%
NW	25.6%	22.3%	20.8%	17.6%	13.7%
WC	**8.6%**	**13.3%**	**18.4%**	**28.0%**	**31.7%**
SA	20.0%	20.0%	20.0%	20.0%	20.0%

Source: (Grant, 2013)

Appendix 2: The Percentage distribution of learners in the education system 2016



Source: (Education, 2018b)

Appendix 3: Educators learners and schools by ratios by province

Ratios: Learner-educator ratio (LER), Learner-school ratio (LSR) and Educator-school ratio (ESR)

Province	Learners		Educators		Schools		Indicators		
	Number	As % of National Total	Number	As % of National Total	Number	As % of National Total	LER	LSR	ESR
Eastern Cape	1 961 547	15.2	61 629	14.7	5 676	22.2	31.8	346	10.9
Free State	688 349	5.3	23 523	5.6	1 282	5.0	29.3	537	18.3
Gauteng	2 326 584	18.0	82 078	19.6	2 813	11.0	28.3	827	29.2
KwaZulu-Natal	2 877 544	22.3	89 799	21.5	6 142	24.0	32.0	469	14.6
Limpopo	1 765 555	13.7	54 418	13.0	4 018	15.7	32.4	439	13.5
Mpumalanga	1 074 352	8.3	34 404	8.2	1 847	7.2	31.2	582	18.6
Northern Cape	292 595	2.3	9 136	2.2	574	2.2	32.0	509	15.9
North West	829 467	6.4	26 108	6.2	1 534	6.0	31.8	541	17.0
Western Cape	1 116 572	8.6	37 518	9.0	1 687	6.6	29.8	662	22.2
South Africa	**12 932 565**	**100.0**	**418 613**	**100.0**	**25 574**	**100.0**	**30.9**	**506**	**16.4**

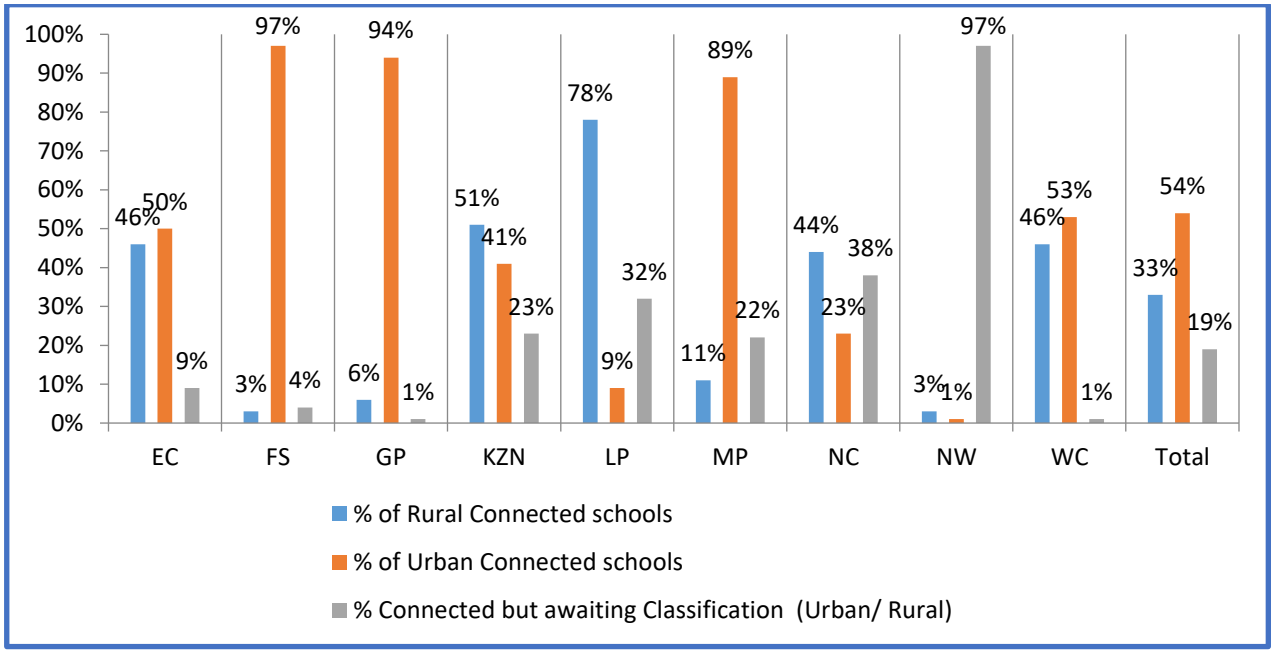
Source: (Education, 2018a)

