Readiness of South African fee-paying public high schools in Gauteng in adopting 4IR technologies in alignment with Education 4.0

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

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ABSTRACT

Far-reaching implications are being observed regarding how people engage, live, work, and educate themselves due to the requirements of the Fourth Industrial Revolution. The fusion of physical, human, and digital worlds is becoming increasingly evident. The redefinition of industries and the edification of people has led to the emergence of concepts like Education 4.0. which is characterised by intelligent technologies like three-dimensional printing (3D Printing), the Internet of Things (IoT), big data, data analytics, machine learning (ML), gamification, and augmented reality (AR). Literature in this field highlights the disruptive nature of these 4IR technologies, particularly in the education sector.

Purpose: This study investigated the readiness level of South African fee-paying public high schools in Gauteng in their adoption and implementation of 4IR technologies in alignment with the objectives of Education 4.0. The outcomes of the study aimed to provide valuable insights into the factors that may have impacted the adoption or lack thereof of 4IR technologies in the classroom and thus offered remedial solutions where applicable.

Research Design and Methodology: A generic qualitative research design was employed to explore stakeholder perspectives on the benefits of 4IR technologies in education. Semi-structured interviews were conducted using snowball sampling to gather data. Thematic analysis, specifically an inductive approach, was chosen to identify and interpret emerging themes from the interview transcripts. This research design and methodology provided an in-depth understanding of stakeholder experiences and insights. The total sample size comprised eleven participants.

Key Findings: The study revealed both potential benefits and challenges associated with adopting and integrating 4IR technologies in the educational facilities under study. Educators generally perceived value in 4IR technologies for enhancing education quality. Potential benefits identified included personalised learning, active learning, and preparing students for future work

contexts. However, challenges such as restricted access to technology, inadequate infrastructure, and insufficient training were also identified as potential barriers to adoption.

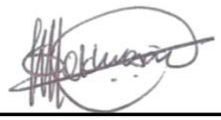
Recommendations: The study recommends targeted interventions to address challenges and leverage opportunities for integrating 4IR technologies in foundational education contexts. These include exploring alternative financing models, implementing comprehensive and ongoing training programs, revising the curriculum policy statement, and effecting infrastructural improvements.

KEYWORDS

4IR, Education 4.0, UTAUT, Personalised learning, Artificial Intelligence, Virtual Reality.

DECLARATION

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

Name: Ramanti Mokhwesana Signature: 

Signed at ……. Fourways……

On the ……28th……... day of …February…… 2024….

DEDICATION

For my grandmothers, Dorcus Mokhwesana and Noko Anna Mabusela, as well as my parents, Matseleng Miriam Mabusela and Theledi Moses Mokhwesana, this dedication is but a whisper in comparison to the roar of love and gratitude I hold for you in the depths of my heart and soul. You have been my guiding stars whenever I felt lost, the unwavering anchors that have kept me grounded, and the warmest hearts around which my fondest memories dance.

Your love has been a constant safe haven in my life. Your wisdom is a guiding light that has helped me navigate my chosen paths. Thank you for all that you are, have been and continue to be in my life. Thank you for the patient lessons you have imparted, and for the continued unwavering support you've offered. You have instilled in me the values of kindness, resilience, compassion, giving and hard work that will forever shape my journey through life.

This dedication is a testament to the love and foundation you have so lovingly built. May it, in some small way, reflect the depth of my affection for you.

With boundless love and most profound respect,

Your Loving daughter and granddaughter

Ramanti Mokhwesana

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I would first like to thank God for all the love and blessings that have been bestowed upon my life. For giving me the strength, resilience, and courage to pursue my studies. I take none of it for granted.

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Additionally, I thank my husband Dr Mashudu Mabela for your patience and support during my studies. For the late-night snacks to fuel my energies as I burnt the midnight oil. Thank you for your continued encouragement. Your work ethic, many personal academic achievements and general love for education inspired me to continue my own academic journey. I appreciate you.

I also thank my beautiful daughter Tshwanelo Mashugane who is in matric this year. I'm SO proud of you and extremely blessed and grateful to have had you chosen for me. I know my absence was felt during my studies, thank you for being patient with me and for being gentle and understanding. Thank you for the back rubs, for the tea and for the special warm water you made for me throughout my studies and thank you for your encouraging words throughout this journey. You are the absolute joy of my life. A big thanks to brother Thabang Mokhwesana and my sister Noko Katlego Mokhwesana as well for your unwavering love and continued encouragement during this journey. I'm so lucky to have you guys to lean on. Thank you. Also, a great extension of my gratitude to Ntante Cenenda for all your support and assistance.

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LIST OF ACRONYMS

Abbreviation	Definition
AI	Artificial Intelligence
DBE	The Department of Basic Education
DL	Deep Learning
Education 4.0	Education for the 4th Industrial Revolution
4IR	Fourth Industrial Revolution
IoT	Internet of Things
ML	Machine Learning
NDP	South African National Development Plan
3D Printing	Three-Dimensional Printing
UTAUT	Unified Theory and Acceptance and Use of Technology
VR	Virtual Reality

CHAPTER 1. INTRODUCTION

1.1 Statement of purpose

This generic qualitative study sought to assess the readiness levels in adopting 4IR Technologies in the learning process of fee-paying public high schools in Gauteng in alignment with the principles of Education 4.0.

1.2 Background of the study

According to The World Economic Forum (2018) and Schwab (2016), the fusion of physical, human, and digital worlds typifies the very nature and function of the Fourth Industrial Revolution (4IR) technologies that have brought about a wave of change across disciplines, industries, and economies. This transformative potential of 4IR technologies is equally evident in education, giving rise to the term Education 4.0 (Ayanwale, 2023). Education 4.0 envisions intelligent learning environments that facilitate proactive, participative, and agile interactions between technology, learners, and educators (Dervojeda, 2021). Some 4IR technologies driving these shifts include Artificial intelligence (AI) applications, big data, IoT, and machine learning (Marr, 2019).

According to Halili et al. (2019), the implementation of innovations like data analytics and other AI-enabled applications in schooling environments holds the promise of providing essential insights into improving learners' critical learning paths. These technologies also enable customised learning such as the tailoring of study materials to address identified learning disparities, red flagging areas of learning challenges, and developing focused learner-educator engagements thus imparting deep learning (Bhutoria, 2022).

In their research on the readiness of Ghana to implement intelligent technologies in the learning environment, Narh-Kert et al. (2022) hypothesise that data analytics helps allow learners to influence the adaptation of the curriculum, thereby not only keeping educational programs current and relevant to learning outputs but in also propelling educators to assume their new roles as facilitators in the learning process. Incorporating digital technologies in the learning processes can thus help facilitate technology-aided, personalised, and adaptive learning outcomes (Holmes, 2018). The Internet of Things (IoT) defines key 4IR technologies, which connect physical objects to the Internet, thus enabling them to store and share data insights intuitively (Stojanović et al., 2023). Stojanović et al. (2020) assert that using and incorporating IoT devices in the learning process propels the delivery of tailored and instructional learning experiences and allows for the insightful tracking of progress made by individual learners.

Learning by doing is one of the essential components of Education 4.0, which can be effectively applied and given effect through the principles of Gamification (Park & Kim, 2021). Gamification in education delimits the application of game-like elements in non-game contexts to stimulate proactive collaborations and the participatory engagement of learners (Almeida & Simoes, 2019). The ability of transcendent and personalised learning environments to offer learners access to experiences that would not be possible otherwise is a significant feature of virtual reality (VR) technologies (Calvert & Abadia, 2020). These technologies can offer learners unique opportunities to engage in immersive and transformative learning. These technologies offer immense educational benefits, and schools need to be prepared to reap the benefits of these 4IR technologies. According to Bhutoria (2022), countries leading with 4IR technologies in education are the USA, India, and China, leaving most developing nations behind, including South Africa. In corroboration, Olaitan et al. (2021) highlight the identification of South Africa as one of the countries to "watch out for" by the Digital Evolution Index due to its indicated low digital development and broadening socio-economic digital skills gap.

However, to mitigate these challenges, The South African NDP: Vision 2030 underscores South Africa's preparedness for the 4IR as being one of the Government's primary objectives, which is to be implemented through advancing technological innovation and skills in education as an imperative (The National Science and Technology Forum, 2019). Understanding how far the South African Basic Education Department has come in its efforts to implement 4IR technologies in public schools is thus essential in determining the strides being made in this area of focus (Moloi & Mhlanga, 2021).

1.3 Research Problem

Studies conducted by Mawas and Muntean (2018) and Ayanwale (2023) focused on the importance of steering secondary schools towards 21st-century teaching methodologies like personalised learning and the incorporation of innovation and related pedagogical approaches in the learning process. Thus, the gap between educational ideals like the employment of technological innovations, customised learning, and the practical implementation thereof in schools must be investigated (Ramra & Marimuthu, 2019). To this end, Oke and Fernades (2020) investigated the general adoption and acceptance of digital technologies in education. Additionally, Alharbi (2023) and Ramírez-Montoya (2021) analysed the complexity of thinking approaches related to educational practices and open innovation as fundamental requirements in applying and facilitating learning outcomes using 4IR technologies. However, none of these studies have explored the levels of readiness in adopting 4IR technologies such as Robotics, 3D printing, gamification, learning companions, virtual reality, and intelligent tutors in the learning process such that these technologies support, align and deliver the requirements of Education 4.0 at basic educational levels, particularly in the public schooling system in South Africa.

To comprehend the requirements and potential limitations to successfully integrate 4IR technologies in the classroom, factors like affordability, teacher training, upskilling, and accessibility to technological tools required in the learning process need exploration (kayembe & Nel, 2019).

Additionally, the apparent influence of 4IR technologies on learning outcomes, digital equity, and workloads for educators within the public schooling system in South Africa also needs to be investigated (Carrim, 2022). In 2018, the Minister of the Department of Basic Education, Angie Motshekga, announced the Government's plan to start preparing learners at the foundational phase for the 4IR (SAnews, 2018). As a result, a review of the role of government policies and the related initiatives geared towards anchoring the adoption of 4IR technologies in public schools requires examination.

1.3.1. Research questions:

RQ1: What is the perceived value of implementing 4IR technologies in public high schools?

RQ2: How can 4IR technologies be used to improve the quality of education in public high schools?

RQ3: What are the challenges faced by educators in incorporating 4IR technologies into their teaching strategies?

RQ4: Which barriers exist to the adoption and implementation of 4IR technologies in public high schools?

1.4 Rationale

There is knowledge of the state of readiness for the 4IR, specifically within the education sector across the world (Ayanwale, 2023); (Halili et al., 2019); (Narh-Kert et al., 2022). The level of preparedness by the education sector in terms of the use, adoption, and general state of readiness by schools in terms of infrastructure, educator training, learner development, and pedagogical adaptation in developing countries, including Africa and South Africa, is also gaining prominence. Some of the literature in this regard includes that by Oke and Fernandes (2020), who generalised their study to the African content. Narh-kert et al. (2022) focused their study on Ghana, and both Sikhakhane et al. (2020) and Carrim (2022) dedicated their attention to South Africa. The primary research studies on the use of 4IR technologies facilitated in alignment with the goals of Education 4.0 in the basic education sector have focused on the following aspects: pedagogical differences between the current teaching methods and the requirements in learning practices associated with educator training, the factors impeding the implementation of 4IR technologies in South African public schools, the digital divide and related inequalities as factors preventing access to 4IR technologies. The current study hopes to add to the current body of knowledge regarding the actual types of 4IR technologies that can be adopted and implemented in South African public high schools. The study also hopes to contribute to the conversation on the practical application of these technologies and their incorporation into the curriculum across all subjects, not just for STEM (science, technology, engineering, and mathematics) subjects. Additionally, the study seeks to highlight the importance of aligning the use of 4IR technologies in the learning process with the objectives of Education 4.0. Contribution towards educators' training on effectively incorporating these technologies as part of their educational outcomes and teaching practices also requires focus.

1.5 Study Delimitations

i. The study focused on the perceptions of educators and senior officials of fee-paying public high schools in Gauteng, South Africa. It did not include the perspectives of learners and parents.

ii. The data collection for this study occurred at a specific time, which may have limited the generalisability of the findings to future contexts where technology and educational practices may evolve.

iii. The study was conducted using a qualitative approach, with subjective data being gathered through interviews. It was acknowledged that individual experiences and interpretations significantly shaped the understanding of 4IR technology adoption.

iv. The study was delimited to fee-paying public high schools within the Gauteng province. This decision was made to provide a focused and in-depth analysis of a specific context. Non-fee-paying public schools and private schools were excluded, potentially impacting the overall representation of South African public high schools in Gauteng.

1.6 Assumptions

i. The actual level of readiness for schools to adopt and implement 4IR technologies might have differed from what the participants conveyed.

ii. Honest opinions and insights were shared willingly during participant engagement.

1.7 Report Outline

The purpose of the study and its overall background are stated in Chapter One, which also offers background information about the problem the study sought to investigate, along with the related research questions, study rationale, and envisaged delimitations. Further context to the study was provided in Chapter Two by reviewing related literature. The research propositions for the study were positioned in this chapter together with the theoretical framework underpinning the study. Also included in the chapter is a conceptual framework as a lens through which the study was approached

The approach to the research methodology was delineated and justified in Chapter 3 by elaborating on the methods used to collect data, the related research instrument, the parameters of the study population, and the related data analysis methods. The analysis of the data collected for the study was presented in Chapter Four, which presents its findings. A discussion of the critical study findings was offered in Chapter Five, and the study's limitations, related recommendations, and proposed future research are presented in Chapter Six.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

The educational landscape is experiencing significant reconstructive shifts driven by the relentless march towards the 4IR (Teel & Lund, 2023). This chapter delved into the theoretical underpinnings of this phenomenon by exploring some of its foundational tenets and their related implications for education. The starting point was to establish a clear understanding of the 4IR by delineating the key technological advancements that typify this era and their possible impact on various aspects of society. Subsequently, the chapter defined Education 4.0 as a paradigm shift within the education space that aims to equip learners with the requisite skills and knowledge crucial to thrive in a 4IR-driven world (Tikhonova & Raitskaya, 2023).

In this chapter, the four foundational research questions underpinning the study are presented. Corresponding propositions for the respective research questions were then formulated to help elucidate the significance of the established connection between these two elements.

The Unified Theory of Acceptance and Use of Technology (UTAUT) is identified and positioned as the theoretical framework that underpins this study. UTAUT serves as a lens, allowing us to examine the factors that influence the adoption of new technologies (Venkatesh et al., 2003). Building upon this framework, the chapter concludes by outlining a conceptual model that highlights the key factors influencing the readiness of South African fee-paying public high schools in Gauteng to adopt 4IR technologies.

Fourth Industrial Revolution

According to Moloi and Mhlanga (2020), the 4IR has brought about fundamental shifts in all spheres of life, shaping how we engage as a society. Schwab (2016) brings into perspective the successive progression of each of the preceding three industrial revolutions in the following order: first, the mechanisation of production using steam and water; second, the development of mass production; and third, the automation of production using information technology and electronics respectively. Marr (2019) further entrenches this point by stating that each of the industrial revolutions throughout history has helped define the needs of societies by applying various technological innovations of the time (Marr, 2019). Additionally, Lee et al. (2018) define the 4IR as critical changes in society which are denoted by significant technological innovations brought on by the second Information Technology Revolution. According to the WEF (2017), the 4IR is characterised by AI-enabled technologies that have distorted the physical, biological, and digital worlds. Figure 1 below depicts the components and characteristics of some of these 4IR technologies. The components include cloud computing, network security, IoT, big data, robotics, and Virtual Reality, whereas the characteristics incorporate data, integration, innovation, interconnectedness, and transitioning capabilities (Yusuf et al., 2020). According to Ayanwale (2023), applying 4IR technologies revolutionises work, social and educational spaces. There seems to be consensus by the previous authors on this subject that the 4IR will bring rapid societal changes, more so than the previous industrial revolutions (Haynes, 2022).

