



**A FRAMEWORK FOR THE APPLICATION OF THE FOURTH INDUSTRIAL
REVOLUTION IN IMPROVING THE SERVICE QUALITY OF TERTIARY
INSTITUTIONS IN SOUTH AFRICA.**

BY

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DECLARATION

I, Patala Najiyabanu Noormohmed, hereby declare that this thesis titled “A framework for the application of the fourth industrial revolution in improving the service quality of tertiary institutions in South Africa”, for the Doctor of Philosophy in Business Information Systems (PhD BIS) submitted to the department of Business Information Systems at the University of Venda has not been submitted previously for any degree at this or another university. It is original in design and in execution, and all reference material contained therein has been acknowledged.

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ABSTRACT

With the capability of re-shaping the global economy, 4IR necessitates countries to keep up with technological innovations that require most sectors within a country to be restructured drastically. Tertiary institutions are therefore required to transform the delivery of higher education services to the next generation with a seamless combination of skills and knowledge set. Thus, quality measures must be redefined in the context of 4IR. However, very few studies have attempted to define and measure quality from a 4IR perspective and lack frameworks addressing 4IR-based quality improvement solutions. This study investigated how 4IR can be applied within the context of tertiary institutions for improving service quality following a positivist paradigm. A quantitative research design was adopted to obtain an understanding of the 4IR stances and quantitative data was collected through questionnaires to gain an idea of the student and staff members' perceptions of 4IR service quality. The participants were sampled from the University of Venda's population of students and staff. A quantitative method for data analysis was employed through statistical analysis using SPSS software.

The findings of the study identified challenges that inhibits and benefits that could promote a 4IR-based quality of service environment. The study found that 4IR-based quality planning plays a significant role in quality of teaching and learning management. 4IR technologies were perceived to be useful as respondents had some form of awareness. Factors such as 4IR-based institutional responsiveness, empathy and assurance were significantly shown to measure service improvement. Based on the findings, a framework for implementing a 4IR service quality improvement in the teaching, learning, and research context was developed and validated. This study contributed to addressing how best tertiary institutions can implement 4IR by assessing their readiness levels. The Framework will assist tertiary institutions in gathering knowledge of the policies, strategies, and governance mechanisms required for supporting 4IR initiatives while providing guidance to understand quality 4.0 issues. It is recommended that tertiary institutions redesign their technological pedagogies to keep up with the demands of current educations needs and quality standards.

Key words: 4IR, Service quality, quality management, quality 4.0, service improvement, quality framework, tertiary institutions.

DEDICATION

I dedicate this study to Almighty God, for blessing me with knowledge and strength.

To my parents, husband, siblings and my late daughter for all the encouragement and support throughout the study period.

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LIST OF ABBREVIATIONS

4IR:	Fourth Industrial Revolution	QQ Plot	Quantile-Quantile Plot
AMOS:	Analysis of Moment Structure	SAQA:	South African Qualifications Authority
ASQ:	American Society for Quality	SABC:	South African Broadcasting Corporation
AVE:	Average Variance Extracted	STEM:	Science, Technology, Engineering, Mathematics
AI:	Artificial Intelligence	SEM:	Structural Equation Modelling
BART:	Bartlett's Test of Sphericity	SME:	Small and Medium Enterprises
BPM:	Business Process Management	SW:	Shapiro-Wilk-Test
EDM:	Electronic Data Management	SPSS:	Statistical package for Social Sciences
EFQM	The European Foundation for Quality Management	TAM:	Technology Acceptance Model
CFA:	Confirmatory Factor Analysis	TBP:	Theory of Planned Behaviour
CSF:	critical successes factors	TRAM:	Technology Readiness and Acceptance Model
DHET:	Department of Higher Education and Training	T&L:	Teaching and Learning
DMAIC:	Defining, Measuring, Analysing, Improving, and Controlling	TQM:	Total Quality Management
DOI:	Diffusion of Innovation	TRA:	Theory of Reasoned Action
DW:	Durbin Watson	TVE:	Total Variance Explained
EaaS:	Education-as-a-Service	Univen:	University of Venda
EQMS:	Electronic Quality Management System	UaaS:	University-as-a-Platform
EFA:	Exploratory Factor Analysis	UN:	United Nations
HEIs:	Higher Education Institutions	WEF:	World Economic Forum
ICT:	Information Communications Technology	WHO:	World Health Organisation
IS:	Information Systems		
IoT:	Internet of Things		
KS:	Kolmogorov Smirnov		
KMO:	Kaiser Meyer Olkin		
KMO-	MSA: Kaiser Meyer Olkin Measure of Sampling adequacy		
KPIs:	Key Performance Indicators		
LSS:	Lean Six Sigma		
MOOC:	Massive Open Online Courses		
MD:	Mahalanobis Distance		
PSET:	Post Education and Training		
PP Plot:	Probability-Probability Plot		
PCA:	Principal Component Analysis		
PDCA:	Plan-Do-Check-Act		

CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1. Introduction

It is evident that the fourth industrial revolution (4IR) has altered the standard of living of people around the world in terms of their work and social interactions leading to a profound socio-economic impact (Liu & Stephens, 2019). With the capability of re-shaping the global economy, 4IR necessitates countries to keep up with the pace of technological innovations which requires most sectors within a country to be restructured drastically (Asghar, S., Rextina, G., Ahmed & Tamimy, 2020). The growth of 4IR will have widespread consequences for all actors in today's globalised world inclusive of businesses, governments, and people with a shared understanding (Klaus, 2016a). 4IR refers to the radical change occurring while information technology increases across primary, secondary, and tertiary industries worldwide (M. H. Lee et al., 2018). It is argued that various components such as artificial intelligence, automation, 3D printing, virtual reality, robotics, cyber-physical systems, internet of things (IoT), cloud and quantum computing, nanomaterials, and biotechnology as well as energy storage are interlinked to the definition of 4IR (Klaus, 2016a). A concept that has been closely related to 4IR is the second information technology revolution.

4IR is becoming a lived reality for millions of labourers and organisations across the globe. Such enormous expansions further increased the demands for new roles and balance the falling demands for others. However, skills gap within the workforces is a threat hampering the adoption of 4IR technologies ultimately affecting the quality of services being offered on a national level (Klaus, 2016b).

Awareness regarding 4IR, its adoption, related consequences and concerns has been growing immensely, as more organisations are becoming dependant on information technology and smart knowledge to operate. Although contemporary businesses strive to incorporate 4IR within their business models and organisational culture to remain competitive and innovative (Liu & Stephens, 2019); only economies from ten nations have shown more than average shares in the global market of 4IR investments (Arthur, 2020). The ten nations out of 100 were assessed as illustrated in Table 1.1 and are ranked using a Readiness Diagnostic Framework Model based on their score of readiness for future production in terms of: (i) the drivers of production and (ii) the structure of production components.

Table 1.1: Readiness for the future of production assessment as of 2018. Source: (World Economic Forum, 2018)

Country	Score (Rank)	
	Structure of Production	Drivers of production
Japan	8.99 (1)	6.82 (16)
Korea, Rep	8.85 (2)	6.51 (21)
Germany	8.68 (3)	7.56 (6)
Switzerland	8.39 (4)	7.92 (3)
China	8.25 (5)	6.14 (25)
Czech Republic	7.94 (6)	6.01 (26)
United states	7.78 (7)	8.16 (1)
Sweden	7.46 (8)	7.40 (9)
Austria	7.46 (9)	6.79 (18)
Ireland	7.34 (10)	6.85 (15)

**The scores are out of 10.

Consequently, most developing countries lacked involvement in adopting 4IR-based technologies causing them to remain highly excluded from technological advances with reasons such as lack of preparedness and poor government support (Hamann, 2018). It is also evident from a 2018 report by the World Economic Forum (WEF), whereby most of the African countries fell under the category of “Nascent Countries” indicating their low level of 4IR readiness in which South Africa was ranked 45th in terms of structure of production and 49th in terms of drivers of production. Additionally, due to its limited technological capabilities and low level of technological advancements, South Africa is classified as “falling behind technologically” based on the technology capability index framework (Fagerberg & Srholec, 2017). In contrast, government and industrialists in developed countries have begun to prepare roadmaps for industry 4.0, and some countries have started the application of industry 4.0 in their leading companies from various sectors (Kamber & Bolatan, 2020).

According to (Sutherland, 2019), South Africa lacks adequate skills and an education system that produces leaders, researchers, and labourers to cater for 4IR. Furthermore, The WEF reported that in South Africa, human capital remained a significant challenge due to a lack of digital skills for the future of production preparation. Moreover, an approximate 12% decrease in GDP since 1990s also affected South Africa’s position in the 4IR race (O. O. Olaitan et al., 2021). Hence, education is one of the major industries that the least developed countries could benefit from (Enaifoghe, 2021). In such nations, economic and societal progress depends critically on stakeholders’ ability to initiate a transformation in education and training systems, policies, and skills development approaches.

1.2. Background of the study

In this research study, the process of comprehending the idea of 4IR based quality improvement began by initially understanding the concept of 4IR. According to (Rojko, 2017), the notion of 4IR was first recognized by Germany in 2011, represented by the term “industry 4.0” to introduce a digital manufacturing paradigm. In 2012, the Industrial Internet Consortium (IIC) in America initiated the concept of industrial internet which enabled the integration of the digital and physical world (Industrial Internet Consortium, 2015). With further advances, the industry 4.0 platform was created in 2013 through German companies involved in drafting the goals and approaches for industry 4.0, and remained active until 2015 (Anderl et al., 2017). However, the term 4IR received immense popularity in 2015 via the WEF, formulated by Prof. Klaus Schwab, a well-known leader in the field of 4IR who later released his book in 2016 detailing the 4IR phenomenon (Xu et al., 2018).

1.2.1. Industrial revolutions history

The concept of 1st industrial revolution commenced in the 18th century, which transitioned man and animal labour to mechanization, enabling people to shift from a rural-oriented society to a modern world (H. Mohajan, 2019). With a first world country like Britain initiating the 1st industrial revolution, economic growth sustained, and the population grew. The 2nd industrial revolution commenced in the 19th century, which created a link between science and technology; also regarded as the age of synergy which gave birth to a modern industrial economy (H. Mohajan, 2020). The 3rd industrial revolution commenced in the 21st century with an emergence of computerization, digital transformation, and interconnectivity through telecommunication (Taalbi, 2019). The 4th industrial revolution is a combination of various technologies interconnected within the physical, digital, and biological domain gaining momentum within major economic sectors including the education industry (Klaus, 2016b).

1.2.2. The fourth industrial revolution and Africa

Emerging countries have promising opportunities for restructuring the informal economy, which will enhance the spread and quality of services particular to the rural communities with improved access to education, medical and nursing services. According to (David & Grobler, 2020), Africa is referred as the “Gold Miner” in achieving swift economic growth through 4IR. Consequently, Africa is also referred to as the “Global PowerHouse” having

the potential to be transformed through 4IR (Ndung'u & Signé, 2020). While the emergence of 4IR contributed as a driving force for socio-economic growth, it also threatened the production and employment patterns with geo-political changes in both developed and developing countries (Ayentimi & Burgess, 2018). The study of (Enaifoghe, 2021) highlighted one of the strategies for leveraging the opportunities of 4IR is for the African governments to collaborate and work together. Furthermore, African countries such as Ghana, Egypt, Rwanda Gabon, Senegal, and South Africa have already began planning for the deployment of 4IR in various industries (Karuri-sebina, 2019). With an alarming concern, it is reported by (Masters, 2021) that the sub-Saharan African countries only contribute an average of 0.4% of their GDP on research and development, which caused the continent to lag behind in global interactions on technological and scientific developments. In comparison, major developed countries accounted for about 80% of world's spending on research and development. The study of (Masters, 2021) also indicated that the presence of over-reliance on external funding (from foreign countries) often leads to limited solutions.

Nevertheless, (Maisiri & van Dyk, 2019a) reported that the adoption of 4IR is significant for sustainable development in South Africa. Research by (Bhaskar Chakravorti et al., 2015) revealed that South Africa is classified as a "break out" country based on the digital evolution index; meaning that it has the potential to grow, improve and build a robust digital economy. Accordingly, South Africa's president Cyril Ramaphosa briefed on the national strategy for harnessing the fourth industrial revolution in early 2020. The president indicated its plans to grow the economy through innovations in the technological field by 2030. The formulation of a committee comprising of various academics, researchers, start-up businesses, specialists of cybersecurity, members from the trade unions, members of several economic sectors and social scientists enabled South Africa as part of their national development plan to report on the following challenges (South African Government, 2020): The country's infrastructure and resources, Technology and innovation, Industrialisation, Legislation, Policy, Research and, and Human capital.

Despite the efforts by the president, a concern is raised by (O. O. Olaitan et al., 2021) indicating that the intended goals pertaining 4IR remains unattained based on their proposed 4IR readiness model. Therefore, their study recommended a need for a "futuristic education curriculum".

1.2.3. The influence of 4IR on the education industry

Amongst other industries, the education industry has also achieved colossal progress with technological changes and has a significant role to play in enabling societies to successfully adjust towards the 4IR. Yet, the technological transition has been moderate and unsatisfactory due to the inability of the educational sector to with the pace of digital innovations (A. Oke & Fernandes, 2020). Furthermore, the education sector lacks appropriate documentation on the barriers and effectiveness of 4IR technology (Moloi & Mhlanga, 2021). Compared to the traditional learning which encompassed undergraduates, graduates, and research, the 4IR requires educational institutions to prepare for lifelong learning giving rise to the concept of “just in time education”. Therefore, a need for reconfiguring the perceptions of individuals on education is raised (Moloi & Mhlanga, 2021). Also, (Mlachila & Moeletsi, 2019) indicated that South Africa suffers from poor quality of education and is a barrier of progress. According to (Gleason, 2018), quality education in 4IR must be inclusive of student-centred training, project-based intellect, and reliable experiences.

The growth of an industrial society significantly requires technical education, but prioritises creativity skills, divergent thinking, and receptiveness to different viewpoints (Lewis, 2018). It is reported by (Karuri-sebina, 2019) that, Africa requires to equip approximately 33 million people with vocational and technical education from secondary schools. However, in South Africa, only 40.9% of public schools have access to computer labs, of which 28% has been functional (African Union, 2019). Therefore, a portion of students enter tertiary institutions without any formal digital literacy, which is a concerning factor contributing towards inequalities in education. The Minister of Higher Education, Science, and Innovation: Dr. Blade Nzimande reported that he was satisfied with the progress of 4IR and indicated that The Department of Basic Education South Africa received monetary aid to improvise teaching and learning by training educators in the field of Robotics, Coding and ICT (Ministry of Higher Education Science and Innovation, 2022). It is highlighted by (Kubayi, 2019) that, for Africa to successfully benefit from educational innovation, the investment in 4IR must be comprehended by rural societies.

1.2.4. The adoption of 4IR in tertiary institutions

Higher educational institutions inclusive of tertiary institutions have acknowledged the urge to keep up with the trends of 4IR in enhancing the delivery of services. Tertiary

institutions have been experiencing systematic changes in terms of technological advancement and digitization (Orr et al., 2019). With 4IR, the concept of education 4.0 have emerged and a smart campus infrastructure becomes a demand for tertiary institutions in remaining competitive (Azizah Binti Junid et al., 2019). Therefore, tertiary institutions are required to define the transformation of delivering higher education to the next generation with a seamless combination of skills and knowledge set (Asmaa, 2016). It is advised by (Penprase, 2018) that, 4IR adoption planning should be relied on the outcomes of the third industrial revolution. In terms of curriculum, the 4IR caused traditional education to be unfit for its purpose and requires the redesign of curricula in fields such as Science, Technology, Engineering and Mathematics (STEM) to suit the needs and cater for challenges of the 21st century (Abdurrahman, 2019). However, despite the use of platforms such as social media, Massive Open Online Courses (MOOC) and e-learning systems; digitization of educational services has not matured (A. Oke & Fernandes, 2020).

Furthermore, no standard measures have been established to determine what constitutes 4IR in a tertiary institution context (Madumo & Kimaro, 2021). Similarly, (Hlobo et al., 2021) alluded that there is not enough data regarding the integration of 4IR in higher education and its implications thereof. On the other hand, the South African government has built pressure on tertiary institutions in becoming entrepreneurial universities with the aim of monetizing research outputs and contributing to the economic growth (Tengeh & Rorwana, 2017). Hence, it is iterated by (Ogunlela & Robertson, 2021) that tertiary institutions rather be more proactive along the 4IR activities than the third industrial revolution and embrace the culture of “innovative talent”. But, according to the Department of Higher Education and Training South Africa (DHET), only eleven universities have incorporated 4IR related courses into their curriculum (Mzekandaba, 2019).

1.2.5. 4IR and Quality of Services in Education

Quality education is referred to as the engine of 4IR. The concept of 4IR necessitated certain changes in the processes ensuring the highest quality of services. Tertiary institutions act as reagents in preparing societies for positive and negative impacts caused by technological transformations. According to (Riaan, 2018), defining and measuring the quality of service is complex yet it remains an important element in

maintaining competitive advantage. This view is supported by (Chikazhe et al., 2022), highlighting the gap of an absence of appropriate indicators of university service quality due to differences in courses, programmes, academics, graduates, and rankings. Quality education is backed up by the United Nations' sustainable goal number four. However, Otilia Chiramba (University of Johannesburg) and Elizabeth Ndofirepi (University of Witwatersrand) emphasized that quality higher education is perceived as a liberal tool for disadvantaged students (Maringe, 2021). It is indicated by (Asembo, 2014) that, various authors view quality in higher education as a synergy of product, software, and service. Service quality is defined as the gap between what customer's expected and the definite service performance they obtain which is highly based on individual perceptions (Al-jazzazi & Sultan, 2017).

It is anticipated that 4IR will improve the quality of teaching and learning; however, the need for a smart, pioneering, and collaborative infrastructure has been identified to support the application of 4IR in the education industry (A. Oke & Fernandes, 2020). The South African Qualifications Authority (SAQA) released a bulletin in 2021 indicating the significance of understanding 4IR and its implications for the education industry (SAQA Bulletin, 2021). One of the topics covered in the bulletin was concerned with Quality Assurance 4.0. The study of Professor Kerry Kennedy in the SAQA bulletin alluded that the quality assurance approaches are rather "backwards-looking" instead of "future focused". Therefore, tertiary institutions are required to rethink on the role of technology in line with their quality teams. In south Africa, the University of Johannesburg is one of the leading institutions in initiating the implementation of a Smart Campus model to improve the overall quality of the institution (Imbar et al., 2022).

1.2.6. The need for 4IR Application framework in tertiary institutions

The Minister of Higher Education, Science and Technology, Dr Blade Nzimande, highlighted that industrial revolutions have been unsuccessful in addressing inequality within the bounds of and amongst countries (Nzimande, 2020). This view is similar to the view of Otilia Chiramba and Elizabeth Ndofirepi, who mentioned that underprivileged students suffer from inequality even in a Post-Apartheid South Africa (Maringe, 2021). Currently, several countries in Africa lacks a comprehensive framework to equip the potential of 4IR towards global progression (Sutherland, 2019). South Africa being one of Africa's greatest technologically advanced country, must play a role in leading Africa

into the sphere of 4IR (Cornell University; INSEAD and WIPO, 2020). As of 2022, the Deputy Minister of Education, Science and Innovation South Africa have indicated that as part of the country's 4IR strategy, various projects have been launched in different TVET colleges across the country (South African Government News Agency, 2022). Furthermore, the 4IR Readiness Diagnostic Model by the WEF referenced a need for an "Institutional Framework" as an important driver of future readiness (World Economic Forum, 2018). The aim of the institutional framework is to understand the effectiveness of government organisations and how its rules and regulations supports technology development. Specific to South Africa, an institutional framework is significant to counter change, stabilise policies and guide innovation. Specific to higher education, a national framework is therefore required: for the formation of 4IR capabilities in South African tertiary institutions, to support the assessment of the broad nature of 4IR in tertiary institutions, and to determine 4IR leverages on specific technological applications in tertiary institutions (Department of Higher Education and Training (DHET), 2019). Mr Rev Frank Chickane in a report by (Gastrow, 2018) mentioned that: "we don't have to respond to it [4IR], we must be part of the creation of it and own it rather than get other people to do it". In support of the previous statement, it was significant to develop a 4IR framework for providing guidance to the policy makers in tertiary institutions in building a well-informed, responsive, and futuristic environment for adapting 4IR.

1.3. Research Problem Statement

Currently, the internet growth has changed how the world utilises technology through platforms such as social media and cloud computing creating various opportunities and obstacles for the education sector (Mashau & Nyawo, 2021). Tertiary institutions remain questionable regarding their purpose in future, although the core mission stays the same regardless of the era. The goal of tertiary institutions is to deliver quality teaching and learning, provision of advanced knowledge via exploratory research and partake in community development services (Xing & Marwala, 2017).