Appendix 4: Status of School Connectivity end of December 2017

PROVINCIAL BREAKDOWN DECEMBER 2017						
Province	MTN	Cell C	Vodacom	Liquid	Total per Province	Total schools in Province
EC	204	201	364		769	5727
FS	166		233		399	1327
GP	72	53			125	2183
KZN	358	218	300	186	1062	5937
LP	205	26	50		281	3924
NW	70	86	70		226	1948
NC	141	76	217		434	573
WC	101	52	45	185	383	1542
MP	43	190	107		340	1614
Subtotal	1360	902	1386	371	4019	24775
TOTAL	4019					

Source: (Kekana, 2018; Maboya, 2018)

Appendix 5: Schools' Connectivity in partnership with the Department of Telecommunications and Postal Services



Source: (Maboya, 2018)

Appendix 6: Accelerated Teachers ICT Training

No	Provinces	No of schools	No of schools trained	No of Schools Remaining	No of Master Teachers trained
1	Eastern Cape	216	178	38	390
2	Free State	150	150	0	276
3	KwaZulu Natal	228	190	38	204
4	Limpopo	213	201	12	336
5	Mpumalanga	168	123	45	173
6	Northern Cape	99	61	38	52
7	North West	197	177	20	342
	Total	**1271**	**1080**	**191**	**1773**

Source: (Services & Education, 2014)

Appendix 7: Research Instrument

ARP

Start of Block: Default Question Block

Introduction:

Good day. I am Lindiwe Gama, a Master of Business Administration (MBA) student at Wits Business School. I would like to invite you to participate in my study entitled: The transformation of primary and secondary education by the Fourth Industrial Revolution (4IR) technologies. 4IR or Industry 4.0 has resulted in radical shifts from traditional methods of imparting knowledge to technology-driven means which develop at a fast pace, consequently, these technologies are viewed to be disruptive to the educational fields they impact.

Please read the following items and answer all questions. Your participation is anonymous and confidential. You have the liberty to withdraw anytime. There are no right or wrong answers.

Q1 SECTION A: DEMOGRAPHICS

Sex:

- ○ Male (1)
- ○ Female (2)
- ○ Prefer not to say (3)

Q2 Age group:

- ○ Under 18 (1)
- ○ 18 - 24 (2)
- ○ 25 - 34 (3)
- ○ 35 - 44 (4)
- ○ 45 - 54 (5)
- ○ 55 - 64 (6)
- ○ 65 - 74 (7)
- ○ 75 - 84 (8)
- ○ 85 or older (9)

Q3 Highest level of education

- ○ Post Matric Certificate (1)
- ○ Diploma (2)
- ○ Undergraduate Degree (3)
- ○ Post Graduate Diploma/Certificate (4)
- ○ Honours Degree (5)
- ○ Master's Degree (6)
- ○ Doctorate (7)
- ○ Other (8)

End of Block: Default Question Block

Start of Block: Block 1

Q4 Annual Income Levels

- ○ No income (1)
- ○ R 1-R 9600 (2)
- ○ R 4801-R 9600 (3)
- ○ R 9601-R19 200 (4)
- ○ R 19 201- R 38 400 (5)
- ○ R 38 401- R 76 800 (6)
- ○ R76 801- R153 600 (7)
- ○ R 153 601- R 307 200 (8)
- ○ R 307 201- R 614 400 (9)
- ○ R 614 401 OR MORE (10)

End of Block: Block 1

Start of Block: Block 2

Q5 Occupation

- ○ Lecturer (1)
- ○ Secondary/ High School Educator (2)
- ○ Primary School Educator (3)
- ○ Student Teacher (Tertiary) (4)
- ○ Other (5)

End of Block: Block 2

Start of Block: Block 5

Q6 SECTION B: UPSKILLING EDUCATORS/PROFESSIONALS

Which 4IR technologies for Mathematics have you received training in? Select all that apply.

- [ ] Thinkster Maths (1)
- [ ] Dr Maths (2)
- [ ] Nokia Mobile Learning for Maths (3)
- [ ] UF Fractions (4)
- [ ] Robotics (5)
- [ ] Teach Me Maths (6)
- [ ] Other (7)

Q6 Which 4IR technologies for Languages have you received training in? Select all that apply.