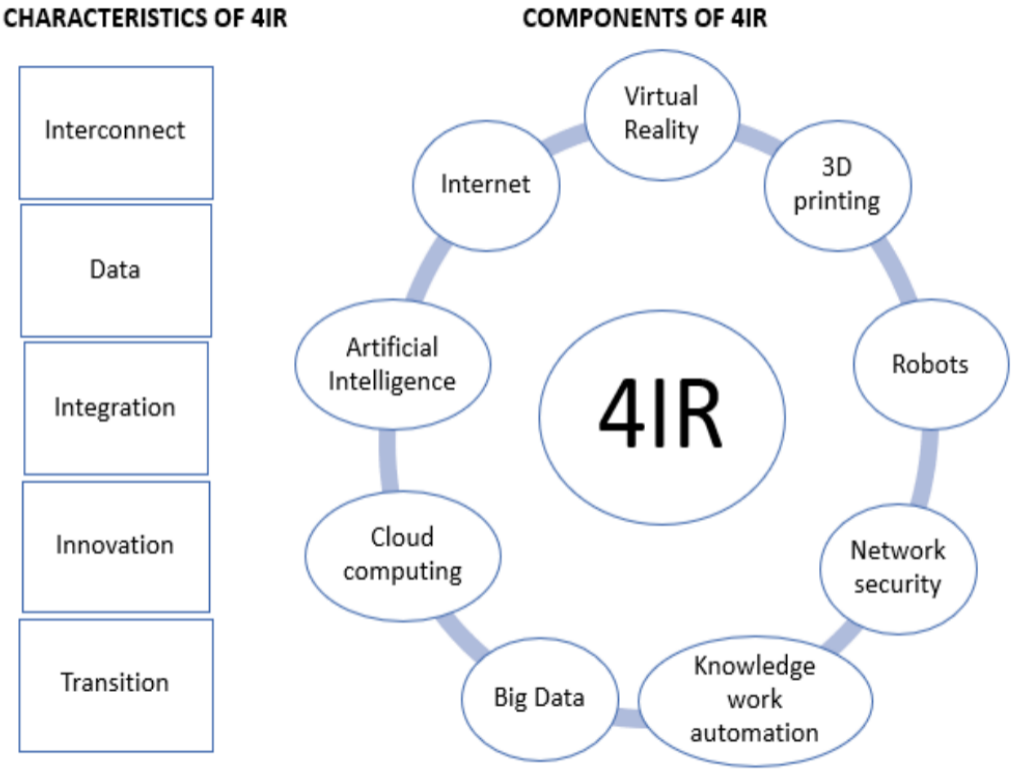

Figure 1: 4IR technology components and characteristics (Yusuf et al., 2020:95)

2.2 Definition of Topic

Education 4.0.

Education 4.0. describes the transformation of education as a direct response to the requirements of the 4IR on society (Ramírez-Montoya et al., 2021). Ayanwale (2023) emphasises the complexity and dialectical nature of the opportunities presented by 4IR education and its power to transform society. Hussin (2018) posits that Education 4.0 addresses the needs of the 4IR by aligning technology and human interaction to facilitate never-thought-possibilities.

In addition, Moloi and Mhlanga (2021) highlight that education 4.0, together with the emerging pedagogical strategies, is the answer to the much-needed reconfiguration of the education system to help address the increasing erosion of some industries and traditional employment opportunities due to the proliferation of these disruptive 4IR technologies. Fundamentally, authors in this field agree that the aim of Education 4.0 is to help learners master educational content by promoting collaborative learning styles and those that entrench critical thinking by adopting 4IR technologies in the classroom (Sikhakhane et al., 2020).

2.3 RQ 1: What is the perceived value of implementing 4IR technologies in public high schools?

The diffusion of 4IR technologies occurs exponentially across various industries, including the education sector (Oke & Fernandes, 2020). This transformation calls for humans with the capability for data and digital literacy (Alakrash et al.,2020). The inculcation of these skills can be facilitated through education and learning using 4IR technologies (Narh-Kert, 2022). Some key 4IR technologies schools can implement to attain these capabilities include AI-enabled technologies like machine learning, augmented reality, gamification, IoT, 3D printing, robotics, digital tutors, and learning analytics through big data (Vaughan, 2023). Sihkakhane et al. (2020) found that using and adopting intelligent technologies in the classroom is critical in promoting meaningful learner interactions. In corroboration, Almeida (2020) asserts that digital technologies augment and transform learning. Whalley et al. (2021) make the point that whilst education policymakers would still be responsible for the crafting of a formal curriculum, learners would now be allowed to personalise their learning experiences by utilising various 4IR technology tools and techniques as self-pacing instruments (Whalley et al., 2021).

Munikwa and Mapara (2022) supplement this point of view by adding that curriculum development in education 4.0 will be co-created by both policymakers and learners by incorporating their inputs.

Perhaps one of the more fundamental reasons why it is essential to implement 4IR technologies in public schools is their capacity to enhance education and bridge the challenges presented by the digital divide by enabling access to quality education even in less affluent schools (Fakomogbon, 2022).

2.3.1. Proposition 1

4IR technologies may assist to improve the quality of education in public high schools by offering learners access to learning experiences that are more tailored and personalised, thereby exposing them to the principles of active learning and preparing them for the future world of work.

2.4 RQ 2: How can 4IR technologies be used to improve the quality of education in public high schools?

Hart (2023) states that one of the most effective instructional strategies in the classroom can be achieved by teaching with education technology due to its ability to deliver learning environments that are interactive and collaborative. For this reason, Hussin (2018) postulates that 4IR technologies can be utilised in the learning process in ways that support curiosity, innovation, and the capacity to solve problems. In support of this sentiment, Van et al. (2021) assert that as a tool, technology is effective in anchoring the learning process, hence the gradual shift from traditional to digital approaches that support 4IR tools. Thus, schools must be deliberate in creating environments that facilitate learning using physical and digital tools like 4IR technologies (Meehir, 2023).

4IR technologies and tools can be incorporated into the learning environment to improve and enhance learning outcomes in some of the following identified ways:

2.4.1. AI in learning

Cope et al. (2020) define *Artificial Intelligence* as a discipline that defines a machine's ability to learn, engage, and respond as human beings do. From an educational perspective, AI can enhance learning outcomes by enabling personalised learning (Holmes, 2018). According to Agus and Samuri (2018), personalised learning can be achieved with learning analytics by using behavioural patterns to enhance learning quality. In practical terms, personalised learning means learner experiences can be customised to fit their personal learning requirements by adjusting activities like the speed of learning, use of educational content and the learning sequence (Carvalho et al., 2022). From an educator's perspective, AI allows for data-driven insights where specific learner data, such as examination results or behaviour patterns, can be collected, consolidated, and analysed (Meerhir, 2023). According to Custer et al. (2018), meaningful data insights allow educators to understand each learner better, thereby enabling them to design personal learning experiences.

2.4.2. Internet of things

Gartner (2016) defines IoT as an interlinked network of physical devices containing embedded technology which enables communication, sensing and/ or engagement between the various internal states of these devices and their external environment. Zeeshan et al. (2022) describe it as a technology employed to collect data which is in turn transmitted to various other devices that are connected to the internet. From an education perspective, IoT is given effect through the rising demand and popularity of mobile gadgets, which enable prompt engagements between learners and educators in and out of the classroom (Halili, 2019). Research conducted by eMarketer estimates that 83.2% of children aged 12 to 17 own a smart phone, making high schools a conducive environment to integrate IoT for educational purposes (Insider Intelligence, 2023).

Velazquez (2022) states that Internet enabled and connected devices like interactive white boards, computers, smartphones, and tablets improve the learning experience by making it convenient and more engaging.

Learners can now automate activities like taking notes, conduct research and engage with both their peers and educators.

2.4.3. Immersive Virtual Reality

There is great potential to revolutionise education through the incorporation of virtual reality as part of the process and practise of learning (Kaura et al., 2020). By immersing learners in simulations that are both realistic and interactive, VR enables learning in an engaging yet effective manner (Oranç & Küntay, 2019). In agreement, Yip et al. (2019) assert that immersive learning though virtual reality offers an alternative to traditional learning experiences in the classroom. Virtual reality has application in various high school subjects. In support of this Makransky (2017) affirms that real world environments and scientific experiments can be simulated using VR, affording learners the opportunity to explore concepts that are complex in nature but conducted in environments that are safe and controlled. In subjects like history or similar cultural studies VR can be used as an instrument for transporting learners through time and across various cultures, providing them with personalised experiences of historic or cultural sites and events that they ordinarily would not have had the opportunity to encounter (Donally, 2023).

2.4.4. Gamification

Gamification is the incorporation of distinctive game components like rules and point system within non-gaming contexts to foster collaboration and interaction (Almeida & Simoes, 2018).

Gamification is an emergent application which leverages the popularisation of games as problem solving tools that enhance the learning process (Alsawaier, 2017). Loganathan (2019) advances that gamification is an ideal solution for educators who have the great responsibility of not only engaging learners in the digital era but keeping them interested and attentive throughout the learning process. From a curriculum perspective, it is not necessary for gamification to be used as a tool to replace traditional methods of teaching, it can be used to rather augment learning through the incorporation of fundamental ideas used in gamification (Yunyongying, 2014). Khan Academy is one of the known successful implementors of gamification through the successful integration of gaming components into their computer science learning platform (McKain, 2019).

2.4.5. 3D printing

3D printing is a process whereby three-dimensional models are produced using digital files, typically achieved by setting down numerous layers of a material (Pai et al., 2018). 3D printing is pegged to potentially be one of the next biggest technological revolutions with significant applications across various key industries (Lewis, 2023). In their article on how 3D printing can be applied in teaching STEM subjects, Sun and Li (2018) highlighted some of the following key applications:

Physical science and biology - 3D printing can be used to print molecules made from three-dimensional models for chemistry and for biology three-dimensional cells, organs and viruses can also be printed.

Engineering - Three-dimensional prototypes can be formed to teach learners about the process of design and bringing ideas to life.

Mathematics – building three-dimensional models utilising mathematical concepts.

2.4.6. Cloud Computing

The provision of on-demand computing solutions and resources such as databases, storage, networking, servers, and software over the Internet removing the requirement for on-site hosting of physical infrastructure is referred to as Cloud Computing (Susnjara & Smalley, 2024). Cloud computing has various applications in education, including using cloud storage to facilitate collaborative group project interactions for real-time document and resource sharing, fostering teamwork and communication among educators and learners. (Govea et al., 2023).

2.4.7. Simulations

Simulations are the replication of real-world situations, practices, and processes through models that are computer generated, allowing users to engage in environments that are safe and controlled (Lamé & Simmons, 2020). Simulations are practical for experiential learning activities in the classroom, offering learners immersive experiences (Ding & Li, 2022).

2.4.8. Artificial Intelligence

According to Li and Wang (2023), Artificial Intelligence refers to Intelligent machines that are developed through algorithms and data analysis to simulate human cognitive functions, like learning, solving problems, and making decisions.

Neendoor (2023) posits that AI within educational contexts can be used to deliver personalised learning objectives to suit individual learner requirements through data-driven platforms, offer customisable tutoring using intelligent tutoring technologies and enable prompt exam or task results through automated grading solutions, thus empowering educators to focus on individual learner needs and complex topics.

2.4.9. Proposition *2*

4IR technologies can offer a broad range of digital resources that can be used as tools to facilitate interactive learning by providing learners with opportunities to engage in real-life problem solving, be more creative, innovate and more collaborative.

2.5. RQ 3: What are the challenges faced by educators in incorporating 4IR technologies into their teaching strategies?

The 4IR impresses upon the education sector to produce learners with the aptitude for critical thinking, capacity to solve complex problems and digital literacy (Moloi & Mhlanga, 2021). Consequently, educators are tasked with the responsibility of helping learners acquire these skills by developing and incorporating contemporary methodologies and related resources in their preparation and planning process (Ramírez-Montoya et al., 2021). One of the most important and influential elements in the effective adoption and implementation of 4IR technologies in the classroom is the educator's capability in effectively integrating these technologies in the learning process (Hameed & Hashim, 2022). In concurrence Avelino and Ismail (2021) highlight the importance in examining the educators' level of understanding and preparedness in incorporating 4IR technologies and related tools in their teaching approaches. To this end, Sikhakhane et al. (2020) emphasises the necessity in aligning the required changes in teaching approaches with the pervasive digital technologies in contemplation of the changing times. These calculated shifts are key in promoting 4IR teaching strategies as they help tackle concerns around the effective engagement of learners during teaching and learning engagements in the classroom Lazarov (2018). According to Kaewchote and Wattanathum (2022) teacher development is a crucial component in learner development and thereby greatly impacts educational outcomes.

There however seems to be general developmental gaps in preparing educators for 4IR teaching practices in schools (Sikhakhane et al., 2020). In further articulating this point Sikhakhane et al. (2020) reveal that traditional teaching models which are educator centred are still very much prevalent in education. Oke and Fernandes (2020) attribute this lack of change to the education sector's limited understanding in terms of the necessary methodologies and approaches required for the effective use and adoption of 4IR technologies in the teaching process, particularly in Africa.

2.5.1. Proposition 3

Schools that provide educators with required training on key teaching strategies vital in facilitating the incorporation of 4IR technologies in the process of learning will be more successful in adopting these technologies than those that do not.

2.6. RQ 4: What are the main barriers to the adoption and implementation of 4IR technologies in public high schools?

Hart (2023) attributes the challenge in incorporating technological pedagogy in some South African schools to the lack of training for educators along with inadequate access to technology and associated digital devices like computers, educational software, smartboards, and tablets. Additionally, Infrastructural challenges in schools like poor access to electricity and the Internet means these digital devices cannot be utilised for the implementation of 4IR technologies in the classroom (Carrim, 2022). Furthermore, Malomane et al. (2022) highlights that the lack of suitable skills to use and support digital technologies is a contributing factor in properly implementing 4IR tools in schools.

Added to this list of challenges is the main contributor to not being able to effectively deploy 4IR technologies in some South African schools, that being limited financial resources to fund the procurement of these tools (kayembe & Nel, 2019).

2.6.1. Proposition 4

The challenges influencing the adoption and implementation of 4IR technologies in public high schools include the lack of access to technology and related digital tools, poor infrastructure, insufficient funding, and inadequate teacher training.

2.7. ANALYTICAL FRAMEWORK

2.7.1. Theoretical Framework: The Unified Theory of Acceptance and Use of Technology

Over the years, extensive research has been conducted to understand the drivers of technology acceptance and adoption (Marikyan & Papagiannidis, 2023). As a result, numerous studies have resulted in significant evidence linking the behaviour of users to the adoption of technology (Hu et al., 1999). Kiwanuka (2015), however, notes the interchangeable use of the terms acceptance and adoption and thus offers a distinction as follows: acceptance is the continuous use of technology, whereas adoption is the first-time use of technology. On the other hand, Biljon and Renaud (2008) define adoption from the perspective of first being aware of the technology, then embracing it, and ultimately using it completely, while acceptance is related to user attitudes that are influenced by various factors about the technology. The different definitions provided indicate the need for a definitive definition which can be universally accepted and used for these terms, notwithstanding their continuous use in technology studies (Kiwanuka, 2015).

Using theories and models in research is extremely important as they guide the process of research (Consultores, 2021). To this end, various potential theories were identified to underpin the current study, including those emanating from numerous empirical studies which focused on understanding the behaviour of users that leads to the eventual adoption of technology, including the theory of planned behaviour (TPB) and the technology acceptance model (TAM) (Ajzen, 1991); (Davis, 1989). To elaborate, TPB is a cognitive theory by Ajzen (1991) which proposes that intentions influence behaviour, thereby influencing three key factors: subjective norms, attitudes, and perceived behavioural control. When applied to the adoption of technology, TPB as an intention-based theory suggests that the intention by users to interact with technology will be influenced by the user's attitudes towards the use of particular technologies, the assumed social pressure to engage with them and the perceived control over the engagement thereof (Siragusa & Dixon, 2008).

Brookes (2023), however, highlights that it is possible to have exogenous factors directly influencing or inhibiting behaviour irrespective of the intention. According to Kim and Crowston (2012), TPB, as a framework, offers a theoretical background for TAM as a theory applied to understand technology adoption. TAM asserts two key factors influencing potential users' acceptance of a particular technology: its perceived usefulness and ease of use (Davis, 1989). Based on TAM, technology acceptance happens in three steps; first are the cognitive level responses, in the form of perceived ease of use and perceived usefulness, which then formulate affective level responses of user attitudes towards the use of technology, which ultimately influence the usage behaviour (Davis, 1989); (Davis, 1993).

However, researchers noted that TAM in its original format, much like its antecedent TPB, has been applied in empirical research more as a measure of behavioural intention to adopt and use technology instead of behaviour leading towards actual acceptance (Oke & Fernandes, 2020). TAM has subsequently evolved into various iterations, TAM2 and TAM3, in which additional factors influencing behavioural intention, like age, social influence, and gender, have been incorporated (Venkatesh & Davis, 2000).