Additionally, a study by (Grinshkun & Osipovskaya, 2020) revealed that automation will take over approximately 75 million jobs across the globe by 2025. However, it will further create 133 million new opportunities for employees retaining digital skills. Therefore, tertiary institutions are required to develop retraining programs which are supported by 4IR technologies. The position of DHET concerning 4IR is highlighted in a report by

(Department of Higher Education and Training, 2020) which focused on transforming the Post-School Education and Training System (PSET) and visioning standardised quality assurance practices. However, the study of (Mashau & Nyawo, 2021) points that DHET did not emphasize on educational technology to enhance teaching and learning and that emerging technologies of the 4IR are underutilized.

In 2020, the covid-19 pandemic further affected approximately 219 countries worldwide with South Africa ranked 16th across the globe and 1st in the African continent with higher number of reported cases (WHO, 2021). Most countries were forced to implement a hard lockdown to control the increasing spread of the virus (Woldegiorgis, 2022). With most of the sectors and industries negatively affected, the education sector was no different leaving 1.6 billion people out of school (Mhlanga & Moloi, 2020a). Tertiary institutions started utilising the online platforms for carrying out teaching, learning and other administrative activities as a measure to mitigate the catastrophe (Haleem et al., 2022; World Bank, 2020). In the African continent, traditional schools and tertiary institutions were closed during the initial lockdown as they were not equipped with 4IR tools. South Africa already had the efforts to strengthen online learning within the education industry prior to the pandemic. However, the pace was slow in the presence of challenges such as infrastructural deficiency, lack of broadband facilities and expensive data charges. This view is supported by the study of (Woldegiorgis, 2022) which reported that most universities are finding difficulties in aligning with the 4IR era.

Although the usage of online platforms for teaching and learning increased by 90%, for developing countries like South Africa, research was required to determine how quality of services can be improved using 4IR tools in tertiary institutions. Many other research innovations in the 4IR field were widely conducted in the manufacturing sector with little focus on the service industry, particularly the tertiary education industry (A. Oke & Fernandes, 2020). Significantly, a report by the National Advisory Council on Innovation highlighted that as of 2019, South Africa only contributed 0.54% of world publications through its scientific publications concerning 4IR (National Advisory Council on Innovation, 2021). The report also indicated that only 39 4IR patent applications were filed by South Africa compared to 1687 4IR applications by China. Additionally, the idea of education 4.0 in tertiary institutions in the South African perspective is still considered in the early stages of implementation. With technology altering the dynamics of the

education process, the extent of influence of implementing 4IR technologies and practices on the quality of education services needed to be evaluated.

Due to the Covid-19, intense research on how well tertiary institutions have maintained their quality of services was required. This research enabled in determining tertiary institutions level of preparedness and adapting capabilities. It was also essential to propose strategies for tertiary institutions to overcome 4IR challenges and to improve their quality of services. Accordingly, a significant framework was required to be developed in enabling the use of 4IR-based technologies with insights regarding the enhancement of quality of services within tertiary institutions (i.e., quality 4.0).

1.4. Research Aims and Objectives

The purpose of the research was to investigate the application of 4IR-based technologies in the context of tertiary institutions in order to develop a 4IR service quality improvement framework for promoting the implementation of 4IR technologies in teaching and learning environment.

Research Aim

The research aim of the study was to develop a suitable framework for implementing 4IR technologies to assist with improving the quality of services at a selected Rural-based tertiary institution using a case study of the University of Venda.

Research Objectives

To achieve the aim, the study was guided by the following objectives:

- a. To determine the readiness extent and 4IR capabilities required by tertiary institutions for improving the quality of services.
- b. To understand the role of 4IR in contributing to the improved quality of services at a selected tertiary institution in South Africa.
- c. To analyse how the challenges and benefits of 4IR in South African tertiary institutions affected the quality of service in teaching, learning, and research.
- d. To evaluate the level of awareness, expectations, and perceptions of stakeholders towards the application of 4IR in tertiary institutions.
- e. To develop a suitable 4IR driven quality management framework for improving the service quality of teaching, learning and research in tertiary institutions.

1.5. Research Questions

The following research questions needed to be addressed in detail:

- a. What 4IR capabilities tertiary institutions need to develop for enhancing quality of service?
- b. To what extent is 4IR contributing to increased quality of teaching, learning and research processes?
- c. How do the challenges and benefits of 4IR affect the quality of service in teaching and learning, and research?
- d. Are the stakeholders of tertiary institutions aware of 4IR and how do they perceive the application of 4IR technologies?
- e. What measures should be put in place to enhance the quality of services through the implementation of 4IR technologies in tertiary institutions?

1.6. Justification of study

The study is aimed to inspire tertiary institutions in maximising the utilization of 4IR technologies within their environment. The goal was to obtain findings which could be valuable in assisting tertiary institutions in overcoming the digital divide gap between rural and urban areas through 4IR. This research provided a roadmap towards embracing 4IR as a core element in conducting teaching and learning, and research. Hence, it will enable students and educators to understand the various concepts and tools of 4IR that could be applied in a higher education context. The study also enlightened tertiary institutions on the benefits of implementing 4IR technologies in teaching, learning and research context. Furthermore, it enabled to explore education 4.0, university 4.0, and quality 4.0, as a response to the needs of the 4IR.

Consequently, it generates knowledge on the influential factors of 4IR that had an impact on the quality of services at tertiary institutions, as this area was deemed to not be explored enough. The research strengthens the capacity of tertiary institutions in tackling the challenges posed by 4IR and harness this revolution for development and enhancement of quality of services. The study also assists policy makers in the education industry to revise and develop policies that caters for 4IR to support rural-based tertiary institutions in South Africa. The framework developed can assist stakeholders with an insight on specific skills required in the 4IR era. The research also opened room for researchers to give opinions on various 4IR issues and recognize different viewpoints.

The research hopes to educate tertiary institutions on the significance of involving all stakeholders including students and lecturers in effectively implementing 4IR projects.

Along with above context, the study ought to benefit the following:

Students: the implementation of 4IR technologies will enable students to perform better as quality of educational services is expected to improve. The students will be able to embrace the concepts of lifelong learning which comes along with the implementation of 4IR technologies. The students will become more aware of 4IR and its related concepts. The study also motivated students to improve their knowledge on 4IR.

Lecturers: the current study was significant to lecturers as 4IR has vital tools and enormous opportunities which could assist in the teaching processes. This study established the level of awareness of lecturers in the field of 4IR which is important in order to redesign the curriculum to fit the needs of the 21st century. This research also aided in determining the perceptions of lecturers regarding the implementation of 4IR technologies for improving service quality.

Tertiary institutions: this study provided tertiary institutions with insights on understanding its important role in supporting the implementation of 4IR for improving the quality of educational services. In this way, it will be able to identify various opportunities to benefit from through and by implementing 4IR projects. The policy makers in tertiary institutions will understand their position in setting 4IR-related policies specific to quality management. The framework provided a guidance to the management in developing 4IR plans not just from technical perspective, but, from an overall business perspective. Therefore, it motivated them to incorporate recent trends like 4IR in their IT strategies. The quality assurance and management team in tertiary institutions required guidance to monitor and evaluate the progress of 4IR projects with the correct knowledge of expected outcomes in line with quality enhancement.

4IR body of knowledge: the developed framework will complement the frameworks developed by other researchers which attempted to assist with the implementation of 4IR in different industries. The findings of this study contributed towards literature as an extension to 4IR theories within the context of tertiary education and service quality. The findings of this study will also benefit future research, as academics and researchers can use knowledge gained from this study for their literature review.

1.7. Delimitations of the study

The research was limited to 4IR in the education industry, which leaves out other industries and its related crucial aspects of 4IR. The study only focused on a selected South African Rural based tertiary institution which was: the University of Venda, a historically disadvantaged institution with limited resources, capacity, and finances. However, the study focused on this rural-based institution because there is a lack of literature accommodating them with insights regarding the implementation of 4IR for quality-of-service improvement. The study was concerned with registered students, academic staff, and the IT team at the University of Venda. It is also important to note that due to the nature of the study, the responses and perceptions of the participants were evaluated at a specific time-period, therefore, the analysis were deemed significant for that particular period of time.

1.8. Operational Definitions

The following are the operational definitions which have been used in this study:

- **Higher education institution** is referred to any state authorised institution providing post-secondary education based on a fulltime, part-time and distance learning in accordance with the higher education Act 101 of 1997. According to (Alemu, 2018), contemporary higher education institutions are referred as a systematic tertiary education and training institutions with an academic environment, which are inclusive of Universities, Colleges, and Technikons. For the current study, higher education institutions were referred to as tertiary institutions and universities.
- **Fourth Industrial Revolution (4IR)** is regarded as an integration of digital, physical, and biological spheres through the interaction of technologies such as artificial intelligence, big data, advanced robotics, 3D printing, IoT, automation and wireless technologies (Klaus, 2016a).
- **Quality** for this study, quality was defined as the “Fitness for Purpose”, which is complying to acceptable standards set by tertiary institutions, quality assurance bodies together with academic and professional communities. For tertiary institutions, quality is affected by vision and goals, staff expertise, infrastructure, educational environment, graduate capacities, admission requirements,

assessment criteria, and management's effectiveness and leadership (Van Tonder, 2018).

- **Service quality** covers any form of measures for comparison between consumers perceptions of expected and actual service performance (Parasuraman et al., 1985). It is also considered as a tool for obtaining operational business competence through which it is depicted if customer satisfaction is negatively or positively affected (Uzunboylu, 2016). In this study, service quality was referred as a valuation of the extent to which service delivery levels met the needs and expectations of service users in order to detect problems and improve services (Ramya, 2019).
- **Quality Management** is defined as a process of management through a set of agreed upon principles backed up with various techniques and practices (Barros et al., 2014). It is also considered as a process of ensuring that the activities and tasks required to obtain an expected level of service excellence remain consistent and functional in order to efficiently plan, assure, control and improve quality. However, for this research, quality management was referred as a systematic approach to reaching the desired quality by implementing particular processes, resources, methods, and tools, which would assist in planning, controlling, assuring and improving quality (Popescu et al., 2017).
- **Education 4.0** is referred as an innovative paradigm for rethinking the concepts of schools, learners, learning, educators, and teaching in accordance with the requirements of 4IR for improving the process of information transfer and knowledge creation (Miranda et al., 2021). It is also considered as a disruptive innovation in educational institutions for personalising learning and promoting the trend of "sustainable open education" (Chaka, 2022). For the current study, education 4.0 was regarded as an approach of learning in the context of 4IR with the aim to transform educational future and enhance tertiary education experience by integrating emerging technologies into the curriculum (Joshi, 2022).
- **Quality 4.0** is recognized as a term for "future of quality" in the era of 4IR (ASQ, 2020). It occurs when quality management and approaches are digitized for quality improvement (Jacob, 2017). It is also considered to be a blend of traditional quality methods with emerging technologies to assist organisations in achieving innovation, operational excellence, and enhancing performance (Antony et al.,

2021). For this study, quality 4.0 was referred to the application of 4IR technologies to service quality improvement in higher educational institutions (A. V. Carvalho et al., 2021).

- **Framework** a basic structure (i.e. overview or outline) underlying a system or concept which supports a specific approach to meet an objective and acts as a guide that can be altered and adjusted (English Dictionary, 2018).

1.9. Structure of the Thesis/Dissertation

This section provided an outline of how the research study is organised. The study comprised seven chapters as outlined and briefed below:

Chapter one: Introduction and Background – this chapter gave an overview of the study. This chapter was of significance as it enlightened the research focus. It provided a background of the research topic, the problem statement, significance of the study as well as the aim and objectives. It also highlighted the delimitations and essential definitions of the study.

Chapter two: Literature Review – this chapter presented a review of existing literature on 4IR in the context of education. It also discussed the underlying factor of quality in relation to 4IR in the educational context. This chapter was essential as it assisted in recognising the present literature gaps to support the current study.

Chapter Three: Theoretical Underpinnings – this chapter focused on identifying the various theories and models used in information systems research. It then reviewed selected theories which assisted in developing the conceptual framework and hypothesis of the study.

Chapter Four: Research Design and Methodology – this chapter explained the research methods and approaches for the study. It also determined the strategies for collecting data, justified the research instruments and the population and sampling selection. The chapter was of significance as it accounted for the development of the 4IR service quality framework.

Chapter Five: Data Presentation, Interpretation and Analysis – this chapter interpreted and discussed the results of the study. It aligned the results with the research questions to achieve the objectives of the study.

Chapter Six: Discussion of the findings and proposed 4IRQI framework – this chapter discussed the findings of the research with literature synthesis proposed the 4IR service quality improvement framework that tertiary institutions can use based on the findings of the study.

Chapter Seven: Conclusions and Recommendations – this chapter provided concluding notes of the research study. It also presented the limitations of the study. It made recommendations based on the outcomes of the study and highlighted the contributions to the body of knowledge. Lastly, it also presented the suggestions for future research.

1.10. Summary

This chapter outlined the fundamental concepts of the study and provided a holistic view of the of the current research. Based on available literature, it is revealed that 4IR is significant in improving quality of services. Therefore, a 4IR framework is a requirement in implementing 4IR technologies to enhance quality of services. The chapter also showed that the concept of 4IR is a trend in various industries and the education industry should support the trend. Through literature review, a narration of the problem was stated, after which the aim and objectives of the study were derived. A few subsections were dedicated in explaining the research background, research questions, justification of the research as well as the delimitations of the study. The next chapter presents an overview of the literature to depict the relationship between current knowledge and the topic of the study together with providing a basic structure to the study.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter presents previous research findings in the field of 4IR and service quality within tertiary institutions. The aim of this chapter is to obtain an in-depth knowledge of the research topic, which is achieved by identifying the developing themes in the research area. It looks at 4IR as a concept, 4IR in the context of Africa and South Africa. It also highlights the significance of 4IR emerging in the education sector and sheds light on the level of preparedness thereof. The chapter further illustrates the current challenges raised in the adoption of 4IR at tertiary institutions as well as 4IR application in education. Additionally, it also views the state of quality 4.0, and how it transitioned across the different industrializations. Lastly, chapter then recognises the challenges of quality 4.0 implementation and studies the aspects of 4IR in enhancing the quality of service.

2.2. The Concept of 4IR

4IR is recognised as an integration of the latest technologies with advanced tools, smart devices, and media as well as suitable processes for adoption in various economic sectors (Alzahrani et al., 2021). It also has a significant impact on society's cultural, social, and economic progress. According (Klaus, 2016a), 4IR plays a significant role in transforming the following factors:

- **Economy:** 4IR is said to have an impact on the growth of an economy with an increase in productivity and sustainable economic growth. In terms of the labour market, 4IR is already changing the nature of work in all industries compelling labourers to reposition their skills or become unemployed. On the other hand, 4IR technologies will create innovative job opportunities with new fields of prosperity.
- **Business:** 4IR requires businesses to work with speed and agility. Most business sectors are compelled to operate digitally, which creates a difference in price and quality. However, 4IR is not just about maintaining digitization, but re-examining business processes to adapt and use a combination of various technologies. Business leaders must consider the effects of 4IR such as changes in customer expectations, enhancement in asset productivity, value of collaborations and partnerships, and transitions in business models inclusive of biological digital and physical worlds.
- **Society:** like any other technological change, societies become overwhelmed commonly due to unawareness. The presence of robotics and algorithms have been

contributing to inequalities especially in developing countries and middle-income societies creating a fear of social unrest, instability, and lifestyle changes. As 4IR empowers communities through digital and social media, it can also contribute to spreading political agendas with harmful intentions by terrorist groups.

- **Individuals:** 4IR has affected individual identities as it is influencing factors such as buying behaviours, careers, skills set, health, morals, and ethics. Although technologies have increased the ability to remain connected, 4IR has posed a fear of losing empathy and ability to engage physically. Privacy also becomes a concerning factor for individuals, as data ownership in 4IR has become a fundamental challenge.
- **National and global government:** 4IR is reshaping interactions between governments and their citizens, enabling them to be more transparent, accountable, and engaged. It brings opportunities for citizens to remain more informed and voice their views. Also, facilitating individual needs and accommodating disruptive change determines the government's ability to survive.

2.3. 4IR in the South African Context

According to a study by (Sutherland, 2019), the South African president is said to have infused 4IR in the South African economic policies. The WEF has portrayed a significant role in influencing the South African government to revise policies in support of deploying 4IR technologies. Despite, the government has failed in keeping up with the implementation of such policies due to a lack of interdepartmental coordination (Sutcliffe & Bannister, 2020). Although South Africa could create business opportunities throughout the African continent, challenges such as volatile growth, inability in sustaining public investments, scarcity in quality employment, increased inequalities, and unsustainable productivity have caused a hindrance (Ayentimi & Burgess, 2018). Fields requiring government attention in 4IR adoption does not leave the education sector behind. An investment of 134 billion Rand was obtained by the government to engage with multinational corporations (Kekana, 2018). However, changes are made in a slow pace, with a lack of quality legislation, poor regulations, and high dependence on public-sector enterprises. The industrial policy of South Africa aims to produce employment and enhance the economic growth (PC4IR, 2020). But automation, robotics and customisation have demolished more jobs than it created as 4IR decreased the demand for low-skilled labourers (Naudé, 2017).

2.4. Emergence of Education 4.0 in South Africa and Level of Preparedness

Education 4.0 enables higher learning institutions to reconceptualise the learning environments, learner, and educator needs, together with learning institutions to suit the needs of 4IR. The study of (Mhlanga & Moloi, 2020b) outlined that the presence of covid-19 had an impact of digital transformation towards the 4IR. Covid-19 acted as a driving force in compelling governments to respond to the pandemic in using 4IR technologies to mitigate for the times lost in the lockdown. The following programmes were launched by the government in partnership with various private institutions:

- **Virtual learning** – the ministry of communication and digital technologies had put efforts in promoting online learning to reduce the disruptions caused by covid-19 (Mzekandaba, 2020). Such an initiative was supported by the South African Broadcasting Corporation (SABC), DSTV, E.tv and various radio stations in availing their channels for educational purposes through which live lessons were delivered to the students.
- **Zero-rated applications and websites** – in order to contribute towards the smooth progress of educational activities, mobile networks such as MTN, Vodacom, Cell C, and Telkom partnered with the government to offer free zero-rated websites to accommodate electronic readers and cater for online curricula (Government of South Africa, 2020).
- **STEM based digital schools** – the Department of Basic Education partnered with African Teen Geeks in introducing STEM digital school. Additionally, the Sasol Foundation launched a STEM based educational platform using Artificial intelligence. Through such initiatives, all the educational content was posted on the Department of Basic Education website. However, a challenge to reach out the rural areas with no internet access persisted (Matlali, 2020).
- **A switch to remote online learning** – tertiary institutions in South Africa shifted to online learning after the lockdown announcement to ensure social distance and protection from the spread of the Covid-19 virus (Mpungose, 2020). Platforms such as YouTube, Skype, WhatsApp, Facebook, and Zoom were vastly used. Moreover, the Worksheet Cloud organisation together with My School My Village My Planet Organisation offered financial support in providing costless and unlimited access to live online classroom streaming. This programme also allowed educators to make

use of the online assessment platforms to back the ongoing assessment of activities through ICT (Fourie, 2020).

Table 2.1 depicts an illustration of the various 4IR tools used in the South African Education Sector

Table 2.1: Digital Tools Used During Lockdown in South Africa. Source: (Mhlanga & Moloi, 2020b)

Digital tools used during the lockdown in South Africa					
<i>Tools Used</i>	<i>Description</i>	<i>Connectivity</i>	<i>Platform</i>	<i>Conditions of Use</i>	<i>Target Group</i>
Television (SABC, DSTV, E.tv, Radio (SABC)	Teachers delivering lessons live to learners on TV	Offline	Television Desktop, Radio	Free (lockdown)	Primary Secondary (virtual classrooms)
Use of free zero-rated applications and educational websites Mobile Platforms and applications (Vodacom, Cell C, MTN)	Learners access learning material from educational and informational (reference) websites	Online	Desktop laptop mobile	Free (lockdown)	Primary Secondary Tertiary
Social Media Facebook, Twitter, WhatsApp groups (Sasol Foundation (SF), African Teen Greek, Ms Zora, Siyavula)	Teachers in public and private schools offer classes through a live stream	Online	Desktop Laptop mobile	Free (lockdown)	Primary, Secondary
Internet Websites YouTube, Microsoft teams, Skype, Zoom	Learners Learn on their own at home	Online	Desktop Laptop mobile	All rights reserved, Freemium, free (Lockdown)	Tertiary Primary Secondary

2.5. Challenges of 4IR Adoption Faced by Tertiary Institutions

Developing countries have already begun adjusting their education systems considering the 4IR trends. However, various developing and underdeveloped countries are finding it difficult to prepare for the changes 4IR brings along. According to (Uleanya & Ke, 2019), a sustainable and quality teaching and learning arrangement promotes significant development. Therefore, learning institutions in many rural African regions were established. Despite, rural areas struggle to achieve the desired experiences of learning similar to those of urban areas (Uleanya et al., 2018). Various literature studies revealed several challenges that hinders the adoption of 4IR technologies in rural based tertiary institutions as highlighted below:

National versus international standards: according to (Uleanya et al., 2018), tertiary institutions worldwide are eager to keep up with global standards and design their educational systems and curricula based on an international setup. This created a

challenge of overlooking the educational needs of the local and particularly rural communities. However, it is noteworthy to utilise international standards as a reference in attempting to address the national educational requirements of 4IR and hence to eliminate a mindset of “one size fits all”.