- [ ] Geo Lingo (1)
- [ ] Presentation Translator PPT (2)
- [ ] Natural Language Processing (3)
- [ ] Dr LOL (4)
- [ ] GPT-3 -most advanced AI language model (5)
- [ ] Mindjoy (6)
- [ ] Chat bots (7)
- [ ] Other (8)
- [ ] None (9)

Q7 Which additional 4IR technologies have you received training in? Select all that apply.

- [ ] SASAMS-South African Schools Management Systems (1)
- [ ] LURITS- Learner Unit Record Information System (2)
- [ ] Speedgrader (3)
- [ ] PDF Editor (4)
- [ ] LMS-Learning Management Systems (5)
- [ ] Canvas (6)
- [ ] Canva (7)
- [ ] Zoom (8)
- [ ] Google Classroom (9)
- [ ] Other (12)
- [ ] None (13)

End of Block: Block 5

Start of Block: Block 7

Q8 How often is the training on the additional 4IR technologies?

- ○ Never (1)
- ○ Sometimes (2)
- ○ About half the time (3)
- ○ Most of the time (4)
- ○ Always (5)

Q13 How was the training on 4IR technologies funded? Select all that apply.

- ☐ Employer (1)
- ☐ Bursary/ Scholarship (2)
- ☐ Self-funded (3)
- ☐ Other (4)

Q14 Which digital skills have you learnt from the training. Select all that apply.

- [ ] Computer literacy/ Digital skills (1)
- [ ] Professional engagement (2)
- [ ] Developing Digital resources (3)
- [ ] Teaching and learning (4)
- [ ] Imparting digital skills to learners (5)
- [ ] Data management (6)
- [ ] Other (7)

Q9 Which of the following technological devices do you have access to?

- ○ Mobile phone (1)
- ○ Tablet (2)
- ○ Laptop (3)
- ○ Desktop PC (4)
- ○ Projector (5)
- ○ Other (6)
- ○ None (7)

Q9 How often do you use these technological devices for educational purposes?

- ○ Never (1)
- ○ Sometimes (2)
- ○ About half the time (3)
- ○ Most of the time (4)
- ○ Always (5)

End of Block: Block 7

Start of Block: Block 3

Q11 Which mode of education do you use to teach?

- Face-to-face (1)
- Online (2)
- Hybrid (3)
- Other (4)

Q15 Which services should the DBE offer to improve your digital needs? Select all that apply.

- [ ] Offer monthly training/ workshops (1)
- [ ] Free Online Training Packages (2)
- [ ] Subsidised Online Training Packages (3)
- [ ] Well-staffed teacher development centres (4)
- [ ] Well-serviced teacher development centres (5)
- [ ] Teacher Development Centres within schools (6)
- [ ] Provide reliable connectivity (7)
- [ ] Provide digital devices (8)
- [ ] Other (9)

Q16 SECTION C: LITERACY AND NUMERACY

Which of the following interactive media do you use for educational purposes? Select all that apply.

- [ ] Digital Applications (1)
- [ ] Videos (2)
- [ ] Interactive Workbooks/ Textbooks (3)
- [ ] E-Classroom Worksheets (4)
- [ ] Career Guides (5)
- [ ] Mind the Gap (6)
- [ ] Other (7)

Q17 Identify the literacy skills attributed to interactive media. Select all that apply.

- [ ] Reading (1)
- [ ] Writing (2)
- [ ] Comprehension (3)
- [ ] Visual literacy (4)
- [ ] Phonemic awareness (5)
- [ ] Classroom participation (6)
- [ ] Decoding (7)
- [ ] Fluency (8)
- [ ] Other (9)
- [ ] None (10)

Q18 Identify the digital applications that you use for teaching languages. Select all that apply.

- [ ] Geo Lingo (1)
- [ ] Presentation Translator PPT (2)
- [ ] Natural Language Processing (3)
- [ ] Dr LOL (4)
- [ ] Mindjoy (5)
- [ ] Chat bots (6)
- [ ] Other (7)
- [ ] None (8)

Q19 Identify the numeracy skills attributed to interactive media. Select all that apply.

- [ ] Verbal counting (1)
- [ ] One -to-one correspondence (2)
- [ ] Numeral identification (3)
- [ ] Cardinality (4)
- [ ] Comparisons of sets and/or numerals (5)
- [ ] Ordering numerals (6)
- [ ] Story problems (7)
- [ ] Other (8)

Q21 Identify the digital applications that you use for teaching Maths. Select all that apply.