These modifications must still address behavioural acceptance and applicability to settings outside the organisation and other settings (Kim & Crowston, 2012). The noted limitations of TPB and TAM thus render these two frameworks inadequate for the current study. In response to these shortcomings, Venkatesh et al. (2003) developed a Unified Theory of Acceptance and Use of Technology (UTAUT) model by consolidating eight competing adoption theories. The considered theories making up UTAUT include the Theory of Reasoned Action (TRA), TPB, TAM, TAM2, Social Cognitive Theory (SCT), Diffusion of Innovation theory (DIT), Model of PC Utilisation (MPCU), and Combined Technology Acceptance Model (CTAM) (Venkatesh et al., 2003).

The UTAUT framework was, therefore found to be appropriate to underpin the current study for various reasons, including that its formulation has incorporated and reflected various philosophical perspectives and worldviews relating to technology adoption (Marikyan & Papagiannidis, 2023). Some of the existing studies in education have focused more on the benefits of employing and incorporating intelligent technologies in the learning process. In this regard, Narh-Kert (2022) investigated the impact of 4IR technologies on skills development in the classroom. Sihkakhane et al. (2020) explored innovative technologies' influence on promoting meaningful learner interactions for optimal educational outcomes. Almeida (2020) investigated the transformative power of digital technologies in the classroom. However, the current study sought to investigate schools' readiness level in adopting 4IR technologies within the context of Education 4.0. As such, the choice of UTAUT as a framework was both relevant and appropriate. It provided a practical foundation for the study in that it helped address user acceptance issues, which is central to determining the schools' readiness to adopt 4IR technologies. According to Venkatesh et al. (2003) UTAUT as a framework can be useful in proving context and understanding of the factors that may influence the schools' decisions to adopt and integrate 4IR technologies into their educational practices.

Additionally, the framework allows for the exploration of the various aspects of school readiness, including how schools view the potential of these technologies, the perceived ease of implementation and use, the level of support or pressure felt by school staff, and finally, the adequacy of a school's infrastructure and resources to handle these new technologies (Venkatesh et al., 2003).

The current study also built upon other existing studies that sought to highlight the importance of innovative teaching methods and 4IR technologies in education (Mawas & Muntean, 2018); (Ayanwale, 2023); (Oke & Fernades, 2020). The application of UTAUT as a theory to underpin educational studies thus complemented this existing knowledge as it helped to examine further the specific factors affecting technology adoption readiness within educational contexts (Lock & Shihah, 2021).

As depicted in Figure 1 below, UTAUT infers that four essential components drive technology acceptance: performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003). Venkatesh et al. (2003) further elaborated on these components as follows: performance expectancy, which speaks to the belief that the use of technology improves performance; effort expectancy, defined as the extent to which users believe that the technology will be easy to use, social influence speaks to the belief of those who are deemed necessary in the system on whether they believe technology should be used and finally, the facilitating conditions defined as the level of the individual's belief that there are sufficient resources like technical infrastructure available to support the use of the technology.

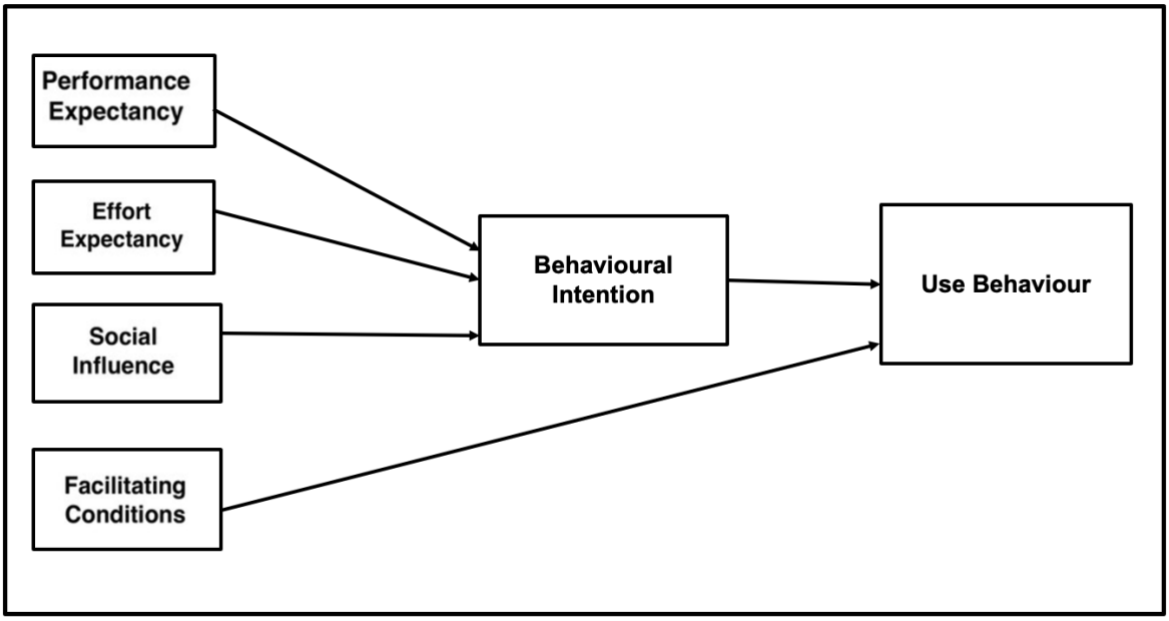

Figure 2: UTAUT model without moderators: gender, age, and voluntariness of use (Osswald et al., 2012: 4)

UTAUT is a model previously applied to numerous contexts, including educational environments, and has been proven valid and dependable as a predictor of technology adoption (Abbad, 2021). As a predictive model, UTAUT was helpful in the current study as it played a significant role in helping to predict and determine the impact of the potential adoption of 4IR technologies in public schools that have not yet introduced these technologies (Taiwo & Downe, 2013).

Additionally, applying this model to the current study helped in effectively providing an understanding of the critical factors that drive technology adoption in schools. The four constructs of UTAUT, as mentioned above, were applied to the current study in some of the following ways (Venkatesh et al., 2003):

Expectancy to perform: This element helped to establish whether using and implementing 4IR technologies in schools could influence and improve learning outcomes. It again helped in yielding insights on whether the stakeholders at the school level believed that 4IR technologies could influence the quality of education.

Effort expectancy: This element helped establish the ease of use and applicability of 4IR technologies in the classroom, particularly by educators during the educational process. Also, effort expectancy as a component of UTAUT helped uncover factors that make it difficult to adopt these technologies in public schooling environments, like the lack of resources.

Social influence: This element was used to assess the perceptions of those deemed important in the system, like educators, and their beliefs about whether 4IR technologies should be implemented in the classroom.

Facilitating conditions: This element was useful in assessing whether the school environment provides the necessary resources and support for using 4IR technologies, such as computers, internet connectivity, and electricity.

In conclusion, UTAUT is usually applied with experience, age, gender, and voluntariness of use as moderating factors that lead to the behavioural intention of technology use. However, in the current study context, these factors were excluded to reduce complexity. Additionally, the current study focused on the generic assessment of the level of adoption of 4IR technologies in fee-paying public high schools in Gauteng. As such, the factors that would necessarily influence technology adoption in this context were likely universal and not so much dependent on individualised characteristics like age, experience, voluntariness of use and gender. The primary constructs of UTAUT were more relevant. Finally, UTAUT as a model used to underpin the current study was an effective tool in helping to provide an understanding of the various factors with the potential to influence the adoption of 4IR technologies in fee-paying public high schools.

2.7.2. Conceptual Framework

It has been established that technology plays a significant role in delivering the objectives of Education 4.0. However, certain factors must be in place for 4IR technologies to be adopted and implemented in the learning process. To this end, Ramaila and Molwele (2022) have identified the factors driving the level of readiness in using and adopting these technologies in schools and the learning process, such as access to 4IR technologies, educator training, access to funding, and school infrastructure. The conceptual model in Figure 3 below shows the causal relationship between these factors and the readiness to adopt and implement 4IR technologies.

Access to 4IR technologies speaks to the importance of having access to them to derive benefits from using them in the learning process (Kayembe & Nel, 2019). Ensuring that schools are furnished with these technologies as required is critical to achieving the goals of Education 4.0. (Ahmad et al., 2023). Educator training focuses on the level of training educators possess in terms of how they use and apply 4IR technologies when delivering educational content during the learning process as another facilitating factor towards adoption (Oke & Fernandes, 2020). Educators trained to incorporate 4IR technologies in their teaching practices will be more likely to adopt and use them effectively (Sikhakhane et al., 2020).

School infrastructure, such as the availability of electricity and internet access, can also affect the level of readiness for the adoption of 4IR technologies. Schools with good infrastructure will be better positioned to support adopting and using 4IR technologies (McCain, 2022). Finally, access to funding is another critical factor; with it, the adoption and implementation of 4IR technologies would be easier (Mlaba, 2021).

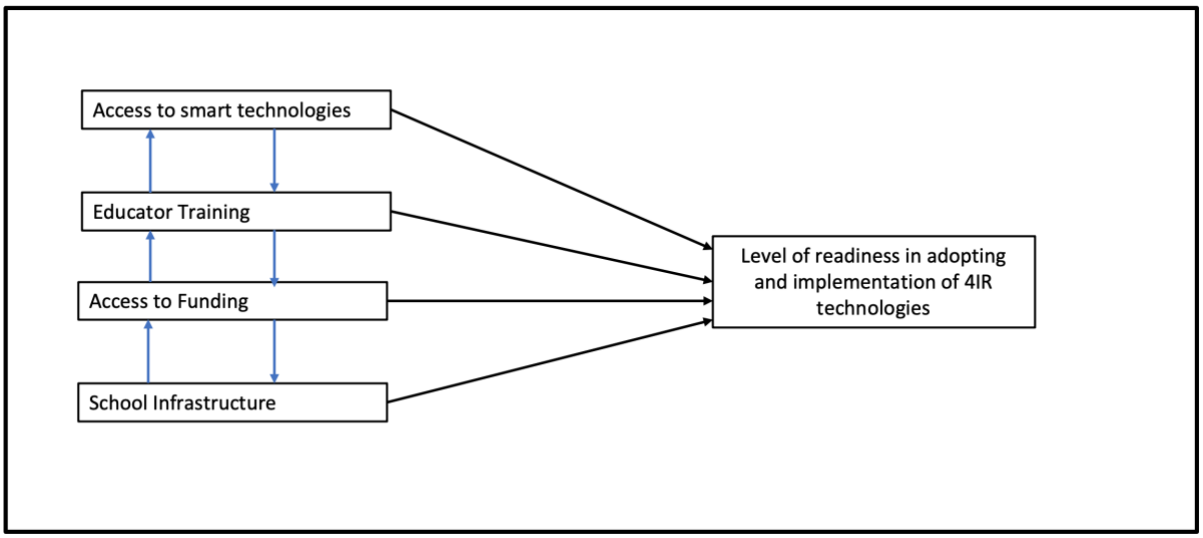

Figure 3: Conceptual framework depicting the factors impacting the level of readiness in adopting 4IR Technologies in the facilitation of Education 4.0.

2.8. Conclusion of Literature Review

In summary, Education 4.0. is characterised by 4IR technologies like Artificial Intelligence (AI), the Internet of Things (IoT), big data, data analytics, Machine Learning (ML), gamification, and Augmented Reality (AR).

Current literature on this topic highlights the disruptive nature of 4IR technologies specifically in the education sector, particularly in how it has brought about fundamental changes in the way education is delivered in the classroom. The effective adoption of these technologies in educational spaces is important as this helps in influencing the intended educational outcomes in alignment with the objectives of Education 4.0. To this end, the application of a technology adoption model like UTAUT was important in bringing into perspective those behavioural factors impacting use and adoption of technologies, such that these can be taken into consideration when implementing 4IR technologies in schools.

The developed conceptual framework highlighted that if the identified factors, being access to 4IR technologies, educator training, access to funding and school infrastructure are not in place, then the level of readiness in adopting and implementation 4IR technologies in the learning process would be negatively impacted. Which in turn means that the key imperatives of Education 4.0 cannot be realised. It is therefore important that a concerted effort be made particularly on the part of policy makers to ensure that these factors are attended to.

2.8.1. Proposition 1

4IR technologies hold the potential to elevate the quality of education in public high schools by offering learners more personalised and tailored learning experiences, immersing them in active learning principles and preparing them for the demands of the future work contexts.

2.8.2. Proposition 2

4IR technologies can provide a vast array of digital resources that serve as tools to foster interactive learning, empowering learners to engage in real-world problem-solving, cultivate creativity and innovation, and collaborate more effectively.

2.8.3. Proposition 3

Schools that equip educators with the necessary training in key teaching strategies that are instrumental in facilitating the incorporation of 4IR technologies into the learning process are likely to achieve greater success in adopting these technologies compared to those that do not.

2.8.4. Proposition 4

The adoption and implementation of 4IR technologies in public high schools are potentially hindered by challenges such as limited access to technology and related digital tools, inadequate infrastructure, insufficient funding, and a lack of comprehensive teacher training.

Overall, the articulated propositions suggest that 4IR technologies have the potential to significantly improve the quality of education in public high schools. However, the successful adoption and implementation thereof is dependent on some the key challenges such as the lack of access to technology, poor infrastructure, and inadequate teacher training being addressed.

3. RESEARCH METHODOLOGY

3.1. Introduction

The 4IR is characterised by the fast-paced development and adoption of new 4IR technologies such as artificial intelligence, machine learning, gamification robotics and virtual reality (Marr, 2019). The current study assessed the adoption and implementation of these technologies in South African fee-paying public high schools in Gauteng within the context of Education 4.0. Education 4.0 as a paradigm focuses on using 4IR technologies to personalise educational interactions and related outcomes for learners (Dervojeda, 2021). 4IR technologies can disrupt humans' lives and work (Moloi & Mhlanga, 2021). The witnessed disruption cuts across industries, including the education sector (WEF, 2018)

The South African Basic Education Department has acknowledged the growing need to prepare learners for the 4IR, specifically in the public school system, as they have announced plans to introduce robotics into the curriculum for grades 3 to 7 (Motshekga, 2019). However, the level of readiness of South African public schools to adopt and implement these technologies requires clarification. Access to the various technologies, along with educator training on how to effectively incorporate these technologies into the teaching process, access to funding and potential infrastructural challenges influencing the levels of adoption of these technologies are also still being determined. To this end, the current study aimed to investigate the influence of the identified factors by conducting research to assess the level of readiness in adopting and implementing these technologies, with a particular focus on fee-paying public high schools in Gauteng.

3.2. Research approach:

A qualitative research approach was adopted for the current study. The naturalistic investigative process of qualitative research aims to find an understanding of social phenomena (Haradhan, 2018). In a qualitative study, methods which focus on gaining more precise insights into the social phenomenon under investigation are employed as an approach to research (Tenny et al., 2022). In this regard, qualitative research was most suited to undertake a study assessing the level of readiness in the adoption of 4IR technologies in fee-paying public high schools in Gauteng because, as an approach, it enabled deep exploration of those complex factors at play (Jain, 2023).

The qualitative nature of the outlined research questions below for the current study necessitated in-depth analyses and exploration, which helped to gain the necessary insights into the experiences and perspectives of the key stakeholders within the educational ecosystem, as follows:

RQ1: What is the perceived value in implementing 4IR technologies in public schools?

The engagement with critical stakeholders in education, including junior and senior educators alongside officials from the Gauteng Department of Basic Education, yielded valuable insights and contributions. The research participants' first-hand accounts and experiences proved insightful as they shared their perspectives on the importance of 4IR technologies and their potential to enhance educational goals. Additionally, the participants demonstrated a firm grasp of 4IR concepts and Education 4.0. These insights helped identify potential roadblocks and opportunities associated with the perceived value of adopting and implementing 4IR technologies in classrooms. However, the research also revealed these stakeholders' subjective experiences and beliefs.

RQ2: How can 4IR technologies be used to improve the quality of education in high schools?

To understand how 4IR technologies could improve the quality of education in Gauteng's fee-paying public high schools, educators were interviewed about their experiences using these technologies for educational improvement. Their specific requirements for enhancing educational quality through 4IR technologies were also investigated. Additionally, concerns regarding potential impediments to such improvement were explored. The qualitative research approach employed in the study facilitated an in-depth understanding of the challenges educators and schools face when attempting to incorporate 4IR technologies in the classroom. This research approach was crucial for identifying how educators could leverage these technologies to address those challenges. Furthermore, the research approach facilitated data collection on stakeholder perspectives regarding using 4IR technologies to implement Education 4.0 objectives, such as personalised learning, instantaneous feedback from learners, responsible technology use, and more engaging learning experiences.

RQ3: What are the challenges faced by educators in incorporating 4IR technologies into their teaching methodologies?