Inequality: the study of (Xu et al., 2018) depicted that a disruption in the labour market due to automation shall contribute towards an increased inequality. This results in an increased gap between high skilled and low skilled labour (K. Zervoudi, 2020). According to (Sulla, Victor; Zikhali, 2018) , South Africa is referred as the most unequal country globally in which the top 10% of its population own 70.9% of the nation’s wealth. While the bottom 60% owns 7% of the nation’s wealth. The introduction of 4IR will leave about 30 million population of the country without access to latest technologies for educational use. Tertiary institutions are lagging in creating a pool of e-skilled workforce which could contribute towards improving the quality of education.

Lack of funding: regardless of an increase in budgeting towards education, it is still not enough to cater for the needs of implementing a 4IR based educational environment. According to (Kayembe & Nel, 2019), limited funding towards technological infrastructure affects the quality of education in rural-based tertiary institutions. This has led to an increase in tuition costs and a decrease in research subsidies. It is reported by (A. Oke & Fernandes, 2020) that the education industry in South Africa needs to acquire substantial investments for enabling tertiary institutions to effectively adopt 4IR. Additionally, there is a lack of ability in determining positive returns on investments through technology whereby tertiary institutions are unable to prioritise the areas of utilising the funding.

Marginalisation of socio-economic groups: despite an increase in black and coloured student enrolment post-apartheid, a study by (Kayembe & Nel, 2019) revealed that their gross participation rate in schooling is lower than white South Africans. Marginalised populations are left behind in the race of 4IR due to a deficiency in financial resources and access to basic ICT infrastructure (Suganya, 2017). Amid the Covid-19 pandemic, certain 4IR technologies were implemented to support students and lecturers. However, poor internet connectivity and electricity in remote areas prevented some groups to access learning online proving that digitization had a negative effect of implementing 4IR. According to (Xing & Marwala, 2017), if attention is not provided towards marginal income

households, 4IR shall aggravate the omission of disadvantaged students from participating in formal education.

Availability of skills and resources: it is highlighted by (Mhlanga, 2020) that for a complete implementation of 4IR in education, the right skills and resources are required to be made available. Extensive digital skills from the student's side are required to understand the instructions of virtual learning. Yet, in terms of 4IR, a set of specialised skills are required apart from the core digital literacy (Petrillo et al., 2018). However, there is lack of provision of training that could enhance the participation of educators and learners in utilising the benefits of 4IR.

Innovative policies: (Manda & Dhaou, 2019) stated that the implementation of 4IR policies should be aligned with the demand of the educational needs. To support the implementation of 4IR, policies and legislation should be reformed. According to (Kayembe & Nel, 2019), although the policies, strategies and regulations exists, the changes are slower with limited capacities. There is an absence of national policies that supports the prioritisation of education and training for all age groups in the STEM context (K. Zervoudi, 2020). Additionally, existing strategies lacks integration of ICT across various educational systems (A. Oke & Fernandes, 2020).

2.6. Application of 4IR in Education

A study by (Elayyan, 2021) reported the perceptions of educators concerning the application of 4IR in education. The report divided the perceptions in four dimensions as highlighted in the Table 2.2. The report revealed that technologies such as blockchain, cybersecurity, robotics and cloud computing will be used for various purposes in the educational sector.

Table 2.2: Application of 4IR technologies in the education sector. Source: researchers own compilation adapted from (Elayyan, 2021)

Dimensions	Perceptions	Ratio
Content learning	The application of 4IR in education will: <ul style="list-style-type: none"> - Decrease the educator's attendance in the learning environment. - Enhance classroom management. - Improve student's verification anywhere through blockchain. - Make storage of student's files easier through cloud computing. - Keep the learner's data secure through cybersecurity. 	Very high
Learning opportunities	The application of 4IR in education will: <ul style="list-style-type: none"> - Deliver more learning resources and databases. - Enable anytime anywhere learning experiences. - Support more opportunities in individual learning. - Enhance global learning without any boundaries and restrictions. 	Very high

	<ul style="list-style-type: none"> - Promote life-long learning. - Expand the learning platforms beyond physical locations. 	
Content and instructional activities	<p>The application of 4IR in education will:</p> <ul style="list-style-type: none"> - Amend the instructional strategies. - Amend the learning outcomes per course. - Produce an integrated curriculum. - Implement teaching and learning through robotics. - Promote non-biased electronic assessment evaluations. - Promote electronic and mobile based controls in education. - Introduce innovative and current concepts in the curriculum. 	Very high
Social implications	<p>The application of 4IR in education will:</p> <ul style="list-style-type: none"> - Reduce expenses of education. - Increase job opportunities. - Promote student's healthcare. 	Very high

Another study by (Masinde & Soux, 2020; Xing & Marwala, 2017) determined the influence of applying 4IR on the three core functions of tertiary institutions:

- **Teaching:** 4IR technologies have been supporting tertiary institutions through the adoption of wearables in teaching, learning, and training assistance. It promoted utilising Massive Open Online Courses (MOOCs) in an off-site and online teaching and learning context, which enhances access and reduce limitations. 4IR also contributed towards the cultivation of innovative talent and prioritised life-long learning in formal and informal education both for student and staff developments. Also, the need for a blended learning environment is generalized in the 4IR making it a feasible option in enabling the learners to be equipped with problem solving capabilities.
- **Research:** open innovations projects in integrative fields consists of a combination of human and computer alliances. 4IR adopts a hybrid system that can perform tasks that humans and machines cannot perform independently. The realignment of research themes becomes a necessity in the 4IR for tertiary institutions to be more technology driven.
- **Service:** 4IR has also promoted the adoption of University-as-a-Platform (UaaP) model to customise the needs of tertiary institutions stakeholder's, staff and students through Internet of Things (IoT) technologies and extended the tertiary institution's community engagement portfolios. Furthermore, the adoption of Education-as-a-Service (EaaS) model enables tertiary institutions to be accountable to the government, the accrediting agencies, and the financiers. Implementing internationally linked programmes aid in curriculum transformation and a mix qualification programme which is the reality of 4IR.

2.7. The Concept of Quality 4.0

The term Quality 4.0 was familiarised in 2015 in a report by ASQ (American Society of Quality) (Arsovski, 2019) and became a significant element of the 4IR. According to (Forero & Sisodia, 2020), Quality 4.0 is defined as applying the 4IR technologies in digitalising total quality management and automating quality functions and analysis. It is highlighted by (Isaacs, 2020) that the purpose of Quality 4.0 is not to substitute traditional quality methods but to improve them. It is acknowledged by (Radziwill, 2018a) that 4IR technologies have enhanced the quality of services together with the performance of the organisation. Additionally, (Sader et al., 2021) believes that 4IR has refined decision making concerned with quality as factual data is instantly availed which eliminates errors in the production process and improves validation of products and systems. However, Quality 4.0 necessitates experienced and competent professionals in regulating how relevant data can be used for effective decisions.

2.7.1. The Evolution of Quality 4.0

The study of (Forero & Sisodia, 2020; Hamid et al., 2019; Sader et al., 2017) illustrated the phases of quality evolution in various business organisations since 1910 to present. Table 2.3 represented a summary of the three phases of quality management:

Table 2.3: Phases of quality evolution adapted from (Forero & Sisodia, 2020)

Phase	Quality control and Inspection	Quality Assurance	Total Quality Management (TQM)	Quality 4.0 (Q4.0)
Scope	Product	Quality control, processes	Quality Assurance, Organization, People	TQM, Systems, stakeholders
Year	1910s and 1924s	1950s	1980s	2015
Meaning of quality	Inspection	Design	Empowerment	Innovation
Characteristics	Correction	Prevention	Continuous Improvement	Timely insights through digital tools
Features	Product specifications, and statistical process control to estimate and eliminate damaged from the product population.	Built- in process quality. Process performance and metrics to assure the production processes are efficient in producing non-defective products.	Links organisational goals to metrics. Quality is considered as a strategic imperative. Quality is implemented in all business activities for maximum customer satisfaction.	Suppliers, customers, and society are integrated.

2.7.2. The Transition Towards Quality 4.0

The study of (Forero & Sisodia, 2020) developed a roadmap which could enable organisations to transition to Quality 4.0. The findings of the study identified six significant phases of transitioning as summarised in the Table 2.4. An additional field is added to the table determining the success factors of each phase based on various available literature.

Table 2.4: The Phases, steps, and success factors of transitioning to Quality 4.0. (Source: authors own extracted from various literature).

Phases	Steps	Success factors
Assessing the readiness	<ul style="list-style-type: none"> - Measuring 4IR maturity level. - Assessing the stability of process and data flows. - Monitoring regulations and standards. 	<ul style="list-style-type: none"> - Top management support. - Leadership. - Organisational culture towards Quality 4.0. - Vision and strategy towards Quality 4.0. - Knowledge and awareness of Quality 4.0. - Training and rewards. (Sony et al., 2021)
Setting up	<ul style="list-style-type: none"> - Aligning strategies to 4IR. - Developing business cases and securing management support. - Anticipating changes. - Managing knowledge. 	<ul style="list-style-type: none"> - Well-established IT infrastructure supporting Quality 4.0.(PTI, 2018)
Systems and stakeholder involvement	<ul style="list-style-type: none"> - Addressing changes in roles and competencies. - Involving suppliers where necessary. - Involving customers where necessary. - Improving systems interoperability. 	<ul style="list-style-type: none"> - Co-creation. - Co-innovation. - Collaboration with consumers, employees, suppliers and the public. (S. M. Lee, 2015)
Finding innovative methods for delivering insights	<ul style="list-style-type: none"> - Data analysis through big data and artificial intelligence. - Keeping up and maintaining the ever-changing customer needs. (Sony et al., 2020a). 	<ul style="list-style-type: none"> - Customization (Finance A. T. C. C., 2015) - Digital tools (Sony et al., 2020a)
Value creation	<ul style="list-style-type: none"> - Decentralization of value chain. - Seamless and real-time communication between customers and suppliers (Kiel et al., 2017). 	<ul style="list-style-type: none"> - Cost reduction. - Waste minimization. - Optimised return on investment (Dave Ryeson et al., 2020).
Data management	<ul style="list-style-type: none"> - Real-time evaluation of quality relevant data through algorithms, sensors, and networking system (DiIT, 2019). 	<ul style="list-style-type: none"> - Connectedness. - Intelligence. - Automation.

Additionally, the study of (Sader et al., 2021) depicted some significant advancements in traditional quality management practices to Quality 4.0 practices. The traditional quality management practices includes statistical quality control and sampling techniques; it uses statistical analysis and regular data collection techniques; presentation of data varies from paper to paperless and electronic which is compiled in a form of documents

or slides; the findings of quality inspection are communicated to stakeholders on a manual basis; the quality management experts are the backbone of quality management; the quality of suppliers is realised when reports of quality issues have been identified; lastly the customers have restricted involvement in the production process and are only engaged in aftersales services.

On the other hand, Quality 4.0 involves the following: using monitoring systems; inspection occurring instantly and in real time; smart devices and dynamic screens being used; the findings of quality inspection being communicated to the stakeholders, suppliers, and other units in the form of knowledge. Also, the quality experts remain the backbone in quality management with additional support from Quality 4.0 technologies and techniques, and the suppliers form part of solving production problems. Lastly customers are considered as contributors of quality and thereby are also involved in the production process.

With quality 4.0 advancements, it is expected that the response time to inferior production or process abnormality is improved. Therefore, the quality methods are more inclined towards predictivity than being proactive or reactive. Hence, corrective actions with precise information are flown simultaneously while cost of quality management is reduced as lean quality techniques are advanced. Additionally, strategic issues are given more focus improving warehousing and stock management, logistics and manufacturing processes together with its related techniques. This leads to maximised customer satisfaction and production of quality goods.

2.7.3. The Challenges of Implementing Quality 4.0.

Various challenges to quality 4.0 implementation were identified from literature as follows:

Unclear competitive advantage: it poses a challenge of sustainability and complicated the process of maintaining competitive advantage. According to (Sader et al., 2021), available literature lacks studies on the relationship between Quality 4.0 and formation of Competitive advantage. Therefore, organisations fail to identify the fundamental requirements for creating a competitive advantage (Adamik & Nowicki, 2018).

Organizational culture: refers to a set of values, beliefs, standards, principles, and assumptions that contributes towards the formation of behaviour and guides commitment, direction, and identity through elements such as trust, communications, and appraisal

systems (Nafchi & Mohelská, 2020). The success of Quality 4.0 depends on a well-established and capitalised traditional quality management foundations. However, quality management teams seemed to be more focused on traditional problem-solving methods. Additionally, Quality 4.0 programs are more led by IT teams than quality management teams with more focus on technology than human labour. Therefore, the quality management teams are lagging behind in leading the process of transitioning towards quality 4.0 and are also limited in understanding the impacts of technological developments on quality (Sader et al., 2021). Lastly, many organisations lack a conducive organisational culture which does not promote achieving quality goals through risk taking, tackling innovative challenges, and backing creativity (Sony et al., 2021).

Lack of implementation knowledge and framework: according to (Zonnenshain & Kenett, 2020), there is no evidence in literature regarding a standardised Quality 4.0 implementation framework. Therefore, there is a challenge in producing improvement in an absence of maturity levels and processes for the quality teams to succeed. Furthermore, there is a shortfall of experience and training for the employees in implementing and operating the quality management systems, thus requiring a need for specialists in the field (Psarommatis et al., 2020).

Lack of resources: various organisations, especially the small and medium enterprises (SMEs) failed to exploit the benefits of Quality 4.0 due to a deficit in human, monetary and infrastructure resources (Psarommatis et al., 2020). Unavailability of financial resources such as cash and credit for operating and maintaining quality management systems posed a challenge to adoption (Sony et al., 2021). Also, unclear return on investments and profitability threatens latest developments. Furthermore, intellectual resources such as technical expertise in the field of databases and artificial intelligence are significant in implementing Quality 4.0. Similarly, lack of resources also leads to organisation's being unable to participate in research projects (Horváth & Szabó, 2019).

Lack of management support: according to (Sony et al., 2021), a key factor in the assessment of organizations readiness towards Quality 4.0 is support from higher level management. A lack of support reduces the credibility of the organisation towards sustainable development (Psarommatis et al., 2020). Furthermore, a lack of support creates a negative perception in implementing change, therefore motivating employees to resist towards the use of Quality 4.0 systems.

Human resources: a study by (Sader et al., 2021) indicated that for the successful application of Quality 4.0, more knowledgeable and experienced talents with higher level degrees and proficiencies are required. A challenge of staff shortage with the right competencies on hand to tackle advanced technologies exists (Vladimir, 2020). Quality 4.0 influences the performance and efficiency of the organisations through automated quality inspection and quality analysis tasks. Therefore, training the human capital for Quality 4.0 has significant role to play in Quality 4.0 implementation (Sima et al., 2020; Sony et al., 2020b). Additionally, human resources failing to involve employees in adapting to the new systems creates a major weakness for the organisation. Hence, more exposure to human resource development is required (Horváth & Szabó, 2019).

2.8. 4IR in Enhancing the Quality of Service in Tertiary Institutions.

Quality being a continuous process of development indicates the reputation of tertiary institutions. Effective quality management implemented in tertiary institutions promotes sustainability and creates a key difference from competitors. According to the study of (Alzahrani et al., 2021), literature revealed various models, tools and techniques implemented by tertiary institutions in improving service quality. This included Total Quality Management (TQM), Lean Six Sigma (LSS) and the Quality Function Deployment, which benefited in terms of cost reduction, productiveness, modernised processes and enhanced customer satisfaction. Nevertheless, traditional quality methods ought to change for maintaining effectiveness through innovation and latest technologies. Therefore, quality practitioners at tertiary institutions are required to explore 4IR based tools, approaches, and devices to be adopted in transforming towards Quality 4.0.

2.8.1. Implementing Quality 4.0 Using the 11 Axes of the LNS Framework

The LNS research institution acknowledged 11 axes contributing to Quality 4.0 which organisations can use to gain insights regarding their readiness for transforming to Quality 4.0. However, the LNS framework is more suitable for the manufacturing industry compared to other industries. Yet, the study of (Alzahrani et al., 2021) made an effort in using the framework to assess the digitization efforts and readiness of tertiary institutions in implementing Quality 4.0. Table 2.5 presented a summary of the 11 axes together with tools associated with each axis in tertiary education context.

Table 2.5: Implementing Quality 4.0 using the LNs Framework (source: researchers own construct from literature)

Axes	Tools	Elements	Application in education context	Purpose of Quality 4.0
Data	Big data	Volume, variety, velocity, veracity, transparency.	Reporting and compliance in terms of information accreditation, transparency & uniformity. Analysis and visualisation for benchmarking and resource optimisation. Security and risk mitigation for detecting network attacks and compliance with cyber protocols. Predictive analytics for studying student behaviours and strategic planning. Decision making. Performance evaluation.	To integrate: data generation and acquisition, data cleaning, storage management. To enable real-time query optimisation through big data management systems.
Analytics	Machine learning, Artificial intelligence.	Descriptive, Diagnostic, Predictive and prescriptive.	Learning analytics to analyse student profiles and study materials to improve learning outcomes. Academic analytics for improving teaching and learning methods. Educational data mining for understanding students and education systems.	To investigate learning analytics capabilities. To examine the significance of data sourcing for creating learning analytics model. To predict student's performance. Discover finest process operational (functioning) methods for activities such as admissions.
connectivity	Enterprise Resource Planning Systems. Enterprise Quality Management Systems	Connected products. Connected testing. Connected supply chain. Connected operations. Connected Worker.	Flow from Information Technology to Operational Technology to aid the management, plan and improvement of operations and quality management tasks. Flow from Operations Technology to Information Technology to aid the execution, informing and improvement of quality management activities.	To facilitate and support administrative activities. To support tertiary institutions in accessing real-time data across different departments. To enhance communication processes of internal staff and stakeholders. To enhance the strategic performance indicators such as the satisfaction level of students and staff,
collaboration	Blockchain, Social media.	Automated workflows.	Building smart contract processes. Tracking proof of work.	To support transactions associated student certificates, data and finance. To increase the security of students records and profiles. To support human resource transactions. To support research publications and provide efficient online access to libraries.
App development	Augmented reality. Virtual reality.	Web client, Native mobile, Browser agnostic, and Mashup tools.	Mobile apps for assessing students learning. Virtual reality for improving learning experiences. Mashup tools for accelerating learning and increasing accessibility of course materials.	To assist faculty and academic staff in electronically inserting and accessing sensitive data.
Scalability	Cloud computing	Data volume, Processes, Analytics, Users, Devices, Platform.	For improving collaboration and knowledge sharing through platforms such as Microsoft Office 365, and Google Query with minimum effort and time at any place. Cloud computing for synchronising processes, competencies, and best practices.	To reduce costs. To support tasks related to admission, registration, enrolment, graduation. To support functions of Human resources, supply chain, payroll, CRM, SCM, LMS and assess management.

Axes	Tools	Elements	Application in education context	Purpose of Quality 4.0
Management systems	Automation	Risks, Compliance, improvement, Reviews, Audits, Monitoring, Production, External, Development, Requirements.	EQMS for linking tertiary institutions systems to Quality Management Systems for improving systems independence. The use of EQMS for strategic management, process management and performance management in facilitating tertiary institution's administrative tasks.	To connect operational and managerial characteristics of the processes in the value chain for innovation.
Compliance	Automation	Compliance services, Electronic submission, Compliant BPM, EDM	Usage of social collaboration, integrated IT/OT data models, and analytics to quality associated risks. Usage of Digital Quality Assurance systems for activities such as auditing, benchmarking, accreditation, licencing, ranking, program evaluation and recognition.	To improve tertiary institution's compliance with standards through automation and connected activities.
Culture		Cross-functional empowerment. Credibility. Responsibility. Process participation.	Offers more connectivity, visibility, collaboration, and additions to quality tasks.	To promote staff participation with shared values, and empowerment in completing activities concerning quality processes
Leadership		Quality KPIs, Executive ownership, Objective Alignment.	Connect the tertiary institutions corporate value with the quality function.	To align quality activities with strategic objectives. To transform cross-functional leadership to executive level.
Competency	Machine Learning, Artificial Intelligence, Virtual Reality, Augmented Reality.	Individuals. Appraisals, Expertise, Experiences.	Structured approaches for improving staff competencies.	To share experiences and lessons learned via social media. To develop new expertise via machine learning, artificial intelligence. To deploy connected staff schemes to guarantee compliance, To enhance training delivery.