- [ ] ThinksterMaths (1)
- [ ] Dr Maths (2)
- [ ] Nokia Mobile Learning for Maths (3)
- [ ] UF Fractions (4)
- [ ] Robotics (5)
- [ ] Khan Academy Maths (6)
- [ ] Teach Me Maths (7)
- [ ] Other (9)
- [ ] None (10)

Q20 Identify the educational outputs in which interactive media improves literacy and numeracy. Select all that apply.

	Languages (1)	Maths (2)
Marks (1)	☐	☐
Progression Rate (2)	☐	☐
Matric Pass Rate (3)	☐	☐
University Exemption (4)	☐	☐
Debates/ Public Speaking Competitions (5)	☐	☐
International rankings on Language Literacy (6)	☐	☐
Science Expos/ Fairs/ Competitions (7)	☐	☐
International rankings on Maths and Science (8)	☐	☐
Other (9)	☐	☐

None (10)	☐	☐

Q23 How are 4IR technologies influencing learners' behaviour? Select all that apply.

- ☐ Learners do extra exercises (1)
- ☐ Learners find information independently (2)
- ☐ Learners can critically evaluate digital media platforms (3)
- ☐ Learners can critically evaluate relevant information (4)
- ☐ Learners explore educational applications not introduced by educator (5)
- ☐ Learners share digital skills with others (6)
- ☐ Change their world view/ globalisation (7)
- ☐ Other (8)

Q24 SECTION D: THE DEPARTMENT OF BASIC EDUCATION (DBE)

	Extremely dissatisfied (1)	Moderately dissatisfied (2)	Slightly dissatisfied (3)	Neither satisfied nor dissatisfied (4)	Slightly satisfied (5)	Moderately satisfied (6)	Extremely satisfied (7)
1. Are you satisfied with the rollout of 4IR Technologies by the DBE? (1)	○	○	○	○	○	○	○
2. Are you satisfied with the policies on the rollout of 4IR Technology by the DBE? (2)	○	○	○	○	○	○	○

3. Are you satisfied with the technical support on 4IR Technologies by the DBE? (3)	○	○	○	○	○	○	○
4. Are you satisfied with the development of e-resources by the DBE? (4)	○	○	○	○	○	○	○
5. Rate the training you received (5)	○	○	○	○	○	○	○

6. Rate the quality of the connectivity (6)	○	○	○	○	○	○	○
7. Rate interactive media on literacy (7)	○	○	○	○	○	○	○
8. Rate interactive media on numeracy (8)	○	○	○	○	○	○	○

Q25 Have you read the Draft White Paper on e-Education of 2004?

- ○ No (1)
- ○ Yes (2)

End of Block: Block 3

Start of Block: Block 4

Q26 Are you aware of the following ICT projects by the DBE? Select all that apply.

- ☐ Operation Phakisa (1)
- ☐ The School Connectivity Plan 2014-2020 (2)
- ☐ Broadband Project (3)
- ☐ Resourced Teacher Centres & Professional Development (4)
- ☐ School Connectivity – Rural vs Urban (5)
- ☐ Universal Service and Access Obligations (USAO) Rollout (6)
- ☐ Other (7)
- ☐ None (8)

End of Block: Block 4

Start of Block: Block 6

Q27 What do you consider to be the most crucial 4IR infrastructure development areas for schools? Select all that apply.

	Public Schools (1)	Private Schools (2)
Computer Laboratories (1)	☐	☐
Connectivity (2)	☐	☐
Teacher Development Centres (3)	☐	☐
Maintenance of 4IR infrastructure (4)	☐	☐
Security of 4IR infrastructure (5)	☐	☐
Educator’s digital skills (6)	☐	☐
Reliable Electricity Supply (7)	☐	☐
Other (8)	☐	☐
None (9)	☐	☐

Q28 What do you consider to be the most crucial human resource areas for 4IR technology development in schools? Select all that apply.

	Public Schools (1)	Private Schools (2)
Workforce and employment empowerment targets (1)	○	○
Digital skills (2)	○	○
Digital Training Fees/ Sponsors (3)	○	○
Talent management/ career progression/ succession plan (4)	○	○
Incentives/ rewards (5)	○	○
Staff turnover (6)	○	○
Job satisfaction (7)	○	○
Other (8)	○	○
None (9)	○	○

Q29 Which of the following factors are most crucial to the achievement of digital transformation in primary and secondary education?

- ○ Income (1)
- ○ Cost of education (2)
- ○ Cost of technology (3)
- ○ Feeder areas (4)
- ○ Policies in ICT Education (5)
- ○ Funding from National Treasury (6)
- ○ Other (7)
- ○ None (8)

End of Block: Block 6