Qualitative research methodologies can explore the varied and multifaceted challenges educators face in integrating 4IR technologies into their teaching strategies. Engaging relevant stakeholders, particularly those most affected within the system, can identify the factors contributing to these challenges. The insights gleaned from such interactions can then be integrated into the research process, particularly to inform the development of strategies that could assist educators in overcoming these challenges, which is one of the study's aims.

RQ4: Which barriers exist to the adoption and implementation of 4IR technologies in public high schools?

Semi-structured interviews were used to collect data from various stakeholders within the educational ecosystem to understand the main barriers to adopting and implementing 4IR technologies in Gauteng's fee-paying public high schools. These stakeholders included school educators and Department of Basic Education district officials. Through these interviews, insights were gathered concerning the barriers that hinder the adoption and implementation of 4IR technologies.

Conclusion

After analysing the articulated justifications above, a qualitative research approach was identified as the most suitable method for this study. This approach aimed to gain deep insights and understanding of the complex interplay of factors influencing the readiness of Gauteng's fee-paying public high schools to adopt and implement 4IR technologies and related Education 4.0 methodologies.

Assumptions

Qualitative studies assume that reality is subjective, which means that a single acceptable or correct response cannot be provided for any of the research questions posed (Shah, 2019). For the current study, the assumptions for employing qualitative research as an approach were considered suitable for the identified research questions and related propositions. These research questions sought an understanding of the perspectives of the various stakeholders in the system of interest. In this regard, it was suggested by the identified propositions that various approaches towards addressing the potential challenges were possible.

The current study also assumed the following in terms of using qualitative research as an approach:

i. The researcher was the principal instrument for collecting and analysing data.

ii. There was a deep understanding of the research context

iii. During the research process, the researcher displayed flexibility and adaptability.

iv. Room for new perspectives, interpretations, and insights was made available to the researcher.

The research process was designed to embrace the flexibility and adaptability of the identified assumptions. The study's evolving needs were accommodated, and the identified participants were considered. This approach fostered a comprehensive understanding of the issues, encouraging openness to new perspectives, interpretations, and insights, thereby creating a space for innovation and discovery.

3.3. Research Design

The appropriateness of using generic qualitative research design for this study was determined by its flexibility (Ellis & Hart, 2023). This approach is particularly well-suited for studies of an exploratory nature that aim to gather perspectives and insights from various stakeholders (Bellamy et al., 2016).

The suitability of a generic qualitative approach for the research questions of the current study was explored in detail as follows:

Using generic qualitative research methodologies, data was collected to explore the perceived benefits of 4IR technologies in education, as the identified educational stakeholders envisioned.

RQ1 focused on exploring the importance of implementing 4IR technologies in public high schools, which was addressed by collecting data from participants to gain insights into how these technologies could impact educational outcomes. RQ2 aimed to establish the practical application of 4IR technologies in learning. In this regard, educators were asked to provide insights on how these technologies could be integrated into their lessons and teaching strategies in the classroom. RQ3 asked about the training of public high school teachers on the teaching strategies necessary to support the adoption and implementation of 4IR technologies. To this end, educators were asked to provide specific accounts of the challenges faced when delivering lessons using 4IR technologies in the classroom to get a sense of their level of training and related proficiency. RQ4 aimed to establish the potential challenges influencing the adoption and implementation of 4IR technologies in public high schools. In response, questions were posed to key stakeholders through interviews to determine the status quo.

The advantages of using generic qualitative research approaches for the current study included:

i. The ability to tailor and adjust research methods that were able to meet the specific requirements of the study instead of being restricted by the rigid structure of specific qualitative design methods (Ellis & Hart, 2023).

ii. It allowed for deep insights into participants' experiences by using various methods to collect data (Ellis & Hart, 2023).

The disadvantages of using a generic qualitative approach for this study included:

i. Qualitative research, despite it being generic, was expensive and time-consuming due to factors like travel costs, the cost of interview transcriptions and the researcher's and participant's time (Prosek & Gibson, 2021)

ii. The data analysis process was a lengthy one (Bingham, 2023)

iii. DBE approvals were required before engaging identified participants; this action caused delays.

iv. Key ethical considerations were considered, and failure to do so would have posed a risk.

3.4. Data collection methods

For the current study, semi-structured interviews were chosen as the method of data collection.

Semi-Structured interviews

According to Adams (2015), semi-structured interviews are a combination of structured and unstructured interviews. Adams (2015) further asserted that this data collection method allows the opportunity to engage in in-depth conversations with a variety of relevant participants. The gathering of various perspectives was then facilitated, particularly on the perceived significance, practical application, and related impediments in adopting and implementing 4IR technologies in fee-public high schools in Gauteng within the context of Education 4.0. With semi-structured interviews, customisation of the identified research questions allowed the study to probe for further information. The interviews were designed to be open-ended, facilitating a free-flowing interaction and conversation with participants. The interviews were either conducted in person or online.

3.5. Sample

3.5.1. Sample and sampling method:

Sample Size

The total sample size comprised eleven participants. The current study employed a generic qualitative research approach, using an open-ended questionnaire as a data collection instrument. This method of data collection provided the opportunity to engage in in-depth conversations with the identified participants, resulting in a point of saturation with this sample size.

Sampling Method: Snowball sampling

This study used snowball sampling to identify participants. As a non-probability sampling technique, snowball sampling allowed for identifying and engaging initial participants, who, in turn, helped identify other participants who met the required criteria (Johnson, 2014). This procedure was repeated until the requisite number of participants was reached.

Selection Criteria of Target Sample:

The target sample selection criteria included participants who had lived experiences within the target environment and who possessed some level of understanding about the factors, challenges, and reasons influencing the adoption of 4IR technologies in their environment. It was required that the participants be full-time qualified educators at fee-paying public high schools in Gauteng and district officials in the DBE.

Target Sample:

As per the snowball sampling method the following process was followed:

Initial Contact: The research began by telephonically contacting a district official from the Gauteng Department of Basic Education (GDE). This individual has a comprehensive understanding of the schools within their district. The district official was the first participant interviewed. They were asked to recommend an educator within one of the identified districts during the interview.

Chain Reaction: The educator identified by the district official was contacted and interviewed. Following the interview, this educator was asked to recommend another educator in a different district who could provide insights specific to their school's context. This process continued until educators from fee-paying public high schools in the four main districts within Gauteng were included in the study.

Gauteng fee-paying public high schools are split into 4 main districts, i.e. Johannesburg (JHB), Ekurhuleni, Sedibeng and Tshwane and further split based on the principal directional points where applicable. For representation purposes, the plan was to interview participants from each of the four main districts. However, participants from Sedibeng district could not be reached for participation. To this end, participants from three of the four main districts were interviewed as part of the study as follows: Johannesburg North= 1, Johannesburg South =1, Ekurhuleni North = 1, Sedibeng = 1, Tshwane East = 2, Tshwane West 2, Tshwane South = 2 and The Gauteng Department of Education district office = 1. The initial participants were referred by the district official as outlined above.

The study's purpose and importance were made known to the participants to ensure maximum participation. The research procedure, including the anticipated duration of the study, was outlined. During the interview, the participants' comfort was always prioritised. A participation form was provided to the participants for signature to gain their approval to participate in the study.

The confidentiality of participants was ensured and upheld, with personal information not being included in the final report or findings of the study. Anonymity and confidentiality were ensured by assigning code names to each participant.

3.6. The Research Instrument

The research instrument used in the data collection process with the selected research participants was a semi-structured interview schedule (SEE ANNEXURE X). This interview schedule provided flexibility and allowed for an in-depth exploration of the developed research questions. It also provided a structured framework that focused on key topics.

The interview schedule was divided into five sections. The first section was the introduction of the study to the participants. The second section addressed each of the research questions as follows:

Section 1: Introduction to the study

Section 2: Perceived value of implementing 4IR technologies in schools.

Section 3: Use of 4IR technologies to improve education in the classroom.

Section 4: Challenges faced by educators in incorporating 4IR technologies in the learning process.

Section 5: Barriers to adoption and implementation of 4IR technologies in schools.

The interview schedule was designed to align with the study's research questions, literature, conceptual framework, and theoretical framework. The literature review identified vital benefits of using 4IR technologies in education, particularly in alignment with the imperatives of Education 4.0, including personalised learning and empowering learners to be more creative and innovative.

The interview schedule is designed to extract meaningful information from the research participants about their perceptions of the value of 4IR technologies, how they can be used to improve the quality of education, and the challenges and barriers that influence their adoption and implementation. The data collected from the interviews was used to respond to the research questions and come up with recommendations for improving the use of 4IR technologies in fee-paying public high schools in Gauteng. The instrument is attached to this proposal as Appendix X.

3.7. Procedure for data collection

Development of an interview guide.

A detailed interview guide with semi-structured, open-ended questions was developed by the researcher. This interview format allowed for a deep exploration of the research questions.

The interview process:

Interviews were conducted in-person and online with the identified participants.

Informed Consent

Informed consent was obtained in writing from each individual participant prior to the commencement of each interview. This process involved providing context of the purpose of the study and all related procedures.

3.8. Data analysis strategies and interpretation

The data collected through semi-structured interviews were analysed for the current study using inductive thematic analysis. Thematic analysis is a method of data analysis that emphasises identifying and describing ideas that are both explicit and implicit within the data through themes (Guest, 2014). The identified themes are represented using codes developed and applied as concise markers to the raw data, which are then later analysed (Guest, 2014). This inductive thematic approach was considered most suitable for the current study due to its flexible applicability, as it could be used to analyse various types of data, including interview transcripts from semi-structured interviews conducted with participants (Braun & Clarke, 2006). The various phases in the analysis process are outlined by the authors Braun and Clarke (2006) as six steps as follows:

Phase 1: Getting familiarised with the data, this step involved going through the interview transcripts iteratively to gain better understanding of the content.

Phase 2: Generating the codes, this step spoke to the identification of key phrases or words which represented different themes within the data.

Phase 3: The merging of codes into themes; this involved grouping related codes together.

Phase 4: Reviewing of themes; included the refining of themes.

Phase 5: Determining theme significance meant identifying important themes.

Phase 6: Drafting the results of the report; this spoke to drafting a narrative report in a concise yet clear manner.

These steps were followed for the application of a thematic analysis of the current study.

3.9. Quality Assurance

3.9.1. Transferability

In qualitative research, transferability is akin to validating research findings in the external environment in quantitative research or generalisability (Finfgeld-Connett, 2020).

In qualitative studies transferability speaks to the degree to which research findings can be applied to other settings, at a different point in time or other contexts (Patton, 2015). The current study focused on the perceived value of 4IR technologies, how they can be used to improve the quality of education, the challenges faced by educators in incorporating 4IR technologies into their teaching strategies, and the main barriers to the adoption and implementation of 4IR technologies. These are all factors that are relevant to the adoption of 4IR technologies in any educational setting, thus rendering the study transferrable to other contexts.

3.9.2. Credibility

Credibility is defined by Tracy (2010) as a measure of the accuracy, truth, and correctness of a qualitative study based on the research findings. In the current study, generic qualitative research was employed as a research design method, and data was collected through semi-structured interviews. Semi-structured interviews allowed for in-depth insights to be collected from various stakeholders in the target system. The interviewed participants shared their perceptions of the value, obstacles, and challenges to adopting and implementing 4IR technologies in public schools. These insights would be valuable for educational administrators and policymakers in informing their decisions when developing the required strategies to address these challenges. As such, this study is considered credible.

3.9.3. Dependability

It is affirmed by Stahl and King (2020) that dependability, closely associated with reliability, is an essential factor in the trustworthiness of a qualitative study as it measures the level of consistency and repeatability of the study based on the study's findings and the research methodologies used. A detailed description of the research methods to be adopted for the research, including the sampling approach, the procedure to be followed in collecting data, and the methods to be applied to analyse the collected data, were provided in the current study. The outlined research methodology would be helpful to other researchers interested in replicating the study.

3.10. Ethical considerations

The current study took the following ethical considerations into account:

- **Consent:** It was ensured that participants gave informed consent before commencing with interviews for the study. As part of this process, participants were given the background to the study and its aim. Participants were given a chance to ask clarity-seeking questions.
- **Confidentiality:** Participants' confidentiality was upheld and protected by the research. To this end, participants' personal information was not included as part of the final report or findings of the study.
- **Security of Data:** All data collected during the study was stored and kept in a password-protected laptop, and all data files were password-protected.
- **Minimisation of harm:** The study was designed and conducted in a manner that did not pose any risk to participants. To ensure this, potential risks of the study were always weighed alongside any possible benefits.
- **Benefits:** The study endeavoured to provide some benefits to participants, such as learning about 4IR technologies or contributing knowledge on the topic.

- **Withdrawal:** Participation in the current study was voluntary. Therefore, all participants were free to withdraw from engaging with the study at any point.

Table 1: Proposed schedule and timelines

Task	Detail	Timeline
Proposal Submission	Proposal submitted with all supporting documents for review by panel	13-Aug-23
Ethics Approval	Approval of ethics form	31-Aug-23
Research Panel Preview and Presentations	Presentation of proposal to research panel	31-Aug-23
Presentation outcome from panel	Feedback from panel – proposal outcome	4-Sep-23
Title approval	Title presented to PGC for approval	18-Sep-23
Conduct research	Collect data, analyse collected data and compile final research report	19-Sep-23 to Feb-24
First Draft submission (final proposal)	Draft sent to supervisor for sign-off	Feb-24
Final Report Submission	Final Report Submission	29 February 2024

CHAPTER 4: THE PRESENTATION OF RESEARCH FINDINGS

4.1. Introduction

The study approach and methodology were addressed in the preceding chapter. The current chapter delves into the thematic-based analysis of the data collected for the study, with the view to present the findings on the readiness of fee-paying public schools in Gauteng, South Africa, to adopt 4IR technologies in alignment with the principles of Education 4.0. Significantly, this chapter seeks to provide an account of any emerging themes from the collected data such that the perceptions regarding those factors influencing the adoption and implementation of 4IR technologies in the secondary public schooling sector are presented. To this end, thematic analysis was performed on the data collected through four central research questions (RQs) as follows:

RQ1: The perceived value of implementing 4IR technologies within public high schools.

RQ2: The potential of 4IR technologies to enhance the quality of education in public high schools.

RQ3: The challenges faced by educators in integrating 4IR technologies into their teaching methodologies.

RQ4: The barriers hindering the adoption and implementation of 4IR technologies in public high schools.

Underpinning this analysis were four research propositions that advanced potential challenges and benefits associated with integrating 4IR technologies in the Gauteng fee-paying public educational landscape. The propositions put forth in this regard affirmed that:

Proposition 1: 4IR technologies hold the potential to elevate the quality of education in public high schools by offering learners more personalised and tailored learning experiences, immersing them in active learning principles and preparing them for the demands of the future workplace.

Proposition 2: 4IR technologies can provide a vast array of digital resources that serve as tools to foster interactive learning, empowering learners to engage in real-world problem-solving, cultivate creativity and innovation, and collaborate more effectively.

Proposition 3: Schools that equip educators with the necessary training in key teaching strategies that are instrumental in facilitating the incorporation of 4IR technologies into the learning process are likely to achieve greater success in adopting these technologies compared to those that do not.

Proposition 4: The adoption and implementation of 4IR technologies in public high schools are potentially hindered by challenges such as limited access to technology and related digital tools, inadequate infrastructure, insufficient funding, and a lack of comprehensive teacher training.

4.1.1. Thematic Data analysis process

Braun and Clarke (2006) presented a theoretical process of thematic analysis, which was used as the key guiding principle upon which a meticulous examination of the data collected was analysed. This process included the following key steps:

First Step: Acquaintance with the data - This was achieved by carefully reading the collected data from the interview transcripts. This step also involved transcribing and editing the data, making notes, and identifying preliminary patterns in the data collected from the interviews.

Second Step: Coding of data – This involved the labelling of data, particularly the data with features consistent with the outlined research questions, propositions, and theoretical and conceptual frameworks.

Third step: Identification of themes – This step involved the identification and grouping of themes based on the identified codes, followed by the interpretation and presentation of the research findings:

This process helped uncover valuable insights by emphasising the experiences, perceptions, and challenges centred around adopting 4IR technologies in Gauteng's fee-paying public high schools. These findings are detailed in the sections to follow in this chapter, offering a nuanced understanding of the current state of 4IR readiness within fee-paying public secondary schooling institutions in Gauteng.

Guided by the Unified Theory of Acceptance and Use of Technology (UTAUT) framework, the study sought to comprehend the perceived value of 4IR technologies within the identified schools, their potential to enhance the quality of education along with the critical challenges faced by educators in practically integrating them into their teaching practices and the barriers hindering their adoption and implementation.