2.8.2. Challenges and Gaps of Implementing Quality 4.0 Based on the 11 Axes of The LNS Research

While assessing the readiness of tertiary institutions for Quality 4.0, the study of (Alzahrani et al., 2021) depicted the challenges and gaps that tertiary institutions face in successfully implementing Quality 4.0 using the LNS framework. Insights were gained against each axis of the 11 to understand the role each axis play for application in tertiary institutions. The study revealed through its literature review that in terms of the **Data Axis**, the tools and techniques of Quality 4.0 are restricted to limited processes and individuals in the tertiary institutions than being adopted on an enterprise level. With regards to the **Analytics Axis**, there is a lack of evidence that explores the use of machine learning and artificial intelligence for conducting prescriptive analysis and generating visualisation using big data. Tertiary institutions still face challenges of infrastructure, cross-functional collaboration, and inadequate data volume together with ineffective scale and indicators of data quality. Concerning the **Connectivity Axis**, the tertiary institution's efforts are constrained to the connectivity of individuals and processes than connecting edge devices and products, limiting the use of artificial intelligence and machine learning practices for Quality 4.0. Additionally, the Collaboration **Axis lack** sufficient research in the context of automation and blockchain applications in higher education institutions. In terms of the **Management Systems Axis**, the elements of the Electronic Quality Management System (EQMS) to suit the requirements of Quality 4.0 are absent in the context of tertiary institutions. Also, the integration of Electronic Quality Management System does not form part of the creation of the core value chain due to separated core processes which prevents collective analytics and learnings for enhancing system independence. As for the **Compliance Axis**, studies are limited for adopting pre-configurable technologies and automation of compliance especially in the tertiary education sector. Therefore, tertiary institutions are falling behind in the race of implementing Quality 4.0 for improving compliance management. The **Culture Axis** consists of challenges such as resistance to change and lack of mechanisms to create a cross-functional culture of quality in tertiary institutions. In terms of Leadership Axis, a challenge identified is of leaders refraining from executing quality plans as they believe it will maximise bureaucracy. Lastly, the **Competency Axis** lacks experience, expertise, appraisal, and management of quality approaches.

2.9. Summary

This section provided a brief overview of 4IR and its associated concepts. It explained the stance of 4IR from a South African context. The emergence of education 4.0 and the level of preparedness with case examples was highlighted. Also, the various challenges faced by tertiary institutions in adopting 4IR were identified. Additionally, the applicability of 4IR in the education was recognized. Furthermore, the evolution of quality 4.0 was presented with various classifications and transitions. Common implementation barriers to quality 4.0 were identified. The significance of 4IR in enhancing quality of services in tertiary institutions was discussed from the perspectives of the LNS framework. Moreover, this section also emphasised on gaps and challenges of quality 4.0 based on the LNS framework.

CHAPTER THREE: THEORETICAL UNDERPINNINGS

3.1. Introduction

This chapter complements to the literature review chapter by highlighting some of the well-established theoretical models and frameworks in the literature concerning service quality, technology readiness and acceptance. Theoretical underpinnings provide researchers with a basis to explain the status of the study phenomenon. Currently, there is a lack in theories focused specifically towards the 4IR. The introduction of 4IR in tertiary institutions may result in several challenges for the students and academics due to the digital divide gap, power crisis and cultural differences. The research reviews previous studies which undertook these models to understand the determinants of service quality improvements required for tertiary institutions in the 4IR context. This chapter also looks at various theoretical models to assist and guide the research towards the development of an appropriate research model. For the researcher to choose an appropriate underpinning framework(s), a comparison of various models is required. This assists in selecting the key constructs that will aid in obtaining the research objectives. This chapter discusses the significance of each key construct and develop hypothesis which influences service quality improvement in the 4IR accordingly.

3.2. Service Quality Theories

Service quality improvement is dependent on an organisations ability to conduct quality assessment reliably with adequate measurement techniques (Lemmalodesso, 2012). According to (Riaan, 2018), there is no integrated theory focusing on quality improvement which has been well recognised by quality experts currently. Various research has addressed the concept of quality in higher education forming different opinions in the field as the variables changes with context. Studies have explained quality from several functional perspectives such as operational, human resources, marketing, financial and supply chain but has not been extensively explained from a technology perspective. Literature studies on higher educational quality proposed multiple models for service quality measurement including the SERVQUAL (Parasuraman et al., 1988), SERVPERF(Cronin & Taylor, 1992a), HEDPERV (Firdaus, 2006), Lean Six Sigma (Wheat et al., 2001), TQM - U.S Naval Air System (Malatino et al., 1991), EFQM, and evaluated performance model (Teas, 1993a). Hence, some researchers argued that quality in higher education is undecided, subjective, and multidimensional terminology

(Vykydal et al., 2020). In the context of this study, quality can be perceived differently by students, academics, and other stakeholders of tertiary institutions. The following subsections highlights theories that explains service quality understandings which are of relevance to this research.

3.2.1. The SERVQUAL Model

In any service quality model, quality planning ought to begin with a service quality concept that will determine the institution's service perceptions by its clients (Oyieke, 2015). According to a study by (Riaan, 2018), conceptualising service quality in higher education is complex and depends on stakeholder's perceptions and experiences. For tertiary institutions to improve service quality, a valid and tested quality measurement instrument for measuring service quality perceptions is required. The Servqual model has been used extensively as a tool for service quality measurement and identifying gaps between expectations and perceptions of consumers. (Parasuraman et al., 1985) established significant factors for evaluating service quality in the marketing and retail industry (Davies, 2013; Shuttleworth, 2006). The Servqual model was developed in support of the GAP model which derived quality through customer evaluations (Khattab, 2019). The model consists of the following gaps:

- Consumer expectation versus management perceptions
- Management perceptions versus service quality specifications
- Service quality specifications versus service delivery
- External communications versus service delivery
- Expected service versus perceived service.

Studies in literature have utilised the extended Servqual methods for measuring service quality in diverse contexts. These includes the E-SERVQUAL, HEALTHQUAL, TRANSQUAL, AIRQUAL, HESQUAL, IOT-SERVQUAL, SSQUAL, Web-Qual, LibQUAL and the P-SERVQUAL 4.0 models to name a few (Hizam & Ahmed, 2019; Sumi & Kabir, 2021; Tumsekcali et al., 2021a). The measurement of service quality has adopted approaches such as the Performance only approach, technical and functional dichotomy approach, expectancy dichotomy approach, attribute importance approach and the service quality versus the service satisfaction approach. However, the Servqual model is deemed suitable in the tertiary institution context as it is multidimensional and entails multi-attributes constructs for service quality (Mushunje, 2020). Additionally, the studies

of (Đonlagić & Fazlić, 2015; Fariba et al., 2017; Sultan & Ho Yin, 2010) serves evidence of the applicability of the Servqual model being implemented for assessing service quality in higher education globally. Different aspects of tertiary institutions quality has been measured theoretically and empirically through this model such as quality from student perspectives (Anisseh et al., 2023; Armand, 2010; Gallifa & Batallé, 2010; Hoque et al., 2023; Margolis & Providência, 2021; Naidoo, 2015), academic staff perspectives (Abidin, 2015; Khalid et al., 2019; Musawenkosi & Lawrence, 2023; Yayah et al., 2022; Zafiropoulos & Vrana, 2008), university service departments perspective (Clarke et al., 2007; Sharif & Kassim, 2012), and stakeholders' perspectives (Shurair & Pokharel, 2019). The SERVQUAL model consists of the five dimensions as depicted in Figure 3.1 and briefly discussed below:

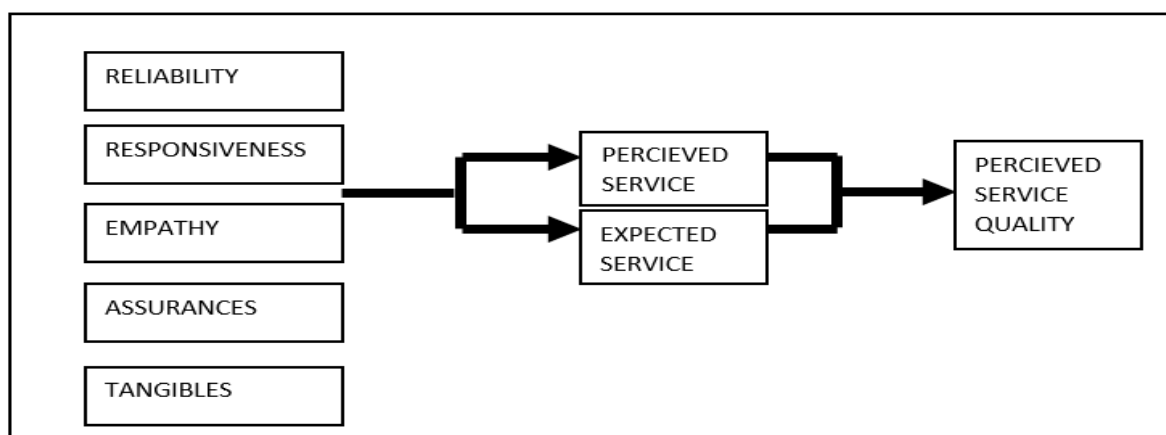


Figure 3.1: the SERVQUAL model by (Parasuraman et al., 1988)

- Reliability: enables to determine the extent to which a service is delivered reliably and precisely. It is significant to understand the extent to which tertiary institutions deliver their services consistently.
- Responsiveness: enables to determine the scale and willingness at which the organisation can deliver a service promptly. It is of importance for tertiary institutions to pay attention to students, staff and academics requests, complaints, and issues. It must be determined how flexible stakeholders' needs are attended to.
- Empathy: enables to determine the organisations' ability to provide personal attention to the clients. Tertiary institutions are required to build a personal relationship with its members and ensure they do not feel neglected.
- Assurances: enables to determine the organisations' ability to instil trust and confidence in their clients. Tertiary institutions need to ensure the presence of loyalty amongst its members.

- Tangibles: refers to the physical environment of the organisations such as facilities, equipment, and the presence of personnel. Tertiary institutions ought to provide a safe operational teaching and learning environment for its members to create a positive brand image of their service quality.

However, within the tertiary education setting, there is a need for a holistic approach in measuring quality. The study of (LeBlanc & Nguyen, 1997) identified 38 service quality attributes in higher education spread across 7 dimensions namely: physical evidence, curriculum, access facilities, contact personnel, responsiveness, reputation, and administrative facilities. In another study by (Lagrosen et al., 2004), 31 higher education service quality attributes were identified and divided into 11 dimensions namely: campus facilities, corporate collaboration, teaching practices, computer facilities, information and responsiveness, library resources, courses offered, internal evaluations, post-study factors, external evaluations, collaboration, and comparisons. Consequently, (Teeroovengadum et al., 2016) is of the view that higher education service quality is an ongoing transformative process to empower the participants (i.e. academics, students, and staff) surrounded in a higher education context, which also requires an increased awareness and confidence. Therefore, their study established the HESQUAL hierarchal model with 5 dimensions namely administrative quality, transformative quality, support facilities quality, core educational quality, and physical environment quality as illustrated in Figure 3.2.

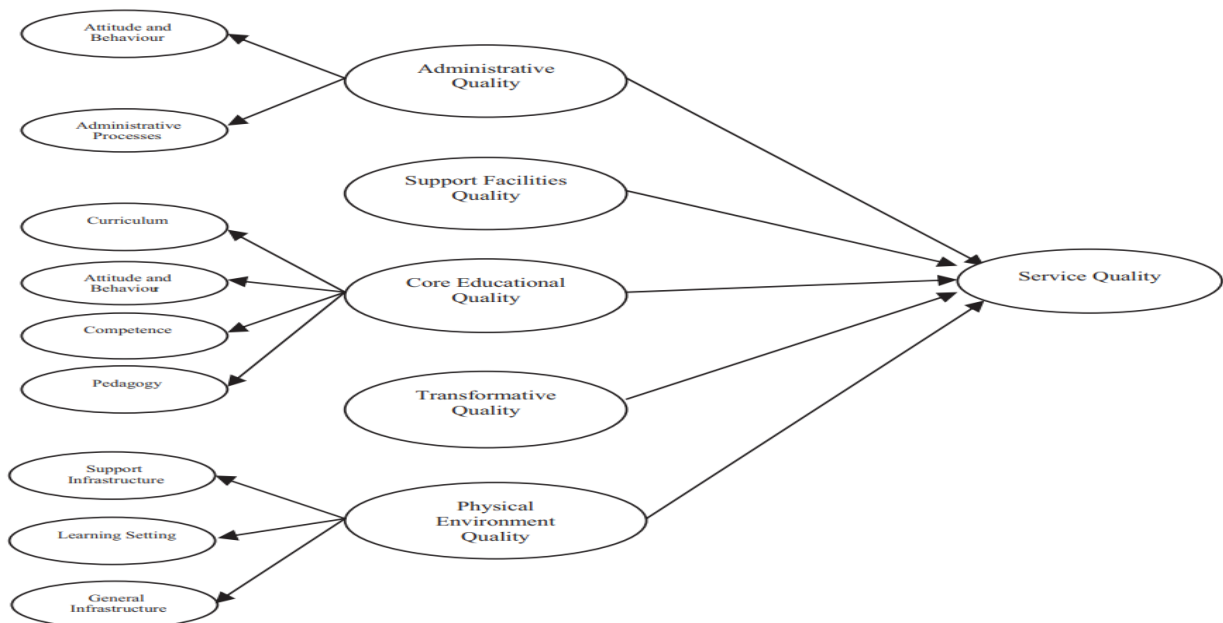


Figure 3.2: the HESQUAL MODEL By (Teeroovengadum, Kamalanabhan and Seebaluck, 2016).

In the context of tertiary institutions, diverse understandings of quality improvement systems and expectations from stakeholders' perspective is underpinned (Browning, 2021). Majority of these studies depicted that service quality expectations were not met from the stakeholders' perspectives. In South Africa, several studies empirically assessed the quality of service (Antwerpen & Schalkwyk, 2023; Dangaiso et al., 2022; de Jager & Gbadamosi, 2013; El Alfy & Abukari, 2019; Enakrire et al., 2022; Green, 2014; Kanakana, 2014) and have conducted service quality assessments using the Servqual model.

Nevertheless, it is important to acknowledge that the Servqual model has received its fair share of criticism as asserted by various researchers such as (Buttle, 1996; Cronin & Taylor, 1992b; Danjuma et al., 2018; Groonros, 1988; Gustafsson & Johan, 1997; Kar, 2016; Kaur, 2020; Kirubashini & Josephine Williams, 2016; Morrison Coulthard, 2004). According to these authors, the dimensions in the Servqual model are uncertain for the educational industry and are more inclined towards the retail industry (Rahim, 2019). It has been disputed that measuring service quality merely based on expectations using an instrument that is process based makes it difficult to answer the questions in the scale (Kang & James, 2004). Also, measuring performance through such a scale requires prior experience and knowledge, especially in educational service institutions. However, the staff and students may have little knowledge of the university at an entry level. Consequently, measuring service quality after the service has been delivered does not appropriately measure expectations because it is influenced by service experiences. On the other hand, it is also argued that measuring expectation before service delivery is not adequate, because what is expected can vary from what is experienced in practical terms.

Despite the criticism, researchers such as (Fariba et al., 2017; Moosavi et al., 2017) believe that Servqual model is the most effective model for measuring higher education service quality. Moreover, this model has been implemented in recent studies (Beny, 2022; Darawong & Widayati, 2022; Esen & Muhammet, 2023; Hai, 2022; Kachwala et al., 2023; S. Khan et al., 2022; Magasi et al., 2022a; Manunggal & Afriadi, 2023; Rozak et al., 2022; Unni et al., 2023; Valencia-Arias et al., 2023) to evaluate the current higher education system quality. Nevertheless, most of these studies have since modified the standard Servqual model to cater for its applicability in the higher education context. This has been motivated by (Parasuraman et al., 1988), that it may be significant to add or delete dimensions of the model depending on the suitability and context of the research.

3.2.2. The Lean Six Sigma

The Lean Six Sigma (LSS) is a combination of the lean and six sigma models for continuous improvement originally introduced in the manufacturing and service sector (Jia Xin et al., 2021). The LSS has been used to eliminate waste and improve quality through minimum resources and timely service deliveries. The LSS Model is supported by various principles in addressing issues such as defining, measuring, analysing, improving, and controlling (DMAIC) quality related processes. The DMAIC methodology was initially implemented by Robert Galin for problem solving (Brits, 2018). The Six Sigma model was established by Mike Harry in the 1980s originally by Motorola for enhancing their products and sustaining quality (Ramanan et al., 2014). The Lean concept was established by Taiichi Ohno for Toyota's production system to eliminate non-value-added processes (Xin et al., 2021). It is argued by (Brits, 2018), that most quality management systems in South Africa are reinforced by the theory of Total Quality Management and hence, there is a lack of studies focusing on LSS experiments in tertiary institutions. Implementing LSS in 4IR is of significance as it provides room for performance differentiation and advanced competitiveness (Yadav et al., 2021).

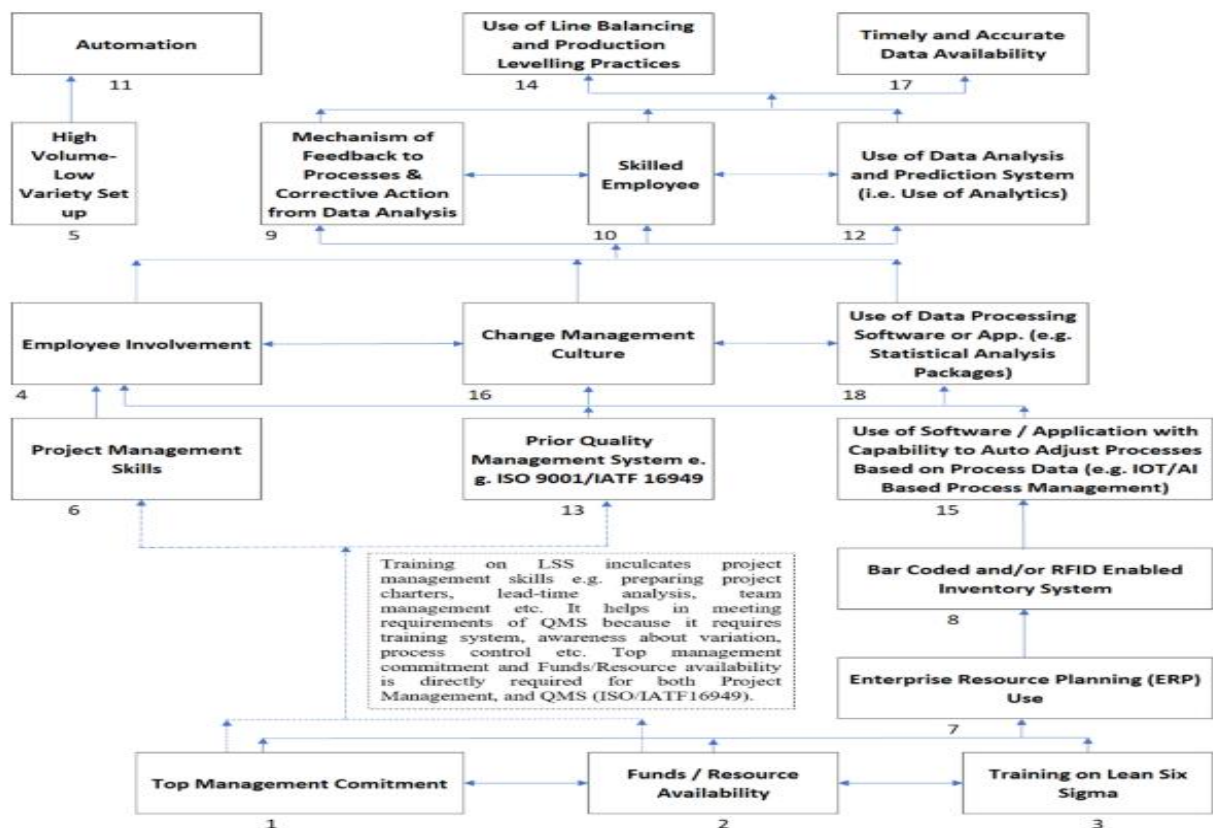


Figure 3.3: CSF for LSS implementation using Quality 4.0 Based on the Total Interpretive Structural Modelling Hierarchical Model. Source (Yadav et al., 2021).

An effort to accommodate LSS for quality 4.0 was made by (Okwu et al., 2021; Yadav et al., 2021). About 18 Critical Success Factors (CSF) were identified for quality improvement in the context of industry 4.0, see Figure 3.3 (Yadav et al., 2021). The model depicts two factors namely Top Management Commitment and LSS training as highly influential drivers.

Table 3.1 further presented that through the cross-impact matrix multiplication applied to classification (MICMAC) method of analysis, the model is created four quadrants through which the factors were divided. The factors categorised under “Drivers” shows a strong driving force, thus, any deviations in those factors could affect the whole system. Factors categorised under the “Dependent” gains thrust from the “Drivers” for contributing towards the system. Lastly, the model suggests that several IT-based services can be used for the LSS implementation such as the Cloud and Networks services. However, a gap exists in the model whereby diverse industries were consulted in formulating the model, and hence, implementing the model for a particular industry such as tertiary institutions may require some adjustments.

Table 3.1: Critical success Factors for LSS in Quality 4.0. source: (Yadav et al., 2021)

Drivers	Linkage
<ul style="list-style-type: none"> - Top Management Commitment - Funds/Resource Availability - Training on Lean Six Sigma - Enterprise resource Planning use - Bar Coded and Inventory/or RFID Enabled Inventory System - Use of software/Application with Auto adjust processes (IOT/AI) 	<ul style="list-style-type: none"> - NIL
Autonomous	Dependant
<ul style="list-style-type: none"> - Prior Quality Management Systems - Project Management skills - Data Processing Software Usage - Change Management Culture - High Volume-Low Variety Set Up - Automation 	<ul style="list-style-type: none"> - Employee Involvement - Mechanism of Feedback to Processes and Corrective Action from Data Analysis - Skilled Employee - Use of Data Analysis and Prediction System - Timely and Accurate Data Availability - Use of Line Balancing and Production Levelling Practices.

Nevertheless, a conceptual model of LSS for quality excellence in higher education context was developed by (Sunder M & Antony, 2018) as illustrated in Figure 3.4. The framework presented an approach of identifying readiness factors for successfully deploying LSS, such as leadership and vision, management commitment and resources, LSS linkage to institutional strategy, customer focus, and choosing skilful people. Therefore, with leadership, a need for change can be communicated positively. In a

tertiary education context, diverse stakeholders are aligned with several directions. Hence, vice chancellors, deans and Hods' could assist in strengthening the quality mindset and set a platform for deploying LSS. Consequently, strategy development is said to create a culture for quality excellence from a strategic perspective. As such, tertiary institutions require to integrate LSS with their vision, mission, and infrastructure. Moreover, creating LSS awareness with the right skills and knowledge enables the members of the institutions to understand the concepts in-depth and contribute accordingly. Typically, organisations utilise LSS tools by adopting the DMAIC approach. Additionally, formulating a team can assist in collaborating different mindsets, skills and capabilities required for innovation. Also, students and staff of the institutions gets encouraged to identify and initiate LSS projects in their respective fields varied from academic to non-academic to technology based. Lastly, the framework suggests a process of review and closure at each phase of the project to trace its progress and success levels.

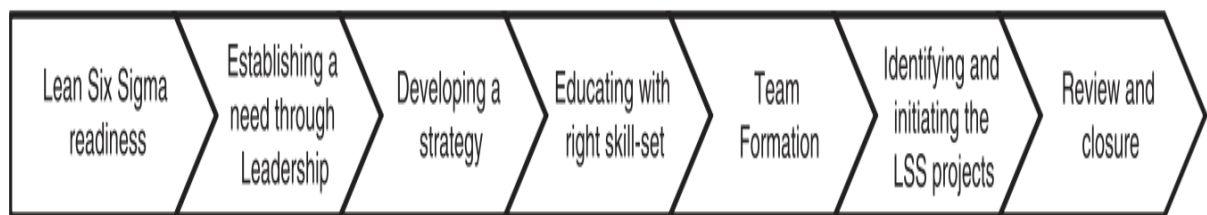


Figure 3.4: LHS Model for Higher Educational Institutions, Source: (Sunder M and Antony, 2018).

The LSS is also used to develop extended models suitable to accommodate various needs of specific industries. Figure 3.5 demonstrated a research model for leaders in implementing LSS at academic institutions. It comprised of five key variables namely: 1) leadership and organisational structure, 2) project selection, resourcing, and delivery, 3) training and development, 4) measuring cultural change and reporting benefits, and 5) sustainability. This framework can enable tertiary institutions to map their maturity in the LSS journey based on five levels namely: Level 0 – indicates that tertiary institutions are not prepared for LSS; Level 1 – indicates that that tertiary institutions are starting to prepare for the deployment of LSS (Yellow Belt); Level 2 – indicates that tertiary institutions are deploying the LSS (Green Belt); Level 3 – indicates that tertiary institutions are leading the LSS (Black Belt); Level 4 – indicates that tertiary institutions are sustaining the LSS (Master Black Belt).

Other studies in literature only identified the critical success factors and limitations for LSS in tertiary education context (Antony et al., 2012; Kuwaiti, 2020; O'Reilly et al., 2019; Sunder M & Mahalingam, 2018; Xin et al., 2021). However, Tertiary institutions often tends to be unconvinced in implementing quality management models such as LSS due to its origination from the industrial environments. Although LSS enables to recognise the requirements of customers and aids in welcoming cultural shifts within the educational sector, the relevancy of the critical successes factors (CSF) in studying the relationship between performance and CSF has been moderate (Xin et al., 2021). Nevertheless, the implementation of LSS from a managerial perspective in teaching and learning processes, library process and services such as finances and infrastructure maintenance has been adopted by tertiary institutions (Vijaya Sunder, 2016). Yet within universities, the complexity of LSS implementation for quality improvement is persistent due to a lack of understanding regarding the establishment of connections amongst clients, teaching and learning, research, and its added value (Nadeau, 2017). According to (Brits, 2018), identifying strategies to eliminate institutional waste is of importance. Through the implementation of LSS model, a process of continuous quality assurance can be achieved. Additionally, a gap in quality can arise due to the actions of governments in pushing increased student enrolments with decreased investments.

Despite, LSS has been adopted in implementing several projects within higher educational institutions. However, it is indicated by (Davidson et al., 2020) that, multiple studies focused on the application of LSS from the administrative perspective within higher education institutions. Projects include processing admission and graduations of learners. Some studies have accommodated for LSS in higher education institutions from the perspectives of Lean and Six Sigma independently, such as the studies of (Kremcheeva & Kremcheev, 2019; LeMahieu et al., 2017; Mazumder, 2014). For instance, the study of (Ramanan et al., 2014) developed a DMAIC framework for Engineering Educational Enterprise to address challenges of quality service offering by applying six sigma. While some studies have solely focussed on systematic literature review of the LSS in higher education context (Brits, 2018; Davidson et al., 2020; Kuwaiti, 2020; Nadeau, 2017). A few studies have employed case study approaches to analyse LSS from a specific university perspective (Bumjaid and Malik, 2019a; O'Reilly et al., 2019).

Academic LSS Maturity Model v2							
			1	2	3	4	5
Factors	Characteristic Name	Score 1- 5	Not Prepared for LSS	Yellow	Green	Black	Mastering deployment
Leadership and Organisational Structure	Leadership Role and Support		1.1 No leadership support or commitment to LSS	2.1 Led by LSS or CI team lead	3.1 Led by Registrar / CIO	4.1 led by Director / Deputy VC	5.1 Led by VC / Board
	Central Team Structure		1.2 No team in place	2.2 Small team reporting / sitting within IT	3.2 Medium to Large Team reporting to non academic department such as student services department	4.2 Small team sitting outside of traditional structure reporting directly to VC / deputy VC office	5.2 Local LSS teams delivering change, coordinated by VC office
	Institutional Involvement		1.3 LSS is not valued by the institution	2.3 LSS is only applied to student service and pure administrative process and problems	3.3 LSS is applied to administrative processes which interact with teaching and research processes	4.3 LSS is applied to administrative, teaching and research processes across all departments	5.3 All institutional activity benefits from LSS thinking
Project Selection, Resource and Delivery	Selecting Projects and Programmes		1.4 No project selection criteria in place	2.4 Projects are based on system / IT project requirements	3.4 Project selection criteria devised by departmental heads	4.4 Project selection linked to institutions corporate strategy	5.4 Project Selection Criteria links back to long term vision and is developed by VC / Board
	Resourcing The Project		1.5 Resource not formally allocated	2.5 Full time resource allocated to delivering LSS projects, held within the LSS team only	3.5 Mix of central LSS team projects and department led LSS projects	4.5 Small central team dealing with large projects but primarily role is supporting departmental delivered projects	5.5 Resource is allocated as required for full time project leads in addition to an expectation that projects form part of the day job, supported by a small central team
	Type of Project		1.6 Only projects delivered are capital projects	2.6 Rapid Improvement Events only	3.6 Mix of Rapid Improvement Events and Lean Projects	4.6 Mix of Rapid Improvement Projects, Lean Projects and Six Sigma Projects	5.6 Rapid Improvement Events, Lean, Six Sigma and Design for Six Sigma are all options for projects
Training & Development	Tool, Techniques and Methods Used		1.7 No understanding of the concepts of quality exist	2.7 Simple problem solving tools form the basis of the training and mentoring	3.7 Basic Lean based tools are used to drive change	4.7 Basic Six Sigma based tools and more advance Lean tools are used to drive change	5.7 Full spectrum of LSS tools - and other improvement philosophies are used to drive change
	Training and Development Programmes		1.8 No formal training exists for LSS	2.8 Training typically last 1-2 days and projects tackled require simple tools	3.8 Formal training programmes exist for Yellow Belt/Green Belt LSS practitioners	4.8 Formal training exists for Black Belts, Senior Leaders and Sponsors of projects	5.8 Fully integrated training strategy is in place i.e. 79% receive YB, 20% GB, 1% BB
	Mentoring and Coaching Support Activity		1.9 No mentoring or support processes exist for LSS project leaders	2.9 Mentoring and support is haphazard and inconsistent	3.9 A central team mentor and support the delegates as they develop their skills	4.9 A formal coaching model is deployed to support GB/YB in delivering projects	5.9 Local teams are empowered to coach, mentor, teach and train their peers
Measuring Cultural Change and Reporting Benefits	The Language of Change		1.10 Individuals react badly to the language of LSS and change	2.10 Language of LSS is altered to avoid offence	3.10 Simple language of LSS is used to build trust and motivate individuals	4.10 Language is no longer a barrier to change and enhances project activity	5.10 Change is part of the DNA of the institution and the language of change is embraced not feared
	Measuring Success - both Culturally and Financially		1.11 Performance of processes and systems are not measured	2.11 Only academic metrics and student staff surveys are used to check progress	3.11 In addition to academic metrics, financial impact is measured	4.11 In addition to measuring financial and academic metrics, cultural change is also measured	5.11 The institution benchmarks itself against both academic and non academic institutions
	Communicating and Reporting the Benefits of Change		1.12 Performance is not reported at any level	2.12 Performance and project results are shared only locally	3.12 Benefits are reported at department/ school level	4.12 Benefits are reported at board level	5.12 Visual management systems, virtual management systems and management reporting exist to share performance across the institution and with outside stakeholders
Sustainability	Sharing Best Practice - Inside and Outside the Institution		1.13 No formal process exists for sharing results and best practice	2.13 The team feedback progress through an establish meeting such as the monthly quality meeting	3.13 Steering group is assembled to drive the initiative	4.13 Forum for sharing LSS best practice and supporting members exists	5.13 The institution has fully integrated LSS into its existing systems and management processes
	Wider Staff and Stakeholder Involvement		1.14 Staff view change as someone else's problem	2.14 Only administrative and IT staff are involved in projects	3.14 Academic staff act as advisors on project teams	4.14 Academic and administrative staff lead projects as and when required	5.14 All staff are involved in change
	Reward and Recognition in a Complex Culture		1.15 No reward or recognition for improving ones processes	2.15 Financial incentives are used to improve motivation for change	3.15 Academic freedom is used as an incentive to improve motivation for change	4.15 Individuals are able to see the value of change, and any reward or recognition system reflects their wider needs	5.15 Staff feel self motivated to change their own processes irrespective of reward or outside recognition. In addition the organisation recognises the importance of succession planning for all staff involved in development

Figure 3.5: LSS Maturity Model in Academics. Source: (Anthony & Antony, 2020)

3.2.3. Total Quality Management

The TQM paradigm has been extensively adopted by various institutions across the world (Todorut, 2013). The term TQM was initially coined by the U.S Naval Air Systems in the 1980s (Martínez-Lorente et al., 1998). TQM in different contexts acts as a management approach, process, model, or framework for comprehensive quality improvement requiring contribution from all members of the institution than executive management only (Milenkovska & Novkovska, 2019). The suitability of TQM in tertiary institutions is subject to its applicability in obtaining quality improvement through a systematic collection of tools and techniques or systematic application of TQM principles (Asif et al., 2013). Various experts have studied TQM and discussed it extensively through different models.

Deming's theory of TQM consists of fourteen steps and believes quality to be an outcome of efforts over costs. He promoted a systematic approach to solve problems through the PDCA (Plan-Do-Check-Act) cycle complimented with the system of profound knowledge. **Juran's theory of TQM** is widely known as the "Quality Trilogy" consisting of three main factors namely: Quality planning, Quality improvement, and Quality control. According to his theory, quality is an outcome of customer satisfaction and established ten steps to improve quality. **Crosby's theory** of TQM is based on four absolutes of quality namely: quality is conformance to requirements, prevention ensures quality, zero defect is a quality standard of performance, and quality measurement is the price of conformance. He established fourteen steps to quality improvement. **Ishikawa's theory** of TQM views quality from a human perspective and believes quality is a companywide issue which requires to be a continuous improvement process. He introduced seven tools for quality improvement and the concept of quality circles. **The European Foundation for Quality Management (EFQM)** established in 1989 is in modern day used as a guide for TQM implementation. It enables to comprehensively assure and assess quality and consists of three key factors namely: quality, sustainability, and efficiency. The EFQM 2020 model is an integration of TQM, 4IR and United Nations' (UN) sustainability goals. The EFQM 2020 model is based on seven criteria within three dimensions. The **ISO9001** first established in the 1987 belongs to the family of the International Organisation for Standardization which addresses the requirements of quality management systems. A later version of the standard was released in 2015 addressing compliance with regulation and continuous quality improvement. The role of ISO9001:2015 has been extensively discussed as a measure to combine processes and resources for obtaining customer

satisfaction and efficiency. Table 3.2 presented an overview of the steps required to be followed in continuous quality improvement grounded on diverse TQM theories as well as tools and criteria required to be followed.

Table 3.2: Theories of TQM (source: self-developed according to literature)

Theory of TQM	Juran's Theory of TQM	Crosby's Theory of TQM	Deming's Theory
Steps	<ul style="list-style-type: none"> - An awareness of the opportunities and needs for improvement must be created. - Improvement goals must be determined. - Organization is required for reaching the goals. - Training needs to be provided. - Initialize projects. - Monitor progress. - Recognize performance. - Report on results. - Track achievement of improvements. - Repeat. 	<ul style="list-style-type: none"> - Attain total commitment from management. - Form a quality improvement team. - Create metrics for each quality improvement activity. - Determine cost of quality and show how improvement will it contribute to gains. - Train supervisors appropriately. - Encourage employees to fix defects and keep issues logs. - Create a zero-defects committee. - Ensure that employees and supervisors understand the steps to quality. - Demonstrate your company's commitment by holding a zero defects day. - Goals are set on 30, 60, or 90 day schedule. - Determine root causes of errors, remove them from processes. - Create incentives programs for employees. - Create a quality council and hold regular meetings. - Repeat from step one. 	<ul style="list-style-type: none"> - Create constancy of purpose. - Adopt the new philosophy. - Stop dependencies on mass inspections. - Don't award business based upon the price. - Aim for continuous production and service improvement. - Bring in cutting-edge on the job training. - Implement cutting-edge methods for leadership. - Abolish fear from the company. - Deconstruct departmental barriers. - Get rid of quantity-based work goals. - Get rid of quotas and standards. - Support pride of craftsmanship. - Ensure everyone is trained and educated. - Make sure the top management structure supports the previous thirteen points.
Ishikawa's Seven Tools for Quality Improvement	EFQM 2020 Models' seven criteria for Quality Excellence		
<ul style="list-style-type: none"> - Pareto Analysis - Cause and Effect Diagrams. - Stratification - Check Sheets - Histograms - Scatter Charts - Process Control Charts 	Dimensions	Criteria	
	1. Direction	1.1. Purpose, vision and strategy 1.2. organisational culture and leadership	
	2. Execution	2.1. Engaging stakeholders 2.2. Creating sustainable value 2.3. Driving performance and transformation	
	3. Results	3.1. Strategic and organisational performance 3.2. Stakeholder perceptions	
ISO9001:2015 Seven Principles for Quality Improvement.	<ul style="list-style-type: none"> - Customer focus - Leadership - Engagement of people - Process approach - Improvement - Evidence-based decision making 		

The study of (Canbay et al., 2019) presented a research model accommodating TQM in the context of industry 4.0 as illustrated in Figure 3.6. Their study focused on the applicability of TQM principles in the 4IR era specifically from a smart factory perspective. Part of what is needed is for some of the TQM principles to be redefined, such as continuous improvement, trainings, teamwork, and leadership. The novice adopters of 4IR may face challenges in terms of elements such as Just-in-Time, supplier management and benchmarking. Thus, the TQM model requires to be strengthened and analysed.

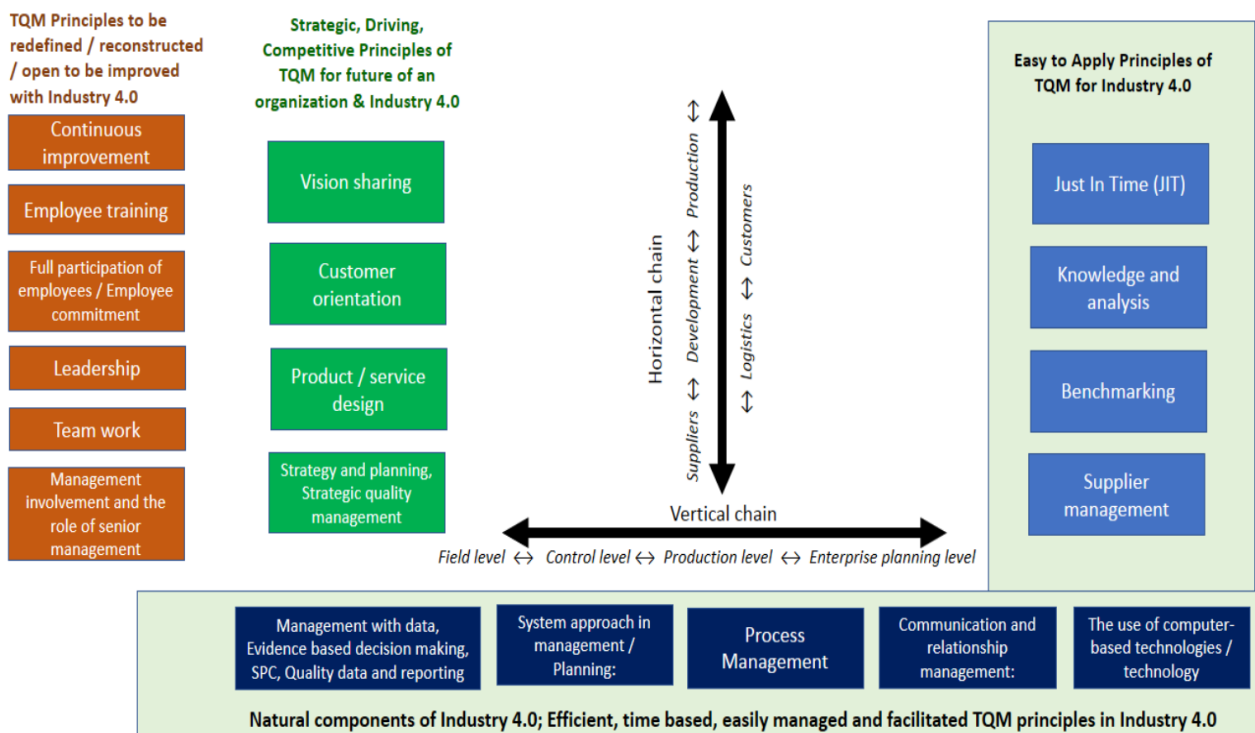


Figure 3.6: Status of TQM principles within Industry 4.0. source (Canbay et al., 2019) .

Additionally, (Sader et al., 2019) also developed a framework incorporating industry 4.0 with TQM using the ISO9001:2015 model as illustrated in Figure 3.7. Their study identified opportunities and barriers of TQM implementation in 4IR. Challenges such as cybersecurity, data protection, complex human-to-machine interaction and limited customer involvement in decision making were introduced in addition to various scientific, socio-political, and techno-economic challenges. To successfully obtain an exceptionally good business position with effectiveness and efficiency, organisations are required to implement TQM practices using an integrated approach. Furthermore, a process approach delivers information regarding time and resource constraints precisely which enables business continuity. The study highlighted that the quality control processes

require intelligent quality control systems with real-time inspections. While quality assurance needs to be conducted at pre-production to predict early failure through smart machinery, smart factories, sensors, big data, and augmented operations. However, the framework ought to be tested empirically to assess its ability and real time impact of patterns between the elements of industry 4.0 and TQM practices with industrial partnerships such as the ISO:9001:2015.



Figure 3.7: Integrated industry 4.0 TQM framework. source: (Sader et al., 2019).

3.2.4. The Grönroos Service Quality Model

The Gronroos theory was developed to accommodate a customer-based service quality assessment model and introduced customer perceptions as the main feature of measuring service quality in the model (Gronroos, 1988). The model motivates for measuring service quality by comparing consumers expectations of the service with the actual/experienced service perceptions, hence contains two dimensions namely functional quality and technical quality (R. Y. Li & Kaye, 1998). Gronroos strongly argued that together with outcome of a service, the way in which a service is delivered also has an influence on consumers perceptions and hence requires to be measured (Khattab, 2018). For instance, in higher education context, with the outcome of students' performance (technical quality), the way teaching and learning is conducted through 4IR technologies also influences the service quality. Additionally, the manner in which stakeholders of the university reacts to the introduction of 4IR technologies could also influence the functionality of the service. The model also highlights that the image of the firm is also a decisive factor of service quality perception. Various elements such as price, physical location, and the behaviour of employees represents the image of the institution. Nevertheless, a positive technical quality experience is a requirement for positive functional quality representation. Gronroos also provided six criteria of positive service

quality perceptions based on his experience including: professionalism and skills, attitudes and behaviour, accessibility and flexibility, reliability and trustworthiness, recovery, and lastly, reputation and credibility.