4.1.2. District Participation and Thematic Rate of Saturation

Also included in this chapter is the district participation in terms of the number of interviews conducted per district and the thematic rate of saturation. To collect data, all four of the main educational districts in the Gauteng province, i.e., Tshwane, Johannesburg, Ekurhuleni, and Sedibeng, were identified for the study. However, three of the four were reached for participation: Tshwane, Johannesburg, and Ekurhuleni.

From these three districts, ten participants from the sub-districts were identified, plus one district official from the Gauteng Provincial Education Department, to make up the sample size of eleven as follows:

Table 2: District participation

Sub-District: Department of Education	No. of Participants
Tshwane South	2
Tshwane West	3
Tshwane East	2
Johannesburg North	1
Johannesburg South	1
Ekurhuleni North	1
District Head office	1

4.1.3. Thematic Rate of Saturation

According to Hennink and Kaiser (2022), a thematic saturation rate speaks to a point in collecting data where the additional information gathered starts repeating and becoming redundant, such that no further insights are likely to be uncovered or new themes yielded. It effectively indicates that sufficient information has been gathered from which robust determinations about the study can be reached (Hennink & Kaiser, 2022). The table below represents the thematic saturation rate of the data collected for the current study.

Table 3: Thematic rate of saturation

District	Approached	Interviews	Consent	Response Rate
Tshwane South	2	2	2	100
Tshwane West	3	3	3	100
Johannesburg North	1	1	1	100
Johannesurg South	2	1	1	50
Tshwane East	2	2	2	100
District Head Office	1	1	1	100
Ekurhuleni North	1	1	1	100
Sedibeng North (Not Covered)	0	0	0	NaN
Total	12	11	11	91.67

Twelve participants were approached as the identified sample for the study. Eleven participants were however reached for interviews (91.66%). All eleven interviewed participants (100%) consented to participate in the study. Overall, the research achieved a 92.86% rate of response. Additionally, all targeted sub-districts apart from Sedibeng North were covered.

4.1.4. Demographic profile of respondents

According to Khalil et al. (2021), the demographic information of research participants is an essential factor in a research study as it brings to light the composition of the participants and their representation of the entirety of the study population. Additionally, demographics help in providing context to the study findings by offering an understanding of how the various participants might experience, express, and interpret the phenomenon under research. As such, this helps provide richer interpretations (Khalil et al., 2021).

The study included a diverse group of participants whose demographics are relevant to the study for the following reasons:

Experience: The study participants have vast experience ranging from 1 to 41 years. Thus, providing perspectives from both new and seasoned educators helped to provide a richer understanding of how the experience could influence the readiness for adopting 4IR technologies.

Roles: The sample included educators with specialities in varied subjects, including Physical Sciences, Mathematics, Life Sciences, Visual Arts, and Technology, an Educational Specialist, and a Deputy Principal. This diversity reflects different points of view at the school level and the broader educational ecosystem concerning 4IR adoption.

Leadership: Including a Deputy Principal and a Subject Committee member in the study helped offer critical insights into leadership perspectives and any potential challenges that could influence the implementation of 4IR technologies at the school level.

Expertise: Furthermore, the presence of educators teaching subjects like Coding and Robotics exposed the study to stakeholders with specialised knowledge and contextual experience in some of the vital 4IR areas.

Therefore, including these diverse demographics in the study offers a richer understanding of the factors influencing the readiness of South African fee-paying public high schools in Gauteng to adopt 4IR technologies in alignment with Education 4.0.

Table 4: Participant demographic profile

Participant No.	Profession	Subjects Taught	Years of Professional Service
1	- Head of Department: Physical sciences - Post Level 2 Educator	Physical Science, Coding and Robotics	30 years
2	- Acting Head of Department Social sciences - Post Level 2 Educator	Life Orientation, Mathematics, Coding and Robotics	23 years
3	Post Level 1 Educator	Life sciences: Natural science, Technology and Physical science	1 year
4	Post Level 1 Educator	Mathematics and Mathematical processing	2 years
5	Educational Specialist: Gauteng Provincial Education Department (GPEDU)	Head: Coding and Robotics implementation (Primary and Secondary public schools)	30 years
6	Post Level 1 Educator	Visual Arts, Coding and robotics	Educator: 9 years
7	Post Level 1 Educator	Natural Science and Technology	28 years
8	Deputy Principal ICT Co-ordinator Educator	Life Orientation and Technology	18 years
9	Post Level 2 Educator Serves on the national Subject Committee for Technology	Technology, Mathematics, Natural Science, Coding and Robotics	41 years
10	Post Level 1 Educator Acting Post Level 2 Educator	Physical Science and Technology	30 years
11	Post Level 1 Educator	Natural Science and Technology	15 years

4.2. Presentation of Thematic Analysis Findings

The type of thematic analysis employed is inductive and it sought to explore the educators' perspectives within Gauteng's public high schools. The process unearthed essential experiences and perceptions related to these institutions' readiness to adopt 4IR technologies in alignment with the principles of Education 4.0. The in-depth analysis conducted using interviews has enabled the study to shed some light on the understanding of educators regarding 4IR concepts, their perceived level of preparedness within their respective schools, and the key opportunities and challenges they have experienced and have come to anticipate on this transformative journey.

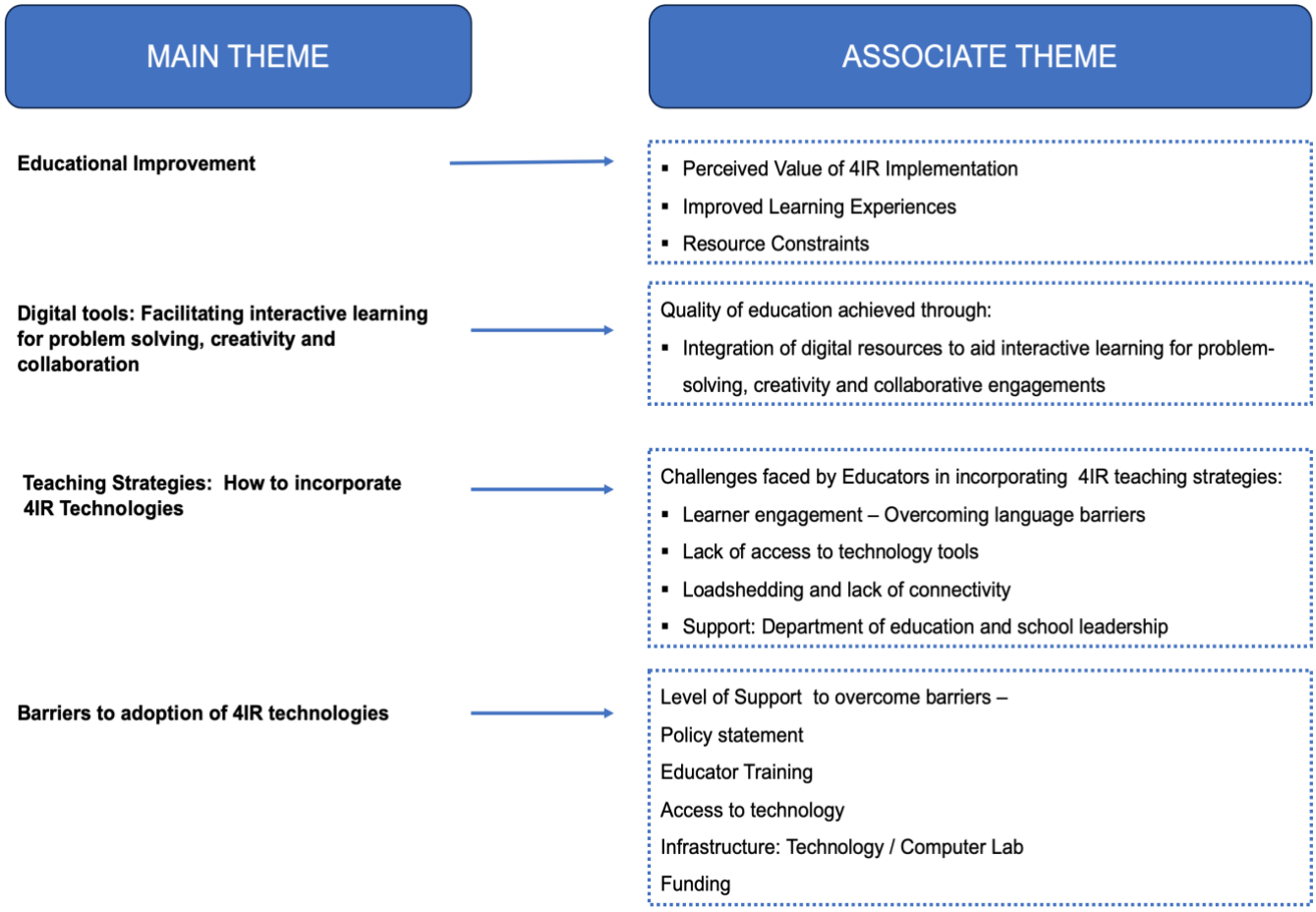

Figure 4: Thematic findings based on Codes and Themes

4.2.1. Proposition 1: 4IR technologies hold the potential to elevate the quality of education in public high schools by offering learners more personalised and tailored learning experiences, immersing them in active learning principles and preparing them for the demands of future contexts.

There is a consensus across all participants interviewed regarding improving educational outcomes through using and incorporating 4IR technologies in the classroom. Additionally, there is a shared view among participants in support of proposition one, which asserts that 4IR technologies can improve the quality of education through personalised and tailored learning experiences for learners. However, participants emphasised resource limitations at the school level as a major hindrance.

To further elaborate, the participants shared their views as captured in the excepts below in response to whether they believed that 4IR technologies had the potential to improve the quality of learning in the classroom under broad research question 1: RQ1, which asked about the perceived value of implementing 4IR technologies in schools.

IMPROVED LEARNING EXPERIENCES

Participant 1 explained the role technological tools play in improving the learner's mathematical skills through problem solving techniques applied using various applications as follows:

"I think these technologies will definitely improve not only the learners' skills in finding solutions, but also their mathematical skills. Because you have to involuntarily do mathematics in order to solve problems with the robotics". The same participant also added "if you apply 4IR technologies practically, they help learners in their thought process for solving problems".

Participant 3 further spoke to the value in using smart technologies like mobile devices and learning apps for educational improvement, along with the ability to achieve continuous learning outcomes inside and outside of the classroom by citing the following:

"Whenever I'm not at school for certain reasons, I share classwork or homework activities via the class WhatsApp group for learners, which I think is conducive for learning. Unlike in the past, when a teacher was absent, it meant that the learners for that particular subject won't be doing anything that day".

Additionally, Participant 3 proclaimed:

"I'm also teaching life science and technology. These are content based subjects. It is therefore hard at times for learners to understand concepts when I just explain to them verbally from the textbook. So, if I find a particular concept or topic to be particularly hard for them to understand, I usually look up a YouTube story or video for reinforcement".

Further to this, Participant 3 added:

"In Technology and natural science there are various topics, for instance, electricity. Sometimes it becomes hard for learners to understand electricity even through videos. In this instance, I use a software I installed on my laptop called the PhET simulator. Where learners get to build electric circuits through simulation, so they can see practically the flow of an electric current".

Sharing similar sentiments towards the positive contributions of 4IR technologies towards educational improvement, in particular helping learners to sharpen their collaborative, computational and critical thinking skills, participant 5 had this to say:

"Yes, 4IR technologies can improve the quality of education a lot, especially towards the learning experience in the classroom. The 4IR technologies assist learners to be investigative and they assist learners in computational thinking.

All those aspects about quality composition and critical thinking. Learners can be creative, and it teaches learners to work together".

RESOURCE CONSTRAINTS

While the educators expressed positive sentiments in their perceived value regarding the implementation of 4IR technologies in their schools and its contribution towards improved educational outcomes, there were concerns expressed by participants in terms of the lack of sufficient resources at school level which seemed to impede the effective implementation and adoption of these technologies. To this end, participant 1 lamented:

"Well, it would definitely need to be economical because you have to buy technology kits. You cannot just do coding without sufficient resources. You can't do robotics with nothing. You actually need equipment to do it with, whether you go the Lego way, which is quite expensive, or you try Arduino, they're also expensive. Also, the kids work in groups, which is fine. However, if you have a class of 35, you will need about seven of the apparatus to at least make seven groups of five each. Five is definitely pushing it. The ideal number is really four if you're in a class situation".

Participant 3 spoke to the same resource constraints in terms of the availability of and access to digital tools in the classroom by stating this:

"For *learners to use the PhET Simulator, I have to put them in groups because access to technology in our school also is a challenge*".

For Participant 4, resource constraint concerns related more to having to conduct lessons using technology tools in inadequate facilities. To this end, this participant explained that:

"It is difficult to teach using these technological tools in normal classrooms. Definitely, under-resourced schools is another problem"

In summary, proposition one is partly supported because the study participants recognise the transformative potential of 4IR technologies in education and the possibility of using them to facilitate personalised learning outcomes. However, resource constraints can be a significant roadblock in successfully implementing and adopting these technologies.

4.2.2. Proposition 2: 4IR technologies can provide a vast array of digital resources that serve as tools to foster interactive learning, empowering learners to engage in real-world problem-solving, cultivate creativity and innovation, as well as collaborate more effectively.

The study also sought to investigate whether the integration of digital resources in the facilitation of learning outcomes could improve the quality of learning by using interactive, creative, and collaborative learning tools such as gaming and other tools as problem-solving techniques to achieve educational objectives.

In this regard, the participants expressed that 4IR technologies offer interactive learning resources that can be incorporated into various subjects, which helps promote a deeper understanding of concepts for learners, thereby fostering the necessary development of cognitive skills.

INTEGRATION OF DIGITAL RESOURCES TO AID INTERACTIVE LEARNING

Participant 6 expressed the importance of learning through play by using digital tools like gaming. In this regard this participant had the following to say in terms of using these digital resources in the classroom for improved educational outcomes:

"I have found that kids who game a lot do better when engaging with new technologies and this helps to improve educational outcomes. I've realised that gaming is not a waste of time, but you need to understand why you are gaming and use it productively. One can use gaming to solve mathematical problems. You can also use gaming to design a car, and that on its own is very educational.

It has a few steps which involve solving problems as part of a project. As such, I've realised that kids can be taught in that way; we therefore don't discourage them from playing these games, but we help them with the games that can actually help enhance their understanding of school subjects in a creative way. So, yes it has worked".

Participant 9 supported the sentiments expressed by participant 6 regarding the importance of gaming and its educational value. Participant 9 demonstrated this point by offering an example of specific gaming applications used in the classroom to help encourage learners in solving complex problems. The educational value of this approach was described as follows:

"We did what is called unplug coding. Where we're using things like rangers, and tanks. These are the games used to release the critical thinking of a child and creativity in terms of actually creating a problem and getting a solution out of it. Tank is a game about hunting down Rhino poachers. The game offers learners various solutions, also positions are given as a problem or a scenario, the learners then have to find a solution to solve this problem. I found these games very encouraging to learners".

Participant 9 further asserted that:

"Gamification is very, very effective. It makes things easier for learners. *"We are also witnessing computational thinking in practice. However, this is not defined in isolation, for example, we've implemented pattern recognition. Pattern recognition algorithms are done through step-by-step solving of problems, and also applying methods of breaking down a problem, and then bringing it together and giving feedback".*

In summary, proposition two is supported as the educators engaged have shared positive accounts about the influence 4IR technologies have in improving learning in the classroom by fostering active engagement, learner collaboration, creativity, and critical thinking. The educators see value in strategically integrating these digital tools and resources to achieve educational objectives.

4.2.3. Proposition 3: Schools that equip educators with the necessary training in key teaching strategies that are instrumental in facilitating the incorporation of 4IR technologies into the learning process are likely to achieve greater success in adopting these technologies compared to those that do not.

The study aimed to uncover the importance of schools offering their educators the requisite training on how to incorporate 4IR technologies effectively and practically in their teaching strategies, because this is regarded as influencing the successful adoption of these technologies in the classroom. To this end, the interviewed participants shared the following insights:

CHALLENGES IN INCORPORATING 4IR IN TEACHING STRATEGIES.

- **Learner engagement: Overcoming language barriers and unequal access to technology**

Participant 2 identified and highlighted a language barrier for learners who are compelled to learn in a language that is not their mother-togue and how digital tools could play an important role in helping to overcome this challenge. The following insights were shared in this regard:

*"*I think if we can incorporate some of these technologies to help the children with language difficulties because *some of the kids don't understand English fully in order to participate in a class, so you're teaching them, and they don't understand half of the time*.*".*

To this end, participant 2 further elaborated as follows:

"there's a lot of technological resources out there that we can use to address that challenge, however, only a few classes in our school have access to technology tools.