Although the model has been accepted in general, it has been criticized concerning the technical and functional quality dimensions not including all the relevant items under service quality (Clewes, 2003). This model is developed for services in which people interact with consumers, and hence does not cater for services in which technologies form vital measures of service quality. Also, it is pointed that amongst its dimensions, none has a preference over the other. Moreover, the six criteria developed were not based on any empirical evidence and tests (Gustafsson & Johan, 1997).

The study of (Fazelina & Nick, 2016) used the Gronroos Model to test its suitability in assessing service quality in distance education in Malaysia. The findings revealed that image is considered as mediating construct influencing overall service quality perception. According to (Kang & James, 2004), the Gronroos model is more suitable in measuring service quality perceptions as a European approach than the American approach. However, the study by (Smith & Ennew, 2001) has given more significance to functional aspects of service quality than technical aspects in a higher education context. In this research, with the presence of 4IR technologies and online teaching and learning facilities, the image of the tertiary institutions cannot be solely dependent on physical location, price, and behaviour of employees, hence the model was not suitable to be implemented in this study.

3.3. Technology Acceptance Models

A significant amount of research has been conducted in IS literature focusing on the acceptance of several technologies in different industries using diverse theoretical models (Al-Shafi, 2009). The success in implementing any technology or system is reliant on its acceptance by the people. The following sub-sections provided an overview of various theories used in the IS discipline to cater for technology acceptance and adoption.

3.3.1. Diffusion of Innovation Theory (DOI)

The DOI theory was developed by Roger in 1995 in the sociology field to assess the influence of innovation characteristics on innovation acceptance in social systems (Rogers, 2003). The model consists of five elements including: perceived attributes of

innovation, type of innovation decisions, diffusion channels, environment, governance structures, and change management (Yavwa, 2019). According to Rogers, in determining the adoption of new technology, the impact of the process of innovation knowledge, attitudes towards adoption, adoption decisions, and implementation of innovation must be determined. The model consists of five variables under adoption rate namely: Relative advantage, Complexity, Trialability, Compatibility, and Observability (Alsaif, 2013).

In IS literature, DOI assisted in assessing innovations such as electronic commerce, digital banking, and digital government systems. With relevance to higher education institutions, the study of (Pinho et al., 2020) applied the DOI theory to the E-learning process in determining the factors which have an impact on learning management systems with Moodle being the case. The findings depicted a positive relationship between the innovation characteristics and use of innovation.

A study was conducted by (Sabelo, 2016) at a South African HEI to understand the adoption of technology use by academics in the mathematics field. The study explained the use of technology by academics, with some being uncertain of the advantages and reported a lack of institutional support. Another study measured the extent of mobile learning use at a selected university in Turkey. The outcome determined a positive relationship between relative advantage and compatibility in M-learning adoption.

Other recent studies measured the diffusion of open educational resources (Menzli et al., 2022); adoption of artificial intelligence applications in online learning (Almaiah, Alfaisal, Salloum, Hajjej, et al., 2022); adoption of virtual reality in higher education (Marks & Thomas, 2022); and the adoption of 4IR and its challenges in HEIs (Lubinga et al., 2023a). However, it is reported by (Yavwa, 2019), that the model supports measuring technology innovations from institutional perspectives than of the people. Also, the model does not have dimensions measuring behavioural adoption. According to (Alsaif, 2013), constructs of DOI such as observability and trialability does not apply in measuring new technology. Hence this study did not implement the DOI model.

3.3.2. Technology Acceptance Theory

The Technology Acceptance Model (TAM) was introduced by Davis in 1989 (Davis, 1989) to empirically measure the acceptance of Technologies. The model advocates that acceptance of technology should be measured with a focus on users' attitudes towards

technology, users' intention to use that technology and the actual use of that technology by users. The model contains the dimensions of perceived usefulness and perceived ease of use that depicts the attitude towards technology usage and intention to use.

Within the field of higher education, (Rosli et al., 2022) conducted a systematic review study of the TAM advancements in the covid19 pandemic within higher education institutions. Their findings revealed that most of the studies had used an expansion of the original TAM; with Self-efficacy, Subjective norms, Experiences and Enjoyment as the most common variables used. Another systematic review was conducted by (Granić & Marangunić, 2019) to determine the efforts made in applying TAM within the teaching and learning domains, technologies, and users. The findings depicted that perceived ease of use and perceived usefulness were significant variables in measuring the acceptance of technology-based learning.

The TAM has also been used in search for reasons of universities' resistance towards new software programs (Siegel et al., 2017); to assess students' readiness toward M-learning (Iqbal & Ahmed Bhatti, 2015); to test students' behavioural intention to accept metaverse technology for education (Al-Adwan et al., 2023); to determine the students acceptance and use of computer-based reading tools due to increased demand in digital learning (Y. Lin & Yu, 2023); as well as to test the acceptance of classroom response systems, chat systems, M-virtual reality, and E-lectureship (Sprenger & Schwaninger, 2021).

Under the 4IR background, the study of (Han & Sa, 2022), used the TAM model to test the satisfaction of students with the introduction of online classes after covid19. Their study advocated for the use of 4IR technologies such as digital twins and virtual reality for increasing online interactions and promoting adaptive learning. Another study by (Castillo-Vergara et al., 2022), assessed students' acceptance of 4IR from rural areas and the results of which indicated a positive relationship between an additional construct being technology optimism and its perceived usefulness and ease of use.

However, this model was not implemented in study due to limitations such as not accommodating additional variables as it ought to be in its simplest form; it does not consider usage behaviour and, facilitating condition, social influence and emotional choices as reported in the study of (Yavwa, 2019). Additionally, it also does not consider

challenges (i.e., financial limitations and time constraints) as predictors that could influence technology use (Al-Shafi, 2009).

3.3.3. Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT model was developed by (Venkatesh et al., 2003) to showcase a comprehensive understanding of technology acceptance and identification of the most dominant variables contributing towards technology adoption. They merged the eight well known IS models (i.e. TRA, TPB, TAM, DOI, motivational model, Social Cognitive theory, Model of PC utilization, and TPB-TAM) which explained technology adoption behaviours to explain intention to use as a dependant variable. The model contains four dimensions namely: performance expectancy, effort expectancy, facilitating conditions and social influence. Numerous studies have been conducted within the tertiary institutions environment to assess the acceptance of technology.

One recent study is focused on determining differences in student's perceptions of e-learning pre and post covid-19 pandemic (Pettersson, 2023). The results suggested a significance change only in effort expectancy construct. Another study focused on assessing the views on mandatory digital learning in higher education of which the findings revealed most students adjusting to the shift towards digital learning without major difficulties (Lehmann et al., 2022). Other studies have mainly focused on the acceptance and use of MOOCs, e-learning and mobile learning in higher education (Almaiah et al., 2019; Alowayr, 2022; Altalhi, 2021; Duc & Hieu, 2023; Mosunmola et al., 2018; Patil & Undale, 2023; Shaya et al., 2023). From a 4IR setting, the study of (Jalil et al., 2022), examined the behavioural intention of 4IR adoption and use by teachers in Malaysia. Their study revealed that out of the four dimensions, only facilitating conditions and social influence seemed to have a positive influence on behavioural intention.

Additionally, the study of (Al-Riyami et al., 2023), measured the acceptance of 4IR technologies in higher education institutions specifically by faculty members. The findings revealed that all the dimensions of the UTAUT model significantly influenced the behavioural intention to use 4IR technologies. Although the model has been tested and validated in various environments, it has faced criticism for its limitations that were not addressed. These limitations include the model containing weak predictability in explaining behavioural intention in diverse events, such as its inability to explain behavioural intention in unforeseen circumstances between formation of intention and

actual use (Moghavvemi et al., 2013). Additionally, computer self-efficacy was not directly tested for its effect on intention (Marikyan & Papagiannidis, 2013). Lastly, the study of (M. D. Williams et al., 2015) highlighted limitations of some UTAUT studies such as biased and limited samples, use of only a few external variables, gender biases, and use of only some UTAUT constructs. Due such deficiencies, the UTAUT model was not deemed suitable for this study.

3.3.4. Theory of Planned Behaviour (TPB)

The TPB was initially proposed by (Ajzen, 1991) as an enhanced version of the Theory of Reasoned Action to accommodate for individuals' intentional behaviour in specific situations. The model consists of an additional construct known as "perceived behavioural control" together with other constructs namely: attitudes and subjective norms. The additional construct accounts for internal and external barriers that prohibits the occurrence of specific behaviour. Additionally, the work of (Taylor & Todd, 1995) introduced the Decomposed Theory of Planned Behaviour to improve the model prediction by adding multiple variables in each of the three constructs. In the field of information systems, various studies have applied the TPB theory to predict behaviour towards technology use (Baker et al., 2007; Ifinedo, 2012; Leong et al., 2022; Morris et al., 2005; Pavlou & Chai, 2002; Riemenschneider et al., 2011; Yousafzai et al., 2010).

The studies of (Aliedan et al., 2022; Anthony Jnr et al., 2020; Cheon et al., 2012; Chris & Jackson, 2018; Mayhew et al., 2009; Rahimi & Tafazoli, 2022; Raza & Awang, 2020; Siragusa & Dixon, 2009) used TPB model within the higher education environment to measure the acceptance of various technologies and tools. However, the model is criticized for not adequately measuring behaviour (Barua, 2013). For instance, humans will only formulate a positive intention when attitude is positive. This means that behaviour will only be performed if individuals are confident. Moreover, the theory is considered rational in terms of its influence on behaviour and has limitation towards predictive validity (Barber, 2011; Sniehotta et al., 2014). The theory was hence not suitable to be applied in this research.

3.3.5. Systems Approach Theory

To understand the stances of systems theory, it is significant to know the concepts of a system. According to (Ackoff, 1971), a system is defined as a combination of interrelated components that works together to achieve a purpose in a changing environment. A

system is purposive and hierarchical, therefore consists of features such as defined environmental boundaries and a dynamic nature. Systems theory as originated within the field of biology by the works of Ludwig Von Bertalanffy in the 1930s has gained various perspectives in different fields such as the health industry (S. J. Williams & Best, 2022). Systems theory takes a holistic approach to problem solving, (Mele et al., 2010). Therefore, all probable causes of a problem are considered and examined individually to determine their role in the system.

The open systems approach was adopted in this study as it is the most suitable model for a university context (Brits, 2011; Kessel & Mink, 1971). The open system enables to freely exchange information and resources within its environment to achieve steadiness (Bertalanffy, 1969). The systems theory advocates for the notion of synergy, meaning that “the whole is greater than the sum of its parts” (Brits, 2011). Tertiary institutions can be influenced by its environment, and hence requires environmental assessments both internally and externally. Tertiary institutions are subsystems of suprasystems such as the social, technological, economical, physical, and political environment which must be reactive to elements such as change, development, growth and industrialisation (Churchman, 1968). Hence, tertiary institutions are interrelated with its various functions such as administration, finance, library, and human resources. Figure 3.8. illustrated Katz and Kahn’s open systems theory:

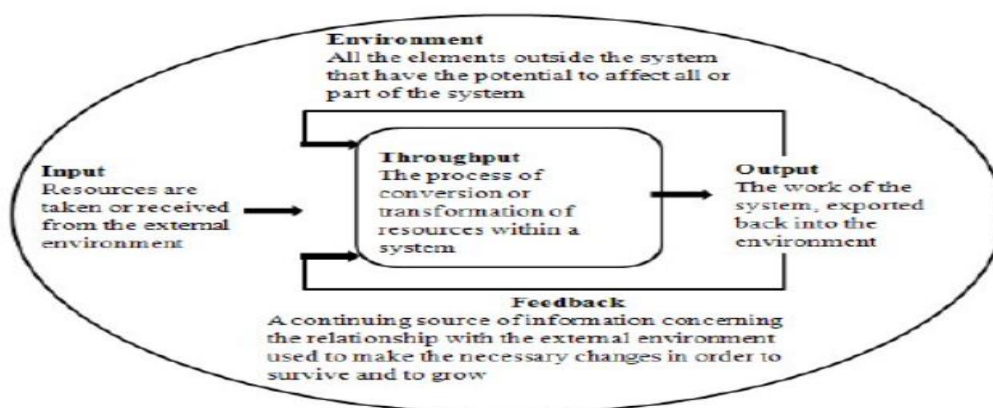


Figure 3.8: katz & kahn’s open system model, 1978

The open systems approach was used as part of the theoretical framework because of its holistic nature, which emphasises on the interconnectedness and interdependence of the aspects that are considered as elements of quality improvement in a tertiary institution system (Halloui & Herrou, 2020). A change in one element causes the behaviour of the

system to change (Mchunu, 2015). Thus, the performance and results of implementing quality 4.0 in a tertiary institution context is dependent on the structured relationship and interaction of various components of the system such as people, 4IR technologies, infrastructure, physical resources, capabilities, and funds/investments. Tertiary institutions as open systems should be diverse and have the potential to self-organise and become a smart system. The use of systems theory in the current study enabled to interrelate different components of quality of service and fourth industrial revolution identified from other theories within the scope of the study. The open systems theory is built upon four factors as discussed as follows (Koçoğlu et al., 2017):

- **Input** refers to the energy that the system receives from the environment. Within the tertiary education context, elements such as capital, equipment, tools, time, policies, and planning are some examples of input. Additionally, members of the institution such as students, staff, and lecturers contribute significantly in accomplishing the systems objectives (Ogunode Niyi & Ayoko Victor, 2020).
- **Throughput** refers to the transformation of inputs into useful outputs. To achieve the objectives of the system, the inputs are reconstructed to a desirable state. Elements such as quality assessments, governance, administrations, and technology implementation are examples of processing elements.
- **Outputs** refers to the outcome of the processed inputs. Elements such as knowledge production and skills developments are typical examples of outputs.
- **Feedback** informs the system if it has reached its objectives. Two types of feedback namely positive and negative is inputted to the system from the environment. This element assists the system to implement necessary corrections when required. The aim of it is to ensure regulation and direct a specific action.
- **Environment** refers to the element which provides input to the system. In the context of the current study, inputs from the external environment such as technological, cultural, governmental, political, social, and economical are transformed into tertiary educational services such as teaching, learning, research, and community engagement.

The study of (Dieguez, 2019) adopted the systems approach to enhance quality and competitiveness in tertiary institutions. The study identified a gap of low interaction among universities and industries which reduces technological competence and

affects quality of education. In contrast, improving human resources leads to a decrease in cultural differences among tertiary institutions and industries which creates room for economic growth and globalization. Furthermore, the study of (Brits, 2011) focused on managing quality effectively by integrating quality management with planning and allocation of resources. The study revealed that attention should be given on establishing a linkage between various functions of tertiary institutions. Figure 3.9 illustrated an integrated approach model proposed for quality management and assurance in a tertiary education context. However, the study does not address the technological aspects such as 4IR as inputs to the university system.

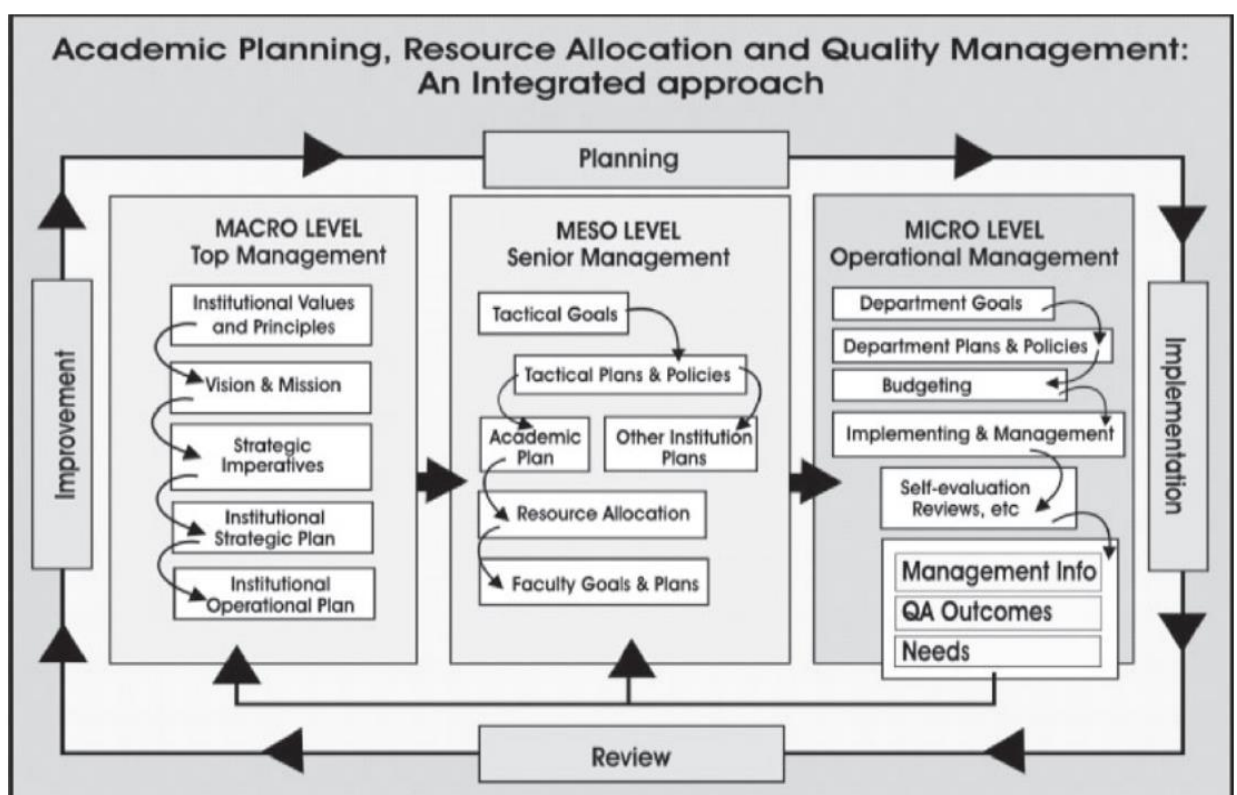


Figure 3.9: Academic planning, resource allocation and quality management. Source: (Brits, 2011)

3.3.6. Technology Readiness and Acceptance Model (TRAM)

The TRAM being a holistic theory introduced by (C. H. Lin et al., 2007) is a result of a combination of the Technology Acceptance Model by (Davis, 1989) and Technology Readiness Index Model by (Parasuraman, 2000) as depicted in figure 3.10. The model attempts to integrate consumer-specific and system-specific constructs to technology adoption. This indicates that focus is on individual factors and individual's perception of technologies. To simplify, technology readiness factors are directly associated to the dimensions of TAM. In higher educational context, studies have focused on the readiness

and acceptance of various new technologies such as cloud computing, internet of things, artificial intelligence, and virtual reality.

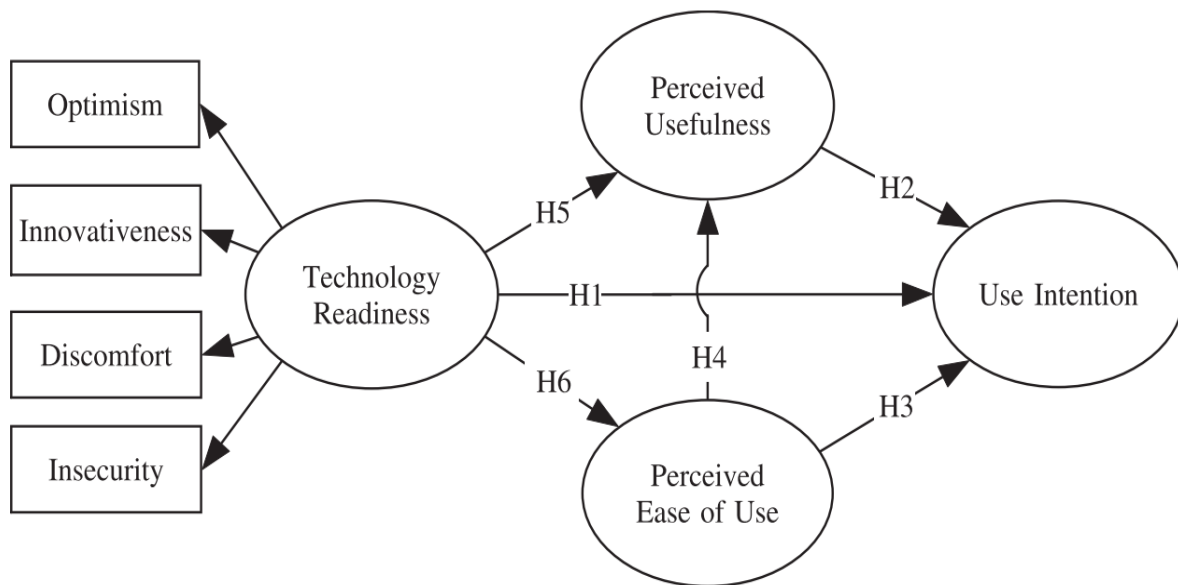


Figure 3.10: The TRAM Model. Source: (C. H. Lin et al., 2007b)

For instance, the study of (Aruleba et al., 2022) looked at the readiness of new technology adoption in South African disadvantaged tertiary institutions during the period of Covid-19. The findings of their study revealed a positive response towards the readiness in using innovative technologies if available, leading to a positive influence in terms of ease of use and usefulness of technology. Additionally, the study of (Peroumal, 2021) measured student's readiness and adoption of machine learning technology for future managerial jobs. The results indicated students' adoption is positively influenced by technology readiness, perceived ease of use and perceived usefulness. Furthermore, (Panday, 2018) looked at the effects of technology readiness on technology acceptance with a case of academic information systems used for delivering services. The study of (Kampa, 2023a) measured the readiness and acceptance of M-learning in higher education. The findings predicted that optimism significantly influenced perceived ease of use and perceived usefulness. Another study looked at the readiness of students in using e-learning for teaching and learning in which respondents had a positive influence of innovation and optimism towards perceived ease of use (Yusuf et al., 2021). However, discomfort and insecurity dimensions had no significant influence.