As such, we don't have what we need to incorporate these technologies in the teaching strategies. So, yes, a lot of these kids don't get to see and experience some of these things".

INFRASTRUCTURE: LOADSHEDDING AND CONNECTIVITY

Participant 3 expressed frustration over some of the challenges that fall outside the control of educators in schools and the classroom, thereby impeding them from being able to incorporate digital technologies in their teaching strategies as follows:

"Currently, the problem we are facing as the nation of South Africa is loadshedding. During loadshedding, we cannot do anything on those technological devices. And then also, the data, for instance, in this school, I sometimes use my own data to teach this coding and robotics".

Participant 6 further elaborated on this point by providing a more technical insight to the challenges faced by educators with some of the technical tools offered to them by their respective schools to deliver digital technology based lessons:

"*Coding and robotics does not run on a simple tablet or cell phone like mine, which is giving me problems just to download this MS Teams. You need to have a laptop with a processor that is running at 8 gigabytes of RAM and upwards. All of us at our schools, we don't have that. If your laptop is good, it would have 4 gigabytes of RAM; for one to get 8 gigabytes of RAM is actually not easy. Smart technologies like VR headset actually work properly with laptops that have a high specification. So, in terms of the devices, it is impossible to get what is required because the schools are not willing to buy those kinds of devices. I 'm not sure if the Department of Education is planning on supplying these types of devices to schools. This then presents a challenge in incorporating technologies as part of out teaching strategies".*

SUPPORT: DEPARTMENT OF EDUCATION AND SCHOOL LEADERSHIP

Participant 10 brought to the fore the challenge of misalignment between the school leadership, the DBE and the educators on the ground in terms of the importance of incorporating digital tools and technology supported teaching strategies into the learning process. In this respect, the following was explained:

"Sometimes it is difficult because our department gives us an Annual Teaching Plan (ATP) to follow, and they are concentrating more on paperwork, and you have to finish that. They don't give you time to reinforce learning using technology in the learning process such that the kids can understand". Also, my other concern is that at the end of the day, you find that you've got a senior or an HOD who doesn't understand any technology. They think that you are just playing games with the kids and not actually teaching. This makes it hard to incorporate technologies in the learning process as a strategy".

In summary, the findings for proposition three are supported as they highlight the need for several improvements for successfully incorporating 4IR technologies into teaching strategies. These include improved access to technology tools and reliable internet connectivity for all students, the investment in devices with the requisite specifications to support advanced 4IR technologies and a more flexible curriculum, allowing educators sufficient time to integrate technology into their teaching strategies. Finally, leadership at a school level that is not only supportive but one that appreciates the value of technology in education.

4.2.4. Proposition 4: The adoption and implementation of 4IR technologies in public high schools are potentially hindered by challenges such as limited access to technology and related digital tools, inadequate infrastructure, insufficient funding, and a lack of comprehensive teacher training.

The study also examined some key barriers that impede the adoption of 4IR technologies by determining whether the schools under study are sufficiently supported.

Furthermore, the study sought to examine these barriers concerning factors like the training of educators, access to technology and technological tools, infrastructure, and funding. The following findings represent the assertions made in this regard.

BARRIERS TO ADOPTION AND IMPLEMENTATION

Policy and support

Participant 5 offered some key insights around policy related challenges faced at school level with regards to the formal introduction of 4IR technologies. Also expressed was the issue of departmental support for the schools in aiding the adoption of 4IR technologies, this participant had this say:

"In terms of the schools being adequately supported, I would say no, they're not adequately supported; but I would understand because currently, there's no school that is offering coding and robotics officially. This is because, the policy statement is still going through the final stages. I think they are done with writing it, so it has to go through the department of basic education's quality assurance and then from there it has to go to Umalusi for approval. So basically, there's no school that is offering coding and robotics officially, but what is happening is schools are just patching, they're taking here and there and then they will start doing coding and robotics, mostly as an extramural activity".

Additionally, participant 5 also added the following in relation to the curriculum policy statement issued by the DBE:

"The department needs to come up with a user-friendly curriculum assessment policy statement and framework"

Participant 6 affirmed this assertion by explaining that only a few selected schools were selected by the DBE to pilot the introduction of 4IR technologies in the form of coding and robotics, speaking to a lack of standardisation, participant 6 had this to say:

"Only a few schools have received some robotics kits from the Department of Education to start teaching learners coding and robotics. I was informed that those are the selected pilot schools. My school is one of the schools selected, whereby we are only teaching coding and robotics as an extramural". "Additionally, Participant 6 affirmed the following "Ultimately, the department needs to sit down and restructure the curriculum before they can even say we are ready for the 4IR".

In further affirmation to 4IR technologies being introduced as an extramural activity at select schools participant 2 proclaimed:

"Currently we are using this Robotics as an extramural activity"

Training of Educators

The adequate training of educators was one of the areas the study focused on to help determine whether the department of education was offering 4IR training to educators and if the training was sufficient in helping educators reach their educational objectives in the classroom using 4IR technologies. In this regard, Participant 10 noted the following:

"I think our department doesn't play its role. The GDE doesn't play its role. I mean, when teachers are qualified, you need to use them and place them adequately, such that when you introduce these technologies, you take the people who are qualified to introduce and teach these technologies in schools".

Participant 4 spoke to the inequity training for educators, whereby not all educators are exposed to 4IR training by the DBE. The selective nature of this training was flagged as a concern. This participant was asserted the following:

"The Gauteng Department of Education offers that training. I attended maybe four or five last year. However, only two teachers per school are allowed to attend the training. Fortunately, I was one of the teachers chosen in that school. Their plan is for these teachers to be the ones teaching coding and robotics in schools, which means this is not training where all teachers are exposed to these technologies. If only two teachers are trained, then what about the other teachers? Are they saying the rest of the teachers won't be needing to use these technologies in their core subjects to facilitate learning? it doesn't make sense for me".

Participant 5 shared inputs around the inadequate nature of the 4IR training programme offered by the BDE from a practicality perspective, as follows:

"I think the training is not yet adequate, as mentioned, it's currently either a three-day training or a four-day training and teachers only see the equipment on the day of the training. Once the training is completed, they don't have access to kits, so it means when they go back to their respective schools, they cannot even practice what they've learnt. They have to wait again for another training session, at this point; they are starting again from scratch".

Access to technology

The study explored access to technology and related tools as a factor contributing to implementing 4IR technologies in schools. Participant 6 offered the following input in terms of some of the technology limitations at school level:

"For Coding and Robotics, you need to have a laptop with a processor that is running at 8 gigabytes of RAM and upwards.

All of us at our schools, we don't have that. If your laptop is good, it would have 4 gigabytes of RAM; for one to get 8 gigabytes of RAM is actually not easy. Smart technologies like VR headset actually work properly with laptops that have a high specification. So, in terms of the devices, it is impossible to get what is required because the schools are not willing to buy proper devices with the correct specification. I'm not sure if the Department of Education is planning on supplying these types of devices to schools at all".

Concerns over access to hardware, devices and storage were raised by Participant 9 as follows:

"*In my school, we've got 40 tablets and I've got three classes. Every class in each grade must have 40 devices and there are three classes. So the capacity, if you use 20 for each and every class, everyone must have their own folders in the very same tablets or laptops. So that means the capacity must be big enough. We cannot use the 128 gig devices. They will not survive. We need 500 gigs or 1 terabyte of storage on each device. And then you are able to carry the load. But tablets with no capacity will not serve any purpose. I'm stuck with the tablets that are old. They came somewhere in 2018 and they have little storing capacity. So I'm now forced to tell kids to bring their phones into class".*

Participant 8 spoke to outdated hardware and technologies in the school's computer lab as well as insufficient access to digital tools like smartboards across all classrooms by noting the following:

"We built a computer lab with computers that were donated, but what we found is that the computers are outdated. So, we must now replace almost all those computers because they've reached end of life". Also, the classes I'm teaching in for instance, don't have access to a smart board but one of my colleagues has one in their class and I can see the difference in results, and I can see the difference in how learners are actually conceptualising things."

Infrastructure: Technology / Computer lab and Internet connectivity

The study sought to uncover the impact of access to the necessary infrastructure for the effective adoption of 4IR technologies. With regards to this, Participant 4 shared the following inputs:

“If coding and robotics is made into one of our formal subjects then maybe the department of education will be forced to ensure that in our schools, we have the necessary tools like computers and internet connectivity so that we'll be able to teach this subject effectively”.

Participant 4 also spoke to the unfair distribution of infrastructure resources across the schools. The following input was shared:

“I think one of the main barriers is that we are not treated equally by the department of education because you'll go to other public schools then you'll find all resources, then you go to our school then you don't find those kinds of resources. Not even just projectors, or the interactive smart boards”

Participant 6 spoke to the school having adequate infrastructure to support learning using digital technologies. However, there are still some areas of improvements in terms of some key infrastructure requirements. This participant shared the following insights:

“We do have Internet Connectivity. We do have projectors, we have tablets, we have solar in terms of loadshedding which is giving a bit of problems but anyway it's better than nothing and but when it comes to coding and robotics as such, we don't have a coding and robotics lab yet.

In terms of access to connectivity as an infrastructural barrier, Participant 7 had this to share:

“Sometimes you find that our Wi-Fi is not functioning, then it becomes a challenge.”

Further inputs on access to connectivity as an infrastructural barrier, Participant 8 emphasised the following:

"The main problem that we are experiencing is that a lot of the educational material must be accessed via the internet. We need to be able to download different educational material from YouTube as an example, so we can project it on the interactive board, but we don't have connectivity".

Participant 9 highlighted the issue of loadshedding as one of the key infrastructural challenges along with the lack of access to coding and robotics laboratories. This participant offered the following insights:

"*we've got connectivity problems in terms of Wi-Fi data. sometimes the Wi-Fi might be very weak and therefore you need the mobile data. And you need electricity for Wi-Fi to work which is impacted by loadshedding. We also do not have a coding and robotics laboratory or what you call a technology laboratory with computers inside".*

Funding

The study considered the influence funding or financial challenges might have on adopting and implementing 4IR technologies in the schools under investigation. In this regard, Participant 3 shared the following inputs:

"Funding could really go a long way because in terms of loadshedding, we don't have solar. So, if we could find a sponsor or funding for solar, such that we do not have to worry about loadshedding would be great. We also need a sponsor for connectivity and for a technology facility because we use this room, which is a science lab. So, you can imagine when science learners are in here, it means we cannot use it".

Participant 6 shared some of the innovative ways employed to try overcome the funding issues faced at the school level by maximising some of the resources at his disposal, to this end this participant had the following to contribute to the discussion:

“Most of the time it's not easy to get what you need from a money perspective, so I have turned my art class into having robotic tables and then I put tabletops for art. So, after school we remove the tabletops and are left with the robotic tables”.

In summary, for proposition 4, the participants expressed a keen interest in integrating 4IR technologies. However, the consensus was that more support from the education department was required regarding access to adequate training in 4IR technologies, technological resources and infrastructure like connectivity and electricity, as well as funding. The general sense was that the department required comprehensive interventions to address these barriers, primarily in formalising the curriculum policy statement that seeks to formalise the introduction of coding robotics and other 4IR technologies in the classroom and at the school level.

Conclusion

This chapter presented the study results regarding the readiness of South African fee-paying public high schools in Gauteng to adopt 4IR technologies in alignment with Education 4.0. Eleven participants agreed to participate in the study. The demographics of the participants who partook in the study included representation from the Department of Basic Education's main educational districts in Gauteng: Tshwane, Johannesburg, and Ekurhuleni. However, the Sedibeng district did not participate. Also included were the participant's demographic profiles: their professions, the subjects they teach and their years of professional experience. The study presented findings based on the inductive thematic analysis of interviews conducted with the identified educators and senior officials. The findings revealed both potential and challenges associated with adopting and integrating 4IR technologies in the educational facilities under study. The discussion of these findings is conducted in the next chapter.

CHAPTER 5. DISCUSSION OF FINDINGS

5.1. Introduction

This chapter acts as a bridge, connecting the data collected to its broader implications for South African fee-paying public high schools in Gauteng and their readiness to adopt 4IR technologies within the context of Education 4.0.

The discussion is structured as follows: Firstly, an outline of the demographic profile of respondents is presented along with the importance to the context of the study. Then, the research questions and related critical findings from the thematic analysis are revisited, thus providing a foundation for further insights. Subsequently, a comprehensive analysis is undertaken, which explores the various themes that relate to existing literature and the theoretical framework previously positioned for this study, which aligns with the context of Education 4.0. This comparative analysis illuminates the alignment and potential gaps between current educational practices and the demands of 21st-century requirements. The implications of these findings are then explored by examining their significance concerning the different stakeholders within the educational context under study. Finally, the study's limitations are acknowledged, and recommendations for future research are offered, thus helping to pave the way for further research in this critical area.

5.2. Discussion of thematic analysis pertaining to Proposition 1

5.2.1. 4IR technologies can assist in the educational Improvement of public high schools through access to tailored and personalised learning experiences, unlocking active learning principles.

The study findings from the thematic analysis of the data collected uncovered a generally positive perception among the participants about the potential ability of 4IR technologies to improve educational outcomes. To this end, the participants acknowledged the importance of 4IR technologies in facilitating and enabling learning experiences that are both personalised and tailored.

Improved learning experiences

Participants emphasised the ability of 4IR technologies to enhance the learner's capacity for computational skills, investigative problem-solving, critical thinking, and mathematical abilities through robotics and simulations. In concurrence with this observation, Ali et al. (2021) affirm that there is an improvement in problem-solving, mathematical concept application, and creativity skills in learners engaged in robotic and simulation projects compared to those not engaged in these projects. Furthermore, the integration of mobile devices and various other educational apps in the learning environment were also sighted as valuable tools for the reinforcement of learning, which can also be used to facilitate learning outside the classroom. Kavousi (2022) shares this sentiment by positing that educators and learners can now interact beyond the classroom using digital resources and applications like WhatsApp. Sehlako et al. (2023) further support this stance by arguing that 4IR optimises the interaction among learners and educators outside and within schooling contexts.

Resource Constraints

Despite the perceived value of 4IR technologies, participants expressed concerns about the limited resources in their schools as one of the key barriers to effectively adopting these technologies. Limited access to technology, along with the cost of technology kits, robotic equipment and related software, was mentioned as one of the significant constraints, particularly for large classes which require multiple devices. In addition, the need for learning environments that can be adapted to accommodate the integration of 4IR education was highlighted. According to Oke and Fernandes (2020), resource constraints impact the adoption of 4IR technologies.

Synthesis

From the study findings, participants reveal a positive perception towards the value of implementing 4IR technologies in the classroom for improved educational objectives. Participants also acknowledged the potential of these technologies in improving the quality of education through personalising learning experiences and promoting active learning. In previous literature, Meehir (2023) and Carvalho et al. (2022) highlight the potential of 4IR technologies in enhancing learning outcomes. Moloi and Mhlanga (2021) also speak in support of the development of critical thinking and problem-solving abilities through the use of technology. Additionally, Almeida and Simoes (2018) posit that 4IR technologies can increase learner engagement and motivation.

From a UTAUT model alignment perspective, the belief held by participants that 4IR technologies can improve learning outcomes through improved computational skills and their ability to think critically suggests a positive performance expectancy towards these technologies. Participants' concerns with regard to the ease of use and resource availability for the implementation of 4IR technologies were expressed. This indicates a mixed effort expectancy as participants see the potential benefits of using 4IR technologies and recognise the challenges associated with its implementation.

The participants expressed positive views towards 4IR technologies, and their implementation within the school environment supports the social influence construct of the UTAUT model. As expressed in the study findings, the need for more technology tools and resources at the school level is viewed as a significant barrier hindering the effective implementation of 4IR technologies. This emphasises the importance of facilitating conditions, such as adequate infrastructure and device access, as crucial factors influencing technology adoption (Venkatesh et al., 2003).

5.3. Discussion pertaining to Proposition 2

5.3.1. 4IR technologies offering digital resources as tools to facilitate interactive learning by engaging learners in real-life problem-solving activities, creative tasks and collaboration.

The integration of digital resources to aid interactive learning.

The views expressed by participants in the study support proposition two, which suggests that 4IR technologies and crucial interactive learning resources can improve the quality of education. Several benefits in this regard were highlighted by participants in the study, including:

- *The promotion of a deeper understanding and cognitive development*

In this regard, participants expressed that a deeper understanding of concepts is fostered by applying digital resources as they enable exploration and engagement in different learning styles. This helps cultivate cognitive skills necessary in the 21st-century world, such as critical thinking and solving complex problems.