The study of (Putri Wardayanti et al., 2022) also tested the readiness of e-learning system in an Islamic university amongst lecturers and students. Amongst lecturers, discomfort

and innovativeness did not impact perceived ease of use and perceived usefulness while insecurity and optimism had a significant influence towards ease of use and perceived usefulness. Amongst students, discomfort did not significantly influence perceived ease of use but positively influenced perceived usefulness. Additionally, (BAKIRTAŞ & AKKAŞ, 2020) reported on the readiness and acceptance of new technology by academic staff. It was revealed that optimism construct had a positive influence on perceived usefulness and perceived ease of use while innovativeness positively influenced perceived ease of use only. Furthermore, the readiness level of students in higher education in terms of Internet of Things required for online learning was measured by (Negm, 2023). The results predicted a positive impact of optimism, discomfort, and insecurity on intention to adopt whilst innovation dimension was not significant.

Other studies in literature focused on the use of TRAM in different fields and industries such as (Buyle et al., 2018) measured the use of data standards in smart cities; (Chen & Lin, 2018) measured attitudes towards the download of applications based on diet and fitness; (Martens et al., 2017) measured the readiness of mobile payments within Germany and South Africa; (Seong & Hong, 2022) measured the effect of virtual reality sports game with the case of “screen golf”; (Peng & Yan, 2022) measured the behavioural intention to use multiple media kiosks; (Panday & Rachmat, 2019) conducted analysis of the TRAM theory on project management operations. Nevertheless, in available literature, there were no significant studies looking at the influence of technology use on the improvement of service quality from the perspectives of TRAM theory.

The focus of the current study required the assessment of 4IR readiness for quality improvement in tertiary institutions. The TRAM model consists of four constructs measuring technology readiness namely optimism, innovativeness, discomfort, and insecurity. Optimism and innovativeness are considered as the drivers of technology readiness while discomfort and insecurity are the inhibitors. In contrast, the TAM model consists of three constructs measuring technology acceptance namely perceived usefulness, perceived ease of use and use intention. For this study, the constructs are explained as follows:

- **Optimism** is referred to as the positive perceptions/feelings regarding technology with a belief that it provides individuals with more control, flexibility, and efficiency

in life. For the current study, this dimension assisted measuring if students and staff considers 4IR technologies to be bring positivity in their lifestyle.

- **Innovativeness** is referred to as the extent to which people consider themselves to be the pioneers of adopting technology. In this study, the dimension assisted in determining if students and staff considers themselves to be the leaders of 4IR adoption in tertiary institutions.
- **Discomfort** is referred to as the extent to which individuals are overwhelmed by technology due to a lack of control. This dimension assisted the current study in determining if students and staff are concerned and feared towards 4IR adoption.
- **Insecurity**: is referred to the extent to which people are sceptical of the functionality of technology. This dimension assisted in determining whether students and staff have a lack of trust in using 4IR technology-based transactions.
- **Perceived usefulness** is referred to as the extent to which an individual perceives technology to improve their job performance. It assisted in determining whether students and staff considers 4IR technologies to improve teaching and learning.
- **Use intention** will assist in determining if individuals will intend use 4IR technologies in future.

However, for the scope of the current study, focus is given to optimism, innovativeness, discomfort, insecurity and Perceived usefulness construct to measure readiness of 4IR with the perceived usefulness of 4IR on improving service quality.

Table 3.3 illustrated a summary of studies consulted in literature which implemented various models to study quality in different contexts.

Table 3.3: Underpinning Theories Used in Previous Studies. Source: Researchers Own Construct.

Author	Study Area	Underpinning Theory	GAP identified
(Hossain & Hossain, 2019)	Quality Management of Private Universities	Third-Order Hierarchical Quality Management Model	Public tertiary education institutions are not considered.
(Noaman et al., 2017)	Higher Education Quality Assessment	SERVQUAL Model	Missing factors addressing Quality 4.0.
(Tan et al., 2021)	The effect of Service Quality on Behavioural Intention.		Service quality is explored only from a behavioural intention perspective variable.
(Moosavi et al., 2017)	The Quality of Educational Services from Students viewpoint in Iran: A systematic Review and meta-analysis		Study is only focused on students' perspective of higher educational services quality. Tertiary institutions are limited to Iran.
(Vykydal et al., 2020)	Higher Education Quality Assessment and Sustainable Development	EFQM MODEL	Study is limited to higher education institutions in Czech Republic within the context of sustainability principles.
(Medne et al., 2020)	Sustainability of a university's quality system: adaptation of the EFQM excellence model		Study looked towards improving quality through strategic development, therefore the technological aspects were not considered.
(Martin & Ali Thawabieh, 2018)	Effect of ISO9001 on Higher Education Operational Performance	Total Quality Management	Study is focused on the applicability of the TQM in Oman higher education within the context of operational performance. The study did not address any aspects of 4IR and Quality 4.0.
(El Hawi & Alzyadat, 2019)	Measure student's satisfaction for institutional excellence		TQM is used to measure institution's excellence from a student satisfaction perspective. Quality 4.0 was not addressed.
(Tausif & Haque, 2021)	Quality management framework in a university: student perspective.		The study depicted student satisfaction having an influence on the quality of education services without a link to 4IR.
(Zgodavová et al., 2015)	Enhancement of Quality Assurance Model	ISO9001	The study is focused on implementing web based QMS to enhance quality assurance model specific to Slovakia only.
(Arcidiacono & Pieroni, 2018)	Revolution of the lean six sigma.	LEAN SIX SIGMA (LSS)	Introduced the concept of Lean Six Sigma 4.0 specific to the health care sector.
(Xin et al., 2021)	Critical success factors of lean six sigma in higher education institutions.		Implementation of LSS discussed in higher education context without any reference to 4IR.
(Bumjaid & Malik, 2019b)	Six sigma implementation in improving higher education quality.		
(Yadav et al., 2021)	Hierarchy of Critical Success Factors (CSF) for Lean Six Sigma (LSS) in Quality 4.0		Focused on the influence of LSS on Quality 4.0 from a smart manufacturing perspective.
(Garira, 2020)	A Proposed Unified Conceptual Framework for Quality of Education in Schools	Systems Approach Theory	Focused on the education context from a school perspective, and quality improvement without focus on 4IR.
(Heitor, 2008)	A system approach to tertiary education institutions towards knowledge networks and enhanced societal trust		Focused on modernising teaching and research, without any background on quality aspects
(Ochara, 2021)	Governance Mechanisms for Fourth Industrial Revolution Artifacts in Higher Education Institutions: A Systems Perspective		Focused on 4IR relevance for corporate governance in the context of tertiary education. The study did not cover the perspectives of quality 4.0
(Özekici & Küçükergin, 2022)	The role of COVID-19 anxiety and social contact within technology readiness and acceptance model for virtual reality.	Technology Readiness Model	Study focused on Virtual Reality from a tourism perspective.
(Lubinga et al., 2023a)	The Fourth Industrial Revolution Adoption: Challenges in South African Higher Education Institutions	Diffusion of Innovation Theory	The study only looked at 4IR Barriers in South African HEIs through a qualitative approach using document analysis

3.4. The Conceptual Framework and Research Hypothesis

After reviewing the above theoretical underpinnings, the researcher borrowed constructs from the Servqual Theory, System Theory, and the TRAM to achieve the aim of the study. A conceptual framework for 4IR application in improving quality of service which was developed for this study (see Figure 3.11) is aimed at establishing a set of standards and best practices in guiding tertiary institutions with the management of 4IR and service quality. To reinforce service quality and 4IR infrastructure of tertiary institutions, various authors have recognised CFSs independently. The conceptual framework depicted the researcher's position on transforming the service quality models through 4IR driven innovations. With the advancements of 4IR, the study proposed five components of the service quality improvement framework and presented the postulated hypothesis:

- a. **4IR key activities and components:** Tertiary institutions are required to provision basic services such as teaching and learning, research, and ICT support. Processing key activities such as applications of students, administrations, registrations, and payments in a timely manner is significant. The quality of tertiary institutions is judged by how best it can offer these services to their students, not forgetting the basic facilities required by staff and management to cater for these services. The process of delivering services can be slow and lead to continuous errors, hence, affects the customer satisfaction. The service processes are slowed down due to its complexity which results in amplified waiting periods. Thus, to enhance the quality of services, tertiary institutions need to innovate their methods for offering services especially in the teaching and learning field. Therefore, implementing 4IR components such as big data, interconnectivity, automation, and integration to facilitate services can contribute effectively to improve quality. The TRAM model assisted in determining the readiness and maturity levels of tertiary institutions by identifying whether the activities and components of 4IR have been implemented to improve service quality. The study focused on addressing the elements of optimism, innovativeness, discomfort, and insecurity in assessing the readiness of 4IR by measuring the initiation of 4IR key activities at higher educational institutions. The following hypothesis was formulated:

H1: 4IR readiness positively influences service quality improvement.

- b. **Key resources, capabilities, and funding (4IR investments):** Tertiary institutions rely on government grants, donations, and self-generated income for sustenance. The

funds are then distributed to various departments to deliver its day-to-day activities. The management and decision makers are responsible to allocate the necessary budget required for 4IR investments to enhance quality of services in the ICT, research and teaching and learning context. The emerging platforms of 4IR enables a 24-hour service delivery to the members of the tertiary institutions with less human interaction. This means that service delivery channel shifts from a basic on-office-desk to a more digital and virtual channel. The resources and funding construct was measured in terms of the degree of funding available, investments plans, knowledge, and capabilities. The dimensions of TRAM theory being optimism, innovativeness, discomfort, insecurity, perceived usefulness, and an additional dimension of investments assisted in testing whether the selected institution had a capability and funding to introduce 4IR technologies. The following hypotheses were formulated:

H2: institutional capabilities of 4IR positively influences service quality improvement.

H3: investments in 4IR technologies positively influences service quality improvement.

H4: perceived usefulness of 4IR has a positive influence on quality-of-service improvement.

- c. **4IR role in continuous quality management (innovations):** Tertiary institutions in developed countries seek to transform meeting the requirements of a digital campus. The potential of 4IR-enabled quality management for obtaining service quality aspirations of tertiary institutions need to be established. Continuous improvement with the involvement of all stakeholders is essential to achieve all quality requirements and decision making, which leads to the acceptance of the services offered. The stakeholders need to possess abilities to improve quality through adoption of emerging 4IR technologies. The role of 4IR in achieving continuous quality management was measured in terms of quality planning, quality assurance, and quality control. To study these elements as a whole, the systems theory was adopted. The value of 4IR in quality management need to be determined and monetized. Therefore, technological innovations with the presence of 4IR allows attainment of long-term quality goals by coordinating and implementing short and medium-term quality initiatives. This enabled to determine the degree of innovativeness and value creation for tertiary institutions. It also enabled to determine if the investments are aligned with the institutions vision, mission, and strategies as

well as to understand the sustainability of the 4IR projects. The following hypothesis was formulated:

H5: establishing the role of 4IR in quality management positively influences service quality improvement.

d. **Enablers and inhibitors of 4IR for assessment of quality excellence:** The identification of factors contributing to the attainment of improved quality through 4IR need to be assessed. This was measured in terms of the drivers (optimisers), critical success factors, challenges (inhibitors) and benefits that enabled or hampered the progress of 4IR. These elements were measured through the constructs of the TRAM model. The following hypothesis were formulated:

e. **4IR awareness, expectations, and perceptions:** The Servqual model assisted the researcher in testing the elements of reliability, responsiveness, empathy, assurance and tangibility of the teaching and learning, and research services. It also enabled to determine the expectations and perceptions of the students and staff regarding 4IR technologies in tertiary institutions. Furthermore, service quality was judged from the perspectives of educational quality which has an influence on teaching, learning and research processes. This assisted in determining whether the students and staff were satisfied with the quality of service, given that the institution has the proper set up required for the implementation and use of 4IR technologies. The following hypotheses were formulated:

H6: perceptions of 4IR have a significant influence on perceived service quality improvement of T&L through 4IR technologies.

H17: expectations of 4IR have a significant influence on perceived service quality improvement of T&L through 4IR technologies.

H8: awareness has a significant influence on perceived service quality improvement of T&L through 4IR technologies.

3.5. The Variables and Constructs of the Study

It was of significance to identify the themes and constructs applicable to the current study, as several isolated studies identified in literature determined the significance of 4IR and service quality in the education sector from independent stances. Therefore, there is a lack of a unified conceptual framework with 4IR in improving service quality with case

examples and considerations in practice. Table 3.4 illustrated the constructs and variables of the study.

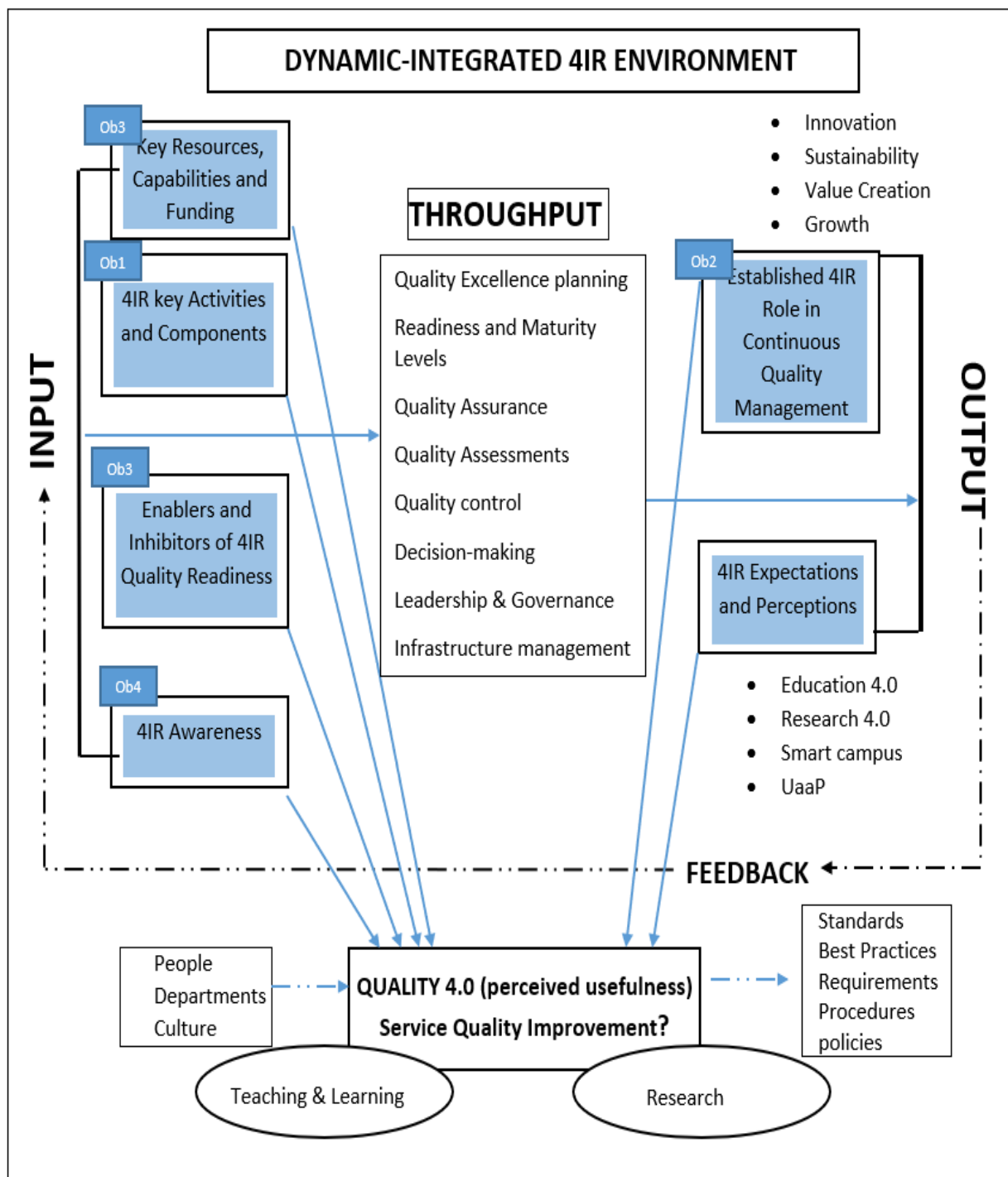


Figure 3.11: the Conceptual Framework of the study.

Table 3.4: Constructs and variables of the study

Concept	Construct	Variables
1. 4IR key activities and components	TRAM (Optimism, innovativeness, insecurity, discomfort)	Incorporation of 4IR technologies in T&L, government, and industry partnerships for controlled T&L, 4IR initiatives for improved productivity, current and future 4IR requirements, training and development, experts for 4IR project management, student leadership, change management culture, 4IR based teaching and learning effectiveness.
2. 4IR Key Resources, capabilities, and Funding	TRAM Optimism, innovativeness, discomfort, investment	Identification of new technologies for convenience, multiple technology utilisation for robust T&L (education 4.0), innovation hub through partnerships (university 4.0), new technology infrastructure allocation, 4IR experts for reducing technology problems in T&L, smart campus T & L environment, support services for difficult 4IR experiences, prioritisation of 4IR investments, government funding, 4IR competency programs investment, 4IR-based entrepreneurship programs,
3. Enablers and inhibitors of 4IR for Assessment of Quality Excellence	TRAM Benefits, Challenges, Drivers, Critical Success Factors.	Customized T&L, improved research facilities, access to education resources, collaboration and networking, student engagements, remote learning, T&L efficiency, real-time feedback. Cost considerations, lack of training and support, resistance to change, technical difficulties, lack of infrastructure, lack of trust, lack of skills, lack of internet connections, privacy, and security. Changing stakeholder requirements, competitive advantage, industry demands, innovation, funding opportunities, sustainability. Funding and resources, skilled experts, policy frameworks, training and support, adequate infrastructure, industry partnerships.
4. 4IR role in quality management	Systems theory Quality planning, Quality assurance, Quality control	4IR Institutional value, 4IR services alignment with educational policies and goals, service evaluation and corrective actions, expansion to wider audience, equal quality standards of T&L through 4IR, assessment of online presence, promotion of sustainable technology, compliance with sustainability goals, compiling sustainability reports, improved quality of T&L practices, alignment of institutional vision and mission with new technologies, adaption to changing technologies on demand.
5. 4IR Expectations, perceptions, and Awareness	SERVQUAL Tangibles, Reliability, Responsiveness, Assurance, Empathy, Awareness	Modern technology equipment to support 4IR T&L, modern technology facilities to support education 4.0, 24/7 availability of 4IR technology-based education services, support staff for solving 4IR based T&L, flexibility in accommodating changing 4IR demands, timely feedback, qualified personnel to acquire 4IR knowledge, individual attention, acknowledgement of feedback from 4IR users. Improved T&L standards, dependability, facilitate tailored education, comprehensive analysis for responding to individual needs, real-time feedback, resourceful monitoring and response to queries, powerful support tool for T&L enhancement, trustworthy and secure T&L service method, platform for interactive T&L, improved research, T&L quality. 4IR facilities, integration of 4IR technologies and equipment, 4IR skills, knowledge and understanding, availability of trainings, support and workshops, implications, benefits and challenges, library resource availability, risks, and consequences.
6. Quality Improvement (Quality 4.0)	TRAM Institutional Ability SERVQUAL Service Quality improvement.	Technology-based curriculums (curriculum 4.0), resource allocation, 4IR facilities management. Intention to use, encourage other stakeholders, remain committed to latest 4IR technology.
7. 4IR service Quality Framework	Systems Theory Dynamic Environment (People, Departments, Procedures)	Frameworks, standards, procedures, policies, strategies compliances,

3.6. Summary

Various common IS theoretical underpinnings related to quality such as Servqual, LSS, TQM, and EFQM as well as technology such TAM, DOI, TPB, UTAUT and TRAM were reviewed; and the gaps in literature were identified. The chapter looked at various studies which implemented the referred theories with careful consideration to the criticism each theory gained till date. The Servqual theory was selected to guide the research from 4IR quality perspectives. The TRAM theory was chosen to explain the technology readiness perspectives of the 4IR. To consider 4IR service quality improvement comprehensively, the chapter also discussed the use of systems theory. Lastly, the conceptual framework of the study was constructed from the selected theories which maps the probable relationship between 4IR readiness and quality improvement. The proposed research model provided a point of reference for designing the empirical research in terms of factors affecting the influence of 4IR in service quality improvement at tertiary institutions. The research model combined the themes of service quality with technology readiness and acceptance dimensions making it unique, since previous studies looked at the factors of service quality and technology acceptance in the context of 4IR separately. This model assists in developing the 4IRSQI framework which could be utilised by experts in the field of tertiary education to understand the value of 4IR in improving teaching and learning service quality.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1. Introduction

This chapter presents an outline of the research methods to conduct the study. The research methodology allows the researcher to guide the investigation and formulate a research strategy. According to (Jilcha Sileyew, 2019), research methodology assists in creating a pathway for conducting research. It also involves implementing a series of steps and activities in conducting research systematically to gain an understanding of the research problem and phenomenon. This chapter covers the research paradigm, research design, and the research approach to be implemented in this study. It also discusses the target population, sampling procedures and sampling techniques. Additionally, the researcher informs the data collection procedures, and analysis methods, together with the ethical considerations.