- *The encouragement of active engagement and teamwork.*

Based on the feedback from the study, this was given effect through the use of interactive digital tools in the classroom, such as games, to encourage active participation, teamwork, and innovation in the learning process. Participants found this particularly effective in engaging learners who enjoy gaming and appreciate exploring different ways of finding solutions to problems. Sharma (2023) concurs with the view that digital technologies help enhance the quality of learning by highlighting that technology plays a crucial role in aiding active learner participation in the classroom and helps with knowledge retention.

Synthesis

Based on the study findings, participants have expressed a view that 4IR technologies can improve the quality of learning in the classroom in alignment with key learning outcomes by increasing learner participation, collaborative engagements, and critical thinking. The literature reviewed indicates concurrence with this sentiment, as Koopman (2023) affirms that digital technologies help facilitate learning environments that are more engaging, interactive, and cooperative, thus improving the quality of engagement and learning in the classroom. These findings further align with previous research by Sikhakhane et al. (2020), who found that using intelligent technologies in classrooms cultivates meaningful learner engagements, while Hart (2023) highlighted the effectiveness of educational technologies in creating interactive and cooperative learning environments.

Furthermore, the study findings show that the positive experiences shared by participants suggest a belief that 4IR technologies can improve learning outcomes while enhancing educational quality. According to Venkatesh et al. (2003), this aligns with the performance expectancy construct and is supported by the literature reviewed, where authors like Agus and Samuri (2018) highlighted the potential of personalised learning using AI as an enabler to improve learning outcomes.

Additionally, the participant's insights from the study findings suggest that they believe that 4IR technologies can be applied to various subjects, thus potentially reflecting a positive effort expectancy (Venkatesh et al., 2003). However, the study should have delved into specific challenges regarding ease of use.

5.4. Discussion pertaining to Proposition 3

5.4.1. Proposition 3: Schools offering educator training on key teaching strategies based on how to incorporate 4IR technologies in the learning process, will be more successful in the adoption of these technologies in schools.

Several challenges faced when trying to incorporate 4IR technologies into the teaching strategies of educators were uncovered from the study findings, supporting the proposition that schools that offer educator training are crucial for the successful adoption of 4IR technologies at schools. Lemin (2019) asserts the importance of evolving teaching practices through targeted training programs for educators to support them in becoming effective facilitators of learning with an ability to leverage technological tools in the classroom. Participants highlighted some of the following challenges they face when trying to integrate 4IR technologies into their teaching strategies:

Challenges in incorporating 4IR in Teaching.

Learner engagement: Overcoming Language barriers and unequal access to technology

***Language barriers*:** The potential of 4IR technologies in supporting learners with language difficulties due to mother tongue disparities was expressed.

However, it was further elaborated that the schools' limited access to technology resources significantly hinders implementation. Afzal et al. (2020) agree with this sentiment by stating that access to essential technological resources is vital in helping to address some of the current limitations experienced in the classroom, such as language barriers.

Unequal access: Also revealed was the concern about the lack of necessary digital tools in their schools as well as technology devices with adequate specifications in terms of factors like storage capacity and individual access of mobile devices for each learner in the classroom, thus hampering equal and necessary access for all learners. In support, Khoza (2023) affirms that unequal access to adequate technology tools and resources for learners and educators in the classroom impacts 4IR adoption in schools.

Infrastructure: Loadshedding and Connectivity

The disruption caused by insufficient access to data and connectivity and load shedding was seen as impacting technology integration in the classroom. In agreement, Carrim (2022) emphasised that electricity challenges present a severe challenge to the effective use and adoption of ICT in schools.

Support: Department of Education and school leadership:

Curriculum constraints: The inflexibility of the current curriculum guidelines was seen as an inhibiting factor because of their significant focus on paperwork, thus prohibiting the effective integration and adoption of 4IR technologies as educators are not afforded enough time for technology integration and adoption at the school. A UNESCO (2018) report emphasises the significance of the agency and autonomy of educators in successfully incorporating digital technologies into their teaching to improve educational outcomes.

The main argument in this regard was that educators must have sufficient space and time for experimentation with individual teaching practices to leverage technology for enriched learning objectives and related outcomes (UNESCO, 2018).

Unsupportive leadership: The need for more understanding and appreciation for technology integration from some of the school leaders was observed as one of the critical limitations in implementing and adopting 4IR technologies at schools. In this regard, the OECD (2019) presented a report that identified the importance for school leaders to develop strong leadership skills in technology to support teachers adequately in integrating technology into their teaching practices and strategies.

Synthesis

Study findings indicate that various factors influence the adoption of 4IR technologies in schools and the integration thereof into teaching strategies by educators. As such, the challenges of learner engagement and inadequate infrastructure at the school level could negatively impact educators' belief in the effectiveness of these technologies and their ability to improve learning outcomes. In this regard, the literature reviewed emphasises the importance of educators understanding how the effective use of 4IR technologies could potentially enhance learning objectives and outcomes (Oke & Fernandes, 2020).

The lack of access to proper devices, reliable internet connectivity, and supportive infrastructure thus contribute to the perceived difficulty of using 4IR technologies in the classroom, which relates to the effort expectancy construct of the UTAUT model (Venkatesh et al., 2003). The reviewed literature supports this, as expressed by Hart (2023), who highlights the importance of addressing infrastructural limitations and providing educators with the necessary resources to facilitate technology integration.

As highlighted in the study findings, the rigid curriculum and lack of support from some school leaders can create negative social influence in alignment with the UTAUT model (Venkatesh et al., 2003), thus discouraging educators from adopting 4IR technologies. This stance aligns with Sikhakhane et al. (2020), who emphasise aligning educational leadership and teaching approaches to promote effective technology integration.

The study findings also emphasised the importance of facilitating conditions outlined by the UTAUT model. To this end, participants mentioned access to technology and reliable internet connectivity as hindering effective technology integration. Additionally, a flexible curriculum that allows for technology integration and school leadership that supports and values technological innovation are crucial components that encourage educator adoption. Finally, providing educator training geared towards empowering educators with the knowledge of how to use 4IR technologies in their teaching strategies could address effort expectancy concerns and thus improve confidence in implementing these technologies.

5.5. Discussion pertaining to Proposition 4

5.5.1. Proposition 4: Barriers to adoption and implementation of 4IR technologies include the lack of access to technologies, insufficient infrastructure, insufficient funding, and poor teacher training.

Barriers to Adoption and Implementation:

The study findings identified several barriers to the adoption and implementation. Participants categorised these as follows:

Policy and Support

Participants expressed a need for a clear policy statement, framework, and support from the Department of Education (DoE) regarding 4IR integration. For example, the absence of a formalised curriculum statement that is formalised for coding and robotics was seen as a significant hindrance to adoption.

Educator Training

The study findings uncovered concerns by participants that the training opportunities provided for educators by the DoE were perceived as inadequate due to limited access and insufficient depth. Participants also emphasised the need for training programs that are comprehensive to equip educators with the necessary skills and knowledge to use 4IR technologies in the classroom effectively.

Access to Technology

According to the study findings, participants expressed that schools faced challenges acquiring and maintaining appropriate technological resources. Outdated devices, limited device availability, and a lack of specialised equipment for 4IR subjects like coding and robotics were identified as critical issues impeding adoption.

Infrastructure and Funding: Inadequate infrastructure, including unreliable internet connectivity, was also cited by participants as a crucial implementation barrier in the study.

Synthesis

The findings of this study align with the literature reviewed on this topic, highlighting several barriers that impede the adoption and implementation of 4IR technologies in public high schools. These barriers are categorised under the facilitating conditions construct of the UTAUT model.

The study participants highlighted a limitation in terms of access to technology and related tools as a significant barrier. The literature reviewed aligns with the perspective of Oke and Fernandes (2020) and Hart (2023), whoviewed the lack of resources as a challenge in incorporating technological pedagogy in schools. Furthermore, participants mentioned outdated computers, insufficient tablets, and a need for specialised equipment for subjects like coding and robotics. These challenges restricted their ability to effectively implement 4IR technologies in the classroom, thereby hindering potential improvements according to UTAUT's constructs of performance expectancy and behavioural intention.

The findings also revealed inadequate infrastructure, including limited access to computer labs and insufficient power supply, as significant obstacles to adopting and implementing 4IR technologies in schools. From the literature reviewed, this is corroborated by Carrim (2022), who highlighted infrastructural challenges like poor access to electricity and the internet as barriers to 4IR implementation. These limitations restrict the ability of educators to use technology effectively, thus impacting effort expectancy and, ultimately, behavioural intention as some of the primary constructs of the UTAUT model.

Limited financial resources emerged as another critical barrier in the study findings. In this regard, participants expressed challenges in acquiring the necessary equipment, maintaining infrastructure, and accessing professional development opportunities for educators due to insufficient or total funding. In terms of the reviewed literature, this aligns with Kayembe and Nel (2019), who identified financial constraints as a key factor hindering the deployment of 4IR technologies in schools.

Based on the UTAUT model, the lack of funding restricts the schools' ability to create facilitating conditions necessary for effective technology adoption, thereby affecting behavioural intention.

The study findings also identified inadequate teacher training as a barrier to effective 4IR implementation. Participants reported limited access to training programs and a lack of comprehensive training in using and integrating 4IR technologies in their teaching practices as a limitation to adopting these technologies. From the reviewed literature, this aligns with studies by Sikhakhane et al. (2020) and Oke and Fernandes (2020), who emphasised the importance of equipping teachers with the necessary skills and knowledge in order to leverage 4IR technologies effectively. The absence of proper training can hinder teachers' effort expectancy and behavioural intention to adopt these technologies as critical constructs of the UTAUT model.

Finally, the participants highlighted the need for a formalised policy statement and curriculum framework for integrating 4IR technologies into the mainstream curriculum as a barrier. A clear policy direction can create certainty and encourage behavioural intention to adopt these technologies at the school level.

5.6. Conclusion

This chapter explored the readiness of South African fee-paying public high schools in Gauteng to adopt 4IR technologies in alignment with Education 4.0. Overall, the findings supported all the stated propositions. Additionally, The findings revealed that while participants acknowledged the potential of 4IR technologies to improve educational outcomes, several challenges hindered their effective implementation. Overall, these challenges align with the facilitating conditions construct of the UTAUT model, emphasising the importance of factors such as access to technology, infrastructure, funding, teacher training, and policy support.

Furthermore, the study identified a positive perception among participants regarding the value of implementing 4IR technologies in the classroom to achieve improved learning objectives. To this end, participants acknowledged the potential of these technologies in improving the quality of education through personalised learning experiences and the promotion of active learning. However, concerns regarding ease of use and resource availability were also expressed.

The findings suggest that educators perceive 4IR technologies as valuable tools that enhance learning through interactive, participative, creative, and cooperative approaches. The analysis of the study through the UTAUT framework focuses attention on the potential role of performance expectancy and effort expectancy in driving the adoption and use of 4IR technologies in schools. However, various factors influence the adoption of these technologies, including learner engagement, inadequate infrastructure, and a rigid curriculum.

The study emphasises the importance of facilitating conditions as outlined by the UTAUT model. Participants highlighted access to technology, reliable internet connectivity, a flexible curriculum, supportive school leadership, and educator training as crucial components for successful technology integration. These findings align with the reviewed literature, highlighting several barriers that impede the adoption and implementation of 4IR technologies in public high schools.

CHAPTER 6. CONCLUSIONS & RECOMMENDATIONS

6.1. Introduction

The preceding chapter discussed the study findings. This chapter culminates the investigation into the readiness of South African fee-paying public high schools in Gauteng to adopt 4IR technologies in alignment with Education 4.0. The chapter seeks to integrate the critical findings acquired from the preceding chapters by presenting the study conclusions and recommendations by addressing the research questions outlined in the introductory chapter.

The research questions underpinning this study are:

RQ1: What is the perceived value of implementing 4IR technologies in public high schools?

RQ2: How can 4IR technologies be used to improve the quality of education in public high schools?

RQ3: What are the challenges faced by educators in incorporating 4IR technologies into their teaching strategies?

RQ4: Which barriers exist to the adoption and implementation of 4IR technologies in public high schools?

This chapter is divided into four subsections. First is a presentation of the summary findings related to the outlined research questions, followed by the conclusions drawn from the summarised findings and the overall conclusions thereof. Then, the recommendations based on the identified study conclusions are presented. Lastly, the study limitations and possible future research are presented to close this chapter.

6.2. Findings and Conclusions for Research question One

6.2.1. Summary of findings: RQ1

The first research question aimed to determine the perceived value of implementing 4IR technologies in public high schools. In this regard, the study found a generally positive perception of the potential benefits of 4IR technologies and their potential to improve educational outcomes in the schools under study. Some of the benefits outlined include acknowledging that 4IR technologies can help facilitate personalised and tailored learning experiences for learners, thereby improving learning objectives in the classroom. This position aligns with previous research, which observed an enhancement in critical skills in learners, such as the ability to think critically when using these technologies in the classroom (Sikhakhane et al., 2020). Another identified benefit of using 4IR technologies is their ability to offer enhanced learning experiences through their potential to reinforce learning using mobile devices and educational apps as well as their ability to develop computational skills and the enhancement of mathematical abilities.

However, despite the articulated perceived value in the implementation of these technologies, resource constraints in terms of limited access to technology tools, cost of 4IR equipment and software as well as adaptable environments which are 4IR ready were sighted as critical barriers to the effective implementation of 4IR technologies in the classroom. Current literature highlights the adverse effects of resource constraints on 4IR adoption (Oke & Fernandes, 2020).

6.2.2. Conclusions: RQ1

The study suggests that while there is support for the potential of 4IR technologies to improve educational outcomes, resource constraints pose a significant challenge.

Addressing these challenges through targeted interventions and effective resource allocation was seen as being crucial to realising the transformative potential of 4IR in South African public high schools.

6.3. Findings and Conclusions for Research question Two

6.3.1. Summary of findings: RQ2

Research question two aimed to determine how 4IR technologies could be used to improve the quality of education in public high schools. The findings in this regard show that 4IR technologies, coupled with interactive learning resources, have the potential to enhance the quality of education in public high schools in a myriad of ways, including their ability to foster a deeper understanding of educational concepts and the promotion of cognitive development in learners. In particular, 4IR technologies and related digital resources achieve this through exploration and catering to diverse learning styles. Additionally, it is observed that 4IR technologies encourage active learner engagement, innovation, and teamwork. Digital resources are used to accomplish this, like gaming as a stimulation mechanism during the learning process, thereby exploring alternative problem-solving approaches for various educational tasks.

These findings align with existing literature, as Sharma (2023) emphasises the role of technology in promoting active learner participation and knowledge retention, while Koopman (2023) underscores its ability to create more engaging, interactive, and cooperative learning environments. Additionally, Sikhakhane et al. (2020) found that intelligent technologies foster meaningful learner engagement, and Hart (2023) highlights their effectiveness in creating interactive and collaborative learning spaces.

Furthermore, the shared positive experiences suggest confidence in the potential of 4IR technologies to improve learning outcomes and enhance educational quality.

A study by Agus and Samuri (2018) resonates with this by emphasising the potential of AI-driven personalised learning as a mechanism to improve learning outcomes.

6.3.2. Conclusions: RQ2

This study suggests that 4IR technologies, when implemented strategically and integrated with effective instructional practices, have the potential to contribute to improved educational quality in public high schools. The achievement of this is evidenced through the promotion of active, participative learning in the classroom using digital resources to diversify learning methods to simultaneously cater to the learning needs of various learners in the classroom.

These findings help build what is known already in this field by providing first-hand accounts from a South African context, specifically focusing on fee-paying public high schools in Gauteng. The study also highlights the importance of integrating 4IR technologies with effective teaching strategies for optimal learning outcomes. Finally, the study offers some critical insights into the positive experiences and perspectives of the stakeholders in terms of the potential of 4IR technologies in education.

6.4. Findings and Conclusions for research question 3

6.4.1. Summary of findings for Research Question 3

Research question three aimed to explore the challenges educators face in incorporating 4IR technologies into their teaching strategies. The findings uncovered that educators with adequate training on effectively incorporating 4IR technologies into their teaching strategies are more successful in adopting these technologies in the classroom. However, the study findings highlighted several challenges experienced by educators when trying to integrate 4IR technologies into their teaching.

Four distinct areas were identified; the first was around learner engagement, where a limitation in the access to 4IR technologies like robotic kits at the school level was pointed out as a hindrance to adoption. The general unequal access to other digital tools like coding apps and the lack of access to individualised mobile devices for each learner was also identified in the same category. The second area concerns infrastructure challenges concerning insufficient Internet connectivity and electricity issues due to load shedding. The third area was centred around support challenges, where the main obstacle is curriculum constraints in terms of inflexibility due to the imbalance in focus, which is skewed towards paperwork, thus restricting educators from focusing on technology integration in the classroom. The fourth area highlighted challenges with leadership that are unsupportive at the school level due to their lack of appreciation and understanding of technology integration, which hinders implementation.

6.4.2. Conclusion: RQ3

These findings of the study contribute to a deeper understanding pertaining to the challenges and opportunities associated with integrating 4IR technologies into the classroom. The study also highlighted the need for multifaceted interventions, including educator training, infrastructure improvements, curriculum revisions, and supportive leadership to help ensure the successful adoption and effective use of 4IR technologies for enhanced learning outcomes. Additionally, the study findings align with previous research, which highlighted the importance of educator training, addressing language barriers through technology, and ensuring equitable access to technology (Carrim, 2022), (Khoza, 2023), (UNESCO, 2018) & (OECD, 2019).

6.5. Findings and Conclusions for research question 4

6.5.1. Summary of findings for Research Question 4

The purpose of research question 4 was to explore the barriers to adopting and implementing 4IR technologies in public high schools.

To this end, the barriers identified in the study findings included the lack of a clear curriculum policy statement on 4IR technologies for schools and the necessary support from the education department. The findings again revealed that the current curriculum policy statement on implementing 4IR technologies like coding and robotics is still a draft policy, thus preventing schools from formally introducing any related subjects into their timetables, meaning all 4IR technology-related subjects were being taught as extracurricular subjects. Another barrier identified in the study is educator training. The findings expressed that the training opportunities offered by the department for educators on 4IR-related technologies like coding and robotics were perceived as limited in terms of access and scope. Also highlighted as a barrier in the findings was the need for access to appropriate digital resources and specialised technology tools, exacerbated by the general use of outdated technologies at schools. Lastly, the study findings highlighted infrastructural challenges like the lack of computer or technology labs, lack of power and poor connectivity, and lack of funding as inhibitors to 4IR adoption. These findings find general support in previous research by (Oke & Fernandes, 2020) (Hart, 2023), (Kayembe & Nel, 2019) and (Sikhakhane et al., 2020).

6.5.2. Conclusion

The study concludes that successfully adopting and implementing 4IR technologies in public high schools requires addressing critical barriers like access to technology, infrastructure, funding, teacher training, and policy support.

These findings contribute to the existing knowledge base by providing specific insights into the challenges faced by fee-paying public high schools in Gauteng, South Africa.

6.6. Recommendations

A report by McKinsey (2022) emphasises the growing prominence in the recognition of the introduction of 4IR technologies that align with the goals of Education 4.0 in schools. This integration can potentially be transformative for the education sector, ultimately preparing learners for the challenges of the 21st century (McKinsey, 2022). Therefore, the strategies deployed to introduce or improve the integration of 4IR technologies in foundational education institutions must be robust in depth and impact. In support of this viewpoint, the following recommendations are made after considering the detailed insights gleaned from this study and the review of existing literature. The recommendations thus focus on addressing the identified challenges and leveraging potential opportunities.

6.6.1. Targeted interventions

It is recommended that targeted interventions are introduced to help address the identified challenges as follows.

1. **Resource constraints**

The Department of Education and school administrators should prioritise addressing resource constraints at the school level by exploring alternative financing models to help fund the acquisition and maintenance of technological resources and tools needed to implement 4IR technologies in schools.

These models could include public-private partnerships and accessing funding from Non-Profit Organisations through collaborative engagements.

2. **Educator training**

Policymakers should proactively identify comprehensive and ongoing training programs to guide educators on effectively integrating 4IR technologies into their teaching strategies. These programs must be accessible to all educators at each public school and not reserved only for those who teach specific subjects if the system hopes to leverage the full potential of 4IR technologies and their capacity to help achieve improved educational goals.

3. **Curriculum alignment**

Active and intentional collaboration between the Department of Education and all its stakeholders, including educators, school administrators, students, parents, student governing bodies and the private sector to revise and improve the objectives of the curriculum policy statement to help embrace flexibility and encourage technology integration while achieving learning objectives.

4. **Supportive leadership**

Foster a school culture that values and supports technology as a foundational and fundamental principle for learning by providing school leaders with leadership training that is aligned with technological imperatives and one that promotes collaboration with educators on technology integration.

5. **Infrastructure improvements**

The Department of Education should address infrastructure limitations by upgrading Internet connectivity across all public schools, providing continuous and reliable power supply.

The department must invest in alternative power sources like solar to address load-shedding concerns and delivering facilities like computer or technology labs at all public schools to ensure equity, as well as invest in the necessary equipment with the requisite specifications that will enable the effective delivery of lessons using advanced 4IR technologies where required.

6. **Policy Advocacy**

Policy amendments must be addressed and advocated for at national and provincial levels of the Education Department to provide clear guidelines.

The curriculum policy framework around implementing and adopting 4IR technologies and subjects needs to be formalised to ensure improved integration in public schools.

6.7. Potential Limitations and Suggestions for further research

6.7.1. Short-term study limitation

The limitations of the current study's focus on school "readiness" and its potential neglect of the long-term impact of implementing 4IR technologies on learning outcomes are acknowledged. Longitudinal studies could be conducted to track the effects of implementation over time to address this.

6.7.2. The size of the sample and Data analysis

In qualitative studies, sample sizes are typically smaller than those of quantitative studies due to saturation (Mills, 2023). In this study, eleven participants were sampled which is consistent with other qualitative studies.

However, it is noted that data collection strategies in qualitative studies are different and can provide rigorous results for one's study (Mills, 2023).

Data analysis for qualitative studies can be subjective as they are open to the researcher's interpretation (Shah, 2019).

6.7.3. Generalisability

The focus on fee-paying public high schools in Gauteng might limit the generalizability of the findings to the broader context of other public high schools in South Africa. As such, further research could be conducted to examine both the feasibility and effectiveness of implementing these technologies in more diverse public schooling contexts, including those in rural communities from lower-income households and schools with diverse technological infrastructure.

6.8. Conclusions

Table 5: Study outcomes

Research Question 1	Research Proposition 1
What is the perceived value in implementing 4IR technologies in fee paying public high schools in Gauteng?	4IR technologies hold the potential to elevate the quality of education in public high schools by offering learners more personalised and tailored learning experiences, immersing them in active learning principles and preparing them for the demands of the future work contexts.

Outcome 1

i. General positive perception of the potential benefits of 4IR technologies and their ability to improve educational outcomes.
ii. **Benefits:** Facilitation in personalised and tailored learning experiences like critical thinking, enhanced learning experiences and improved computational skills
iii. **Barrier:** resource constraints impeding implementation includes limited access to technology and cost of equipment.

Research Question 2	Research Proposition 2
How can 4IR technologies be used to improve the quality of education in public high schools?	4IR technologies can provide a vast array of digital resources that serve as tools to foster interactive learning, empowering learners to engage in real-world problem-solving, cultivate creativity and innovation, collaborate more effectively.

Study Outcome 2

i. Best achieved when 4IR technologies are implemented strategically and integrated with effective instructional practices.
ii. Active, participative learning in the classroom best achieved by using digital resources to help diversify learning methods that simultaneously cater to the learning needs of various learners in the classroom.
iii. The integration of 4IR technologies with effective teaching strategies is critical for optimal learning outcomes.

Research Question 3

What are the challenges faced by educators in incorporating 4IR technologies into their teaching strategies?

Research Proposition 3

Schools that equip educators with the necessary training in key teaching strategies that are instrumental in facilitating the incorporation of 4IR technologies into the learning process are likely to achieve greater success in adopting these technologies compared to those that do not.

Study Outcome 3

i. Adequately trained educators on the effective incorporating of 4IR technologies into their teaching strategies are more successful in adopting 4IR technologies in their teaching strategies.
ii. However, there are several challenges experienced by educators when trying to integrate 4IR technologies into their teaching, these include:
   - Poor learner engagement due to insufficient access to digital resources at the school level.
   - Infrastructural challenges like poor internet connectivity and electricity issues due to load shedding.
   - Curriculum constraints: focus by department of Education skewed towards paperwork thus restricting educators from focusing on technology integration in the classroom.

Research Question 4

Which barriers exist to the adoption and implementation of 4IR technologies in public high schools?

Research Proposition 4

The adoption and implementation of 4IR technologies in public high schools are potentially hindered by challenges such as limited access to technology and related digital tools, inadequate infrastructure, insufficient funding, and a lack of comprehensive teacher training.

Study Outcome 4

Identified Barriers:

- Lack of a clear curriculum policy statement on 4IR technology adoption at school level
- Insufficient support from the Department of Education
- Outdated technologies
- Infrastructural challenges such as the lack of technology facilities like computer labs, electricity, and connectivity
- Lack of funding

Table 6: Consistency table: research questions, propositions, data collection and data analysis

RQ #	State Research Question or Objective	Prop #	State Proposition or Hypothesis	Data collection detail	Data analysis method
1	**RQ1:** What is the perceived value in implementing 4IR technologies in fee paying public high schools in Gauteng?	1	4IR technologies may assist to improve the quality of education in public high schools by offering learners access to learning experiences that are more tailored and personalised, thereby exposing them to the principles of active learning and preparing them for the future world of work	Interview guide questions: 5,6	Thematic analysis
2	**RQ2:** How can 4IR technologies be used to improve the quality of education in public high schools?	2	4IR technologies can offer a broad range of digital resources that can be used as tools to facilitate interactive learning by providing learners with opportunities to engage in real-life problem solving, be more creative, innovate and more collaborative.	Interview guide questions: 7,8	Thematic analysis

RQ #	State Research Question or Objective	Prop #	State Proposition or Hypothesis	Data collection detail	Data analysis method
3	**RQ3:** What are the challenges faced by educators in incorporating 4IR technologies into their teaching strategies?	3	Schools that provide educators with required training on key teaching strategies vital in facilitating the incorporation of 4IR technologies in the process of learning will be more successful in adopting these technologies than those that do not.	Interview guide questions. 9,10,11	Thematic analysis
4	**RQ4:** Which barriers exist to the adoption and implementation of 4IR technologies in public high schools?	4	The challenges influencing the adoption and implementation of 4IR technologies in public high schools include the lack of access to technology and related digital tools, poor infrastructure, insufficient funding, and inadequate teacher training.	Interview guide questions. 12, 13, 14, 15, 16, 17	Thematic Analysis

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APPENDIX LIST

Appendix A: Confirmation of Ethics (Clearance/Waiver certificate or declaration)

Appendix B: Blank Participation Form

Appendix C: Letter from DoE

Appendix D: Turn-It-In Report

Appendix X: Research Instrument

Appendix A: Confirmation of Ethics

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

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

Ethics Clearance Certificate

Ethics protocol number: WBS/DB2395746/452
This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below)

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

Project title	Readiness of South African fee-paying public high schools in Gauteng in adopting 4IR technologies in alignment with Education 4.0
Investigator / Researcher	Ms Ramanti Mokhwesana
Nature of Project	MM (Digital Business)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	2023/10/30
Expiry date	Date of submission of the project / research report
Chairperson	Dr Pius Oba ☎ +27 11 717 3976 +27 82 733 6587 pius.oba@wits.ac.za

Declaration by Researcher

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

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

Signature

2023/10/31
Date:

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Appendix B: Participant Agreement Form

Title of project: The Readiness of South African Fee-Paying Public Schools in Gauteng in Adopting 4IR Technologies in Alignment with Education 4.0

Name of researcher: Ramanti Mokhwesana

I, ……., agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.	YES	NO
I understand that I can volunteer to take part in the study	YES	NO
I agree that the interview may be audio recorded.	YES	NO
I agree that direct quotations from my interview may be used by the researcher in their research report.	YES	NO
I agree that my participation will remain anonymous (my name or other identifying data will not be used by the researcher in their research report.	YES	NO

I agree that other researchers may use the information I provide in my interview (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on.	YES	NO

.....
(name of participant)

.....
(signature)

.....
(date)

.....
(name of researcher/person seeking consent)

.....
(signature)

.....
(date)

Appendix C: Letter From DoE

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**11 December 2023**
Validity of Research Approval:	**08 February 2024– 30 September 2024** **2023/506**
Name of Researcher:	**Mokhwesana R**
Address of Researcher:	**98 Blandford Road**
	Johannesburg
Telephone Number:	**084 599 6826**
Email address:	
Research Topic:	**Readiness of South African fee-paying public high schools in Gauteng in adopting 4IR technologies in alignment with Education 4.0**
Name of University:	**Wits**
Type of qualification	**Masters**
Number and type of schools:	**Secondary Schools**
District/s/HO	**Ekurhuleni North, Johannesburg North, Sedibeng West ,Tshwane South**

Re: Approval in Respect of Request to Conduct Research

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

13/12/2023

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

Making education a societal priority

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

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate.***
4. ***The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COVID-19 test, not older than 72 hours, and Sanitise frequently.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
14. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

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

Kind regards

.....

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

DATE: 13/12/2023

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

Appendix D: Turn-it-In Report

Research REPORT_Final Submission_29022024_Ramanti Mokhwesana_ Student No_ 2395746.docx

ORIGINALITY REPORT

2%	1%	2%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	wiredspace.wits.ac.za Internet Source	1%
2	Lucy Kibe, Tom Kwanya, Hesbon Nyagowa. "Harnessing fourth industrial revolution (4IR) technologies for sustainable development in Africa: a meta-analysis", Technological Sustainability, 2023 Publication	<1%
3	www.scielo.org.za Internet Source	<1%
4	researchspace.ukzn.ac.za Internet Source	<1%

Exclude quotes	On	Exclude matches	< 50 words
Exclude bibliography	On		

Appendix X: Research Instrument

INTERVIEW GUIDE

Format: Semi-Structured Interviews

1. **Interview Protocol.**

- Introduction by researcher: Personal introduction (of the researcher) as well as an introduction to the research project will be done.
- The purpose of the interview and the research questions to be explored will be explained.
- Get consent from participant.

2. **Research Questions**

- RQ1: What is the perceived value in implementing 4IR technologies in public high schools?
- RQ2: How can 4IR technologies be used to improve the quality of education in South African public high schools in Gauteng?
- RQ3: What are the challenges faced by educators in incorporating 4IR technologies into their teaching methodologies?
- RQ4: Which barriers exist to the adoption and implementation of 4IR technologies in public high schools?

INTERVIEW DATE: **PARTICIPANT NO:**	**INTERVIEWER: RAMANTI MOKHWESANA** **STUDENT NO: 2395746** **INTERVIEWEE:**
INTERVIEW START TIME: **INTERVIEW END TIME:**	**IN-PERSON INTERVIEW:** YES ☐ NO ☐ **ONLINE INTERVIEW:** YES ☐ NO ☐
1. **RESEARCHER INTRODUCTION:** My name is Ramanti Mokhwesana, I am a student at the WITS business school currently enrolled in the Master of Management in the Field of Digital Business 2. **STUDY BACKGROUND:** The assessment of the level of readiness in adoption of 4IR technologies in Education 4.0 in fee paying public high schools in Gauteng	
QUESTION	**RESPONSE / COMMENTS**
BUILDING RAPPORT	
1. What is your current position? 2. Which subject(s) do you teach?	
3. How long have you been a teacher? 4. How long have you taught at this school? (Teacher)	
RQ1: What is the perceived value in implementing 4IR technologies in fee paying public high schools in Gauteng?	
5. In your understanding, what are 4IR technologies?	
6. How can 4IR technologies be used to enhance student learning in the school?	
RQ2: How can 4IR technologies be used to improve the quality of education in public high schools?	
7. How have these technologies been used to improve the quality of education in your school? (if implemented already) 8. Have you personally used 4IR technologies in the subjects you teach? How have you used them?	
RQ3: What are the challenges faced by educators in incorporating 4IR technologies into their teaching methodologies?	
9. In your view, what are some of the challenges and limitations of using 4IR technologies in the classroom to enhance learning outcomes?	

10. How do think these challenges can be overcome?	
11. How do you use 4IR technologies to interact with learners?	
RQ4: What are the main barriers to the adoption and implementation of 4IR technologies in South African public high schools?	
12. Have you received training on how to use 4IR Technologies? 13. Based on your training, how have you changed your teaching approaches when using 4IR technologies? 14. How effective is the training you received on how to incorporate 4IR. technologies in your teaching practices? 15. In your view, what are the main challenges to implementing 4IR technologies at your school?	
16. Does your school have sufficient resources to support the implementation of 4IR technologies? In terms of space, facilities, Internet, electricity?	
17. What kind of intervention do you think will help fast tract the introduction of 4IR technologies in your school?	