4.2. The Research Paradigm

Various researchers in the literature provided a broad overview of multiple research paradigms such as positivism, interpretivism, critical theory, post-positivism, and pragmatism. A research paradigm is referred to as an approach and a framework utilized as a reference in the research process (Riaan, 2018). It provided the researcher with a worldview arising from philosophical assumptions, a set of beliefs, principles, and ideas that guided the research methods, tools, strategy, and analysis. According to (Mackenzie & Knipe, 2006), the manner of the study and interpretation of knowledge is affected by the research paradigm. Therefore, following a research paradigm was significant as it provided the researcher with a viewpoint on the knowledge that had to be studied, obtained, and interpreted (Kivunja & Kuyini, 2017). To put in place the intentions and expectations of the research, it was significant to put forward the research paradigm as the first step for building the research methodology, research methods and research design. The subsequent section provided a brief overview of the different types of research paradigms.

4.2.1. Components of the research paradigm

- a) **Ontology** – (Rehman & Alharthi, 2016) iterated that ontology enables researchers to postulate a specific reality in terms of its existence and what can be knowable of it. It is referred as the study of reality or assumptions on the nature of existence. Ontology

is also regarded as the “theory of reality”. The aim of ontology is to provide the researcher with an understanding of the aspects in which reality is constituted of (Ugwu et al., 2021). Therefore, it involves understanding the fundamental concepts containing the themes of the research to make sense of the data collected. Philosophically, the researcher makes assumptions regarding the social phenomenon to believe if it is real and to what extent (Kivunja & Kuyini, 2017). It is significant for the researchers to differentiate amongst various objects and their relationships; thus, ontology offers a criteria (Aliyu et al., 2015). Furthermore, ontology assisted the researcher in positioning the research problem, its importance and how he/she approaches it to provide a solution. It formed an important aspect of a paradigm since it aided researchers to understand the things which constitutes the world as it is known. In other words, to understand the nature of being (Kivunja & Kuyini, 2017). Additionally, the three broad ontological positions as highlighted by (Ugwu et al., 2021) are the realist, the relativist and non-singular reality. Also, ontology encompasses two aspects, 1) objectivism in which it is assumed that social reality is external to the social actors who is also believed to experience one true social reality; and 2) subjectivism in which it is assumed that multiple realities exist as individuals are believed to experience reality differently (Saunders et al., 2019; Sheppard, 2020). Lastly, it was essential for the researcher to seek answers to the following ontological questions (Khatri, 2020):

- Is there an existing reality in the social world?
- What is the nature of being studied?
- Is reality constructed by an individual’s own mind?
- Is the nature of reality objective or cognitive?

b) **Epistemology** – according to (Rehman & Alharthi, 2016), epistemology is guided by ontology to assume a particular verifiable truth. According to (Babbie, 2007), epistemology is referred as the “science of knowing” or “systems of knowledge”. Philosophically, it is the theory of knowledge. It is simply referred as the “grounds of knowledge” expanded into a group of claims and assumptions about the probable ways of obtaining knowledge on reality (Khatri, 2020). Therefore, it provides the researcher with certain bases of knowledge (Kivunja & Kuyini, 2017). That is to determine: what is the nature of knowledge, what are the various forms of knowledge, how can the knowledge be obtained, and how can the researcher communicate that knowledge with other individuals. The aim of epistemology was to assist the

researcher in extending, expanding, and deepening the knowledge gained. Furthermore, the researcher reflected on the following questions while making assumptions about epistemology according to Guba & Lincoln as cited by (Khatri, 2020):

- What constitutes knowledge?
- Is the knowledge valid and acceptable?
- What is the nature of knowledge?
- What is the relationship between the researcher and that which must be known?
- Can knowledge be acquired or experienced?
- What is the relationship between the researcher and what is known?

In answering the questions above, the researcher familiarised with various sources of knowledge (Ugwu et al., 2021). The source of knowledge included: 1) intuitive knowledge – here the source of knowledge is through faith, beliefs and intuition; 2) authoritative knowledge – in this form, knowledge is sourced from expert people, books and leaders; 3) logical knowledge – in order to know the truth, reasoning is the surest path to follow; and 4) empirical knowledge – it involves acquiring knowledge through objective facts and experiences.

c) **Methodology** – the researcher is guided by the methodology to determine how the world should be researched (Rehman & Alharthi, 2016). In other words, it informed how the researcher can go about knowing what can be known. According to (Khatri, 2020), methodology is a general term used to describe the research design, approaches, procedures, instruments, and methods used to fulfil an inquiry of knowing something. The purpose of having a well-planned methodology was to express logic, justify using specific techniques (Dammak, 2015), and obtain a flow of research processes systematically which enabled the researcher to acquire knowledge about the research problem appropriately. It is believed by (Kwadwo Antwi & Hamza, 2015) that, methodology is a strategy that converts principles of ontology and epistemology into guidelines which depicts how a research investigation must be conducted and generate knowledge. Accordingly, it assisted the researcher in answering the following questions (Kivunja & Kuyini, 2017):

- How should I gather data that will help me in answering my research questions?

- How should I go about gathering knowledge which will answer the research questions?
- How should I go about gaining an understanding that will assist in contributing to the body of knowledge?
- What type of data is needed for investigating the research problem?
- Which data collection instruments and tools are suitable for the current research?

d) **Axiology** – the researcher is guided by ethical values in conducting research (Killam, 2013) and as such provides perspectives on the nature of ethics. According to (Kivunja & Kuyini, 2017), axiology is defined as the ethical considerations that must be adhered to when planning the research. Philosophically, it is an approach that enables researchers to make valuable and correct decisions, therefore it is also known as the theory of value (role of value)(Khatri, 2020). These values are attributed to various aspects of research such as the respondents, the readers, the data collected, and the write-up of the thesis (Killam, 2013). The aim of axiology was to define, evaluate and understand what constitutes right and wrong behaviours in research (Kivunja & Kuyini, 2017). Here, the researcher made assumptions about how his/her personal values and beliefs influenced the research process (Saunders et al., 2019). It is an important aspect of the research paradigm because it plays the role of portraying suitable standards and requirements for research approaches and techniques (Aliyu et al., 2015). Axiology in research could be value-free, value-bound, value-laden, value-constituted, and value-driven depending on the type of paradigm chosen to guide the study (Saunders et al., 2019). Overall, axiology assisted researchers in reflecting the following questions based on a report by (ARC, 2015) as cited in (Khatri, 2020; Kivunja & Kuyini, 2017):

- what is the nature of ethics?
- What value is the researcher going to comply with in the study?
- What is the researcher going to do to respect participating individuals' rights?
- What moral responsibilities will the researcher take into consideration?
- How will the researcher respond to the cultural and moral issues raised?
- How will the researcher protect the goodwill of participating individuals?
- How will the researcher fulfil the study in a socially acceptable manner?
- How will the researcher reduce risks and harm associated with the study?

4.2.2. Various Types of Research Paradigms.

Various authors in literature have discussed different categories of paradigms. In this study, four most common paradigms were discussed as follows:

- **Positivism:** according to (Sheppard, 2020), positivism paradigm makes assumptions of reality based on science which allows researchers to be free of bias in finding knowable truth. This paradigm suggests that reality in existence is independent of humans and that the researcher should seek understanding the social world like the natural world by establishing some cause-effect among the social phenomena (Rehman & Alharthi, 2016). Here, the researchers are relied upon laws which govern the social phenomenon such as the application of scientific methods to generate factual statements and quantify knowledge (Saunders et al., 2019). Hence, positivists are not attached to the data and chooses to remain neutral. With this paradigm, researchers aim to test theories through measurements and observations (Mackenzie & Knipe, 2006). This is due to the belief that reality ought to be uncovered empirically and with precision which will then allow them to make future predictions (Ugwu et al., 2021). For the current study, scientific methods will be implemented in terms of statistics to make sense out of data and generalise to a larger population, therefore the researcher relied upon positivism.
- **Interpretivism/constructivism:** (Sheppard, 2020) alluded that interpretivism involves understanding people as social actors and not objects and is usually used by researchers to understand the world of human experience subjectively. That is to comprehend what the subject of the study thinks of the study context and attaches meaning to it. Therefore, it is assumed that truth is not discovered but created and that reality is a result of social construction (Kivunja & Kuyini, 2017; Mackenzie & Knipe, 2006). Here, the researchers are attached with their subjects of study (J. Creswell & Poth, 2018). Also, there is no one accepted or chosen reality over others, but different perspectives of the same phenomena are welcomed through interactions with the social actors (Rehman & Alharthi, 2016). This is due to the belief that people's views differ because of different cultures, experiences, and circumstances (Saunders et al., 2019). The goal of interpretivists is understanding the phenomena purely through the participant's viewpoints without any personal interventions (Dammak, 2015; Elshafie, 2013). Therefore, it is not of the interpretive researcher's interest to generalise findings since this paradigm advocates for the subject's respect in their

differences of viewpoints (Ugwu et al., 2021). According to (B. Norman & Jan, 2017), this paradigm is suitable to “understand from everyday accounts, what has happened and why”. For this research, to obtain some of the objectives, the researcher was not required to understand the viewpoints of individuals, however, the nature of the study involved quantitative data and hence interpretivism could not be dependent upon.

- **Critical/Transformative:** it is stated by (Sheppard, 2020) that critical paradigm suggests that the research study should operate with a goal of seeking social change. Here, researchers assume that the existing reality is based upon factors such as culture, religion, ethnicity, politics, and gender (Rehman & Alharthi, 2016). Furthermore, the researcher engages with social actors in hope of bringing a change in social systems which are depriving social needs of the subjects. While examining reality, the researcher must consider issues associated with power (Elshafie, 2013) since knowledge is reflected through power and social relationships. It is also known as a transformative paradigm because the research context is viewed to be a construction as opposed to discovery with efforts of promoting human rights (Kivunja & Kuyini, 2017). The researcher rejected this paradigm as the study context was not based upon social injustice and political agendas.
- **Pragmatism:** based on the views of (Saunders et al., 2019), pragmatism offers multiple ways of understanding the worldview. With this paradigm is it not required for researchers to commit to a single reality or philosophical system since it believes every person interpret reality uniquely (Mackenzie & Knipe, 2006). Rather, it opens a path for the researcher to remain focused on the “what and how” of the research problem. Through pragmatism, a combination of multiple methods is deemed appropriate, which are then used to know the truth and understand: 1) the actual behaviour of the subjects, 2) the beliefs that led to those behaviours, and the possible consequences of various behaviours regarding the phenomena (Kivunja & Kuyini, 2017; Ugwu et al., 2021). The paradigm holds a characteristic that implies to use “what works” for the researcher to answer the research questions without concern of the question’s being of the qualitative or quantitative nature solely. (Kaushik & Walsh, 2019) supports the view that philosophically, habits and beliefs are socially constructed and forms a basis for knowledge and reality. Furthermore, pragmatism advocates for reality to be true as long as it assists in establishing satisfactory relations with experiences. The aim of pragmatism is to arrive at knowledge of greater

completeness without compromising the rigor of the study. This paradigm was not suitable for the current study as the researcher did not adopt multiple approaches in the investigation and no subjective approaches were necessary to construct reality (Brierley, 2017; J. Creswell & Poth, 2018).

Additionally, Table 4.1 provided a comparison of the four paradigms with its ontological, epistemological, methodological, and axiological positions. It also reflected on the research approaches and design that were suitable along each paradigm.

Table 4.1: The comparison of paradigms through its basic beliefs.

Paradigm	Positivism	Interpretivism/ constructivism	Critical/ transformative	Pragmatism
Ontology	Realist (single reality), foundationalist.	Relativism (Multiple realities)	Historical Realism	Relational (Non-singular reality)
Epistemology	Objective	Subjective	Transactional, subjective	Either objective or subjective, or both
Axiology	Beneficence, Value free	Value-bound, Balanced	Value laden	Value-driven
Methodology	Experimental/ Manipulative	Dialectic/ Hermeneutic, naturalist	Dialogical, dialectical	Mixed methods, Multi methods
Approach	Quantitative	Qualitative	Mixed approach	Mixed methods, Multiple methods, or both.
Methods	Deductive. (Questionnaires, tests, observations, large samples, statistical analysis)	Inductive. (In-depth/ semi-structured interviews, small samples, document analysis, thematic analysis)	Retroductive. (Open ended interviews, focus groups, participant observation, survey, journals, questionnaires)	Abduction. Mixed methods, multiple methods, qualitative, quantitative. (For data collection and analysis)
Design	Experimental, causal-comparative, correlational, quasi-experimental.	Case study, ethnography, narrative inquiry, phenomenology, grounded theory.	Critical ethnography, critical race theory.	Convergent parallel mixed methods, embedded mixed methods, explanatory mixed methods, exploratory mixed methods.
Quality Criteria	Internal and external validity, reliability.	Trustworthiness & transparency (Credibility, transferability, dependability, confirmability)	Erosion of ignorance and misapprehensions, Action stimulus.	Convergent criteria, bespoke criteria, separate criteria. Linking research objectives with research goals, approaches, findings, and literature. Transparency, Respondent validation.

Source: constructed from the works of various authors in literature: (Dammak, 2015; Elshafie, 2013; Guba & Lincoln, 1994; Kivunja & Kuyini, 2017; Kwadwo Antwi & Hamza, 2015; Mackenzie & Knipe, 2006; B. Norman & Jan, 2017; Rehman & Alharthi, 2016; Saunders et al., 2019; Ugwu et al., 2021).

4.2.3. Justification of the Chosen Paradigm

The research adopted the positivism paradigm for its support of the use of empirical evidence in uncovering reality. Positivism influences information systems research profoundly and holds a significant value (Shanks, 2002). The positivist paradigm is derived from the works of philosopher Auguste Comte, who assumed that the existence of reality is autonomous, derived independent to human existence without any senses and mediation from binding laws (Rehman & Alharthi, 2016). It supports quantifiable observations with the aim to uncover causal relationships in the social world. Positivism is referred to as worldview view arising from verifying hypothesis and theory, which assists to predict future of the explained phenomenon (Y. S. Park et al., 2020). This study formulated hypothesis to test and evaluate the influence of 4IR on improving service quality. Factors influencing service quality improvement may not be existing in the mind of the subjects such as students and academics, therefore these factors must be identified, understood, measured, and explained quantitatively in drawing valid conclusions. The researcher also adopted this paradigm to maintain neutrality and reduce biasness in the interpretation of the research (Aliyu et al., 2014). Positivism allowed the researcher to study reality concerning the research phenomena from a practical orientation and accumulate knowledge systematically. With a positivist approach, the researcher was able to determine the perceptions of the subjects towards 4IR-based service quality, which contributes in assisting tertiary institutions possibility to enhance quality of research, teaching and learning services.

This study held a **realist ontological** assumption which guided the reality. This means that the study produced single reality to the research phenomena. The current study aimed to develop a framework for tertiary institutions to enhance the quality of services through the concept of 4IR and Quality 4.0. Therefore, the research required deriving reality through support from events and models such as the SERVQUAL model, the TRAM model, and the Systems Theory. Adopting the positivist approach is justifiable as it provided the researcher with a basis to study the phenomena of the investigation in a manner in which it exists from the academic, student and IT staff perspective in the tertiary institution setting. In order to have an understanding of the truth, the researcher The **objective epistemology** guided the quantitative objectives as the study believed a natural or physical world exists which can be investigated in a structured manner with a significant role of human beings as social factors who can modify their environment. In

this study, the theme aimed to establish a causal effect between 4IR and quality improvement, which was derived from reality that exists. This means the at this point, the researcher did not influence the subjects in gathering data and remained unattached with the subjects during any interactions. Data was collected to understand the views of the subjects on the institutions capability to promote quality through 4IR technologies. Data was also collected to test various relationships between different quality aspect and 4IR. Therefore, truth was determined through statistical measurements based on the opinions of subjects which were likely to have an impact towards change and enabled to gain more knowledge which contributed towards the development of the 4IR service quality improvement framework. The researcher believed this was possible to be achieved using single tools supported by the positivist paradigm. Hence, the finding of the study was based on an authoritative, empirical, and logical knowledge sourced from people and literature.

Accordingly, the researcher followed a **quantitative deductive (Hypothetico-Deductive) research methodology** as guided by the positivist paradigm (Neuman, 2007). This methodology enabled the researcher to study the realistic behaviours of participants and the consequences that could follow from those behaviours by testing hypothesis (Y. S. Park et al., 2020).

The focus of the pragmatic **axiology is value-free**, meaning the researcher may not disregard the opinion of subjects over the others. The researcher believed that all views are significant and should be respected. Hence, the role of axiology in this study was to understand all valuable views regarding the implementation of 4IR in tertiary institutions to enhance quality. The researcher also applied for ethical clearance to the Univen Ethics Committee in which it was justified how the ethical issues were addressed after which an ethics clearance certificate was granted.

4.3. The Research Design

A research design is referred to as a structural workplan or blueprint that assists in the administration of the entire research by linking the research methods and procedures for obtaining reliable conclusions (Akhtar, 2016). It is a framework that governs the data collection and analysis procedures, which assists in logically answering the research questions (Bharat, 2021). Moreover, research design accommodates the function of

establishing a connection between the research problem and empirical evidence, as well as anticipating suitable research decisions for maximizing the research validity.

The current study employed a multi – method research design (J. W. Creswell, 2014). Using a combination of multiple methods allowed the researcher to obtain a complete understanding of the research phenomenon that was to understand the 4IR stances in improving service quality in tertiary institutions. Multi - methods aid the researcher in answering the research questions that cannot be answered using a single method alone (Schoonenboom & Johnson, 2017). Therefore, it eliminates the limitations of each method and exploit the benefits of both methods to enrich evidence and experiences from different perspectives, as different avenues of exploration are facilitated (Shorten & Smith, 2017).

The selected design allowed the researcher to restructure various quality models for tertiary institutions to be inclined towards a 4IR setup. This required to study the research phenomenon using a specific case, hence, require initiating interactions with the audience regarding their understanding of 4IR, their views on current service quality and their perspectives on integrating advanced technologies in their daily activities (Tashakkori & Teddlie, 2016). This design allows researchers to answer questions in supporting explanations and predictions as it reports on relationships among different elements of the phenomenon. Moreover, it allowed to collect survey data from students, lecturers and staff and build case relevant to the selected institutions for determining the best possible solutions to improve service delivery (Creswell, W. John & Creswell, 2018).

4.3.1. Survey Research Design

A survey design is referred as a method of collecting primary statistical data relating to the study phenomenon to understand perspectives, attitudes, and opinions of the research subjects (Francis & Craig, 2016; Nigel & Amanda, 2009). For this study, the aim was to empirically establish whether the implementation of 4IR technologies predicts a subsequent improvement in service delivery. Through a survey design, the attitudes, opinions, and trends within the identified population concerning 4IR were obtained through numeric descriptions (Asenahabi, 2019). It is mentioned by (Julie, 2015) that the goal of selecting survey design is for the researcher to collect a significant volume of data from a large pool of people in a short period of time. For instance, survey design assisted in collecting data concerning the perceptions of the respondents in terms of implementing

4IR based teaching and learning to improve service quality. The researcher was then able to study the large sample and conduct statistical analysis to establish correlational, and cause-and-effect relationships between the variables of the study (Odoh & Chinedum E, 2014). A cross-sectional survey was carried out to study the nature of reality at a particular time (Nigel & Amanda, 2009). Typically, survey design offered the researcher with benefits such as cost-efficiency, internal and external validity, generalisability, preserved identity, and flexibility.

4.3.2. Case Study Design

A case study design is referred as a method of understanding and analysing a specific event under investigation of a particular unit represented with intensive detail (Asenahabi, 2019; Schoch, 2020). It is also defined as an inquiry focusing to describe, understand, predict, or control the unit of the study (Asenahabi, 2019). It has a characteristic of enabling the researcher to investigate the study's phenomenon in its real-life/natural context more in-depth (Crowe et al., 2011). It is indicated by (K. D. Norman & Yvonna, 2017) that a case can constitute an incident or a unit of something which could include an individual, an institution/organisation, a location, a country, a specific action, or an event of something.

For this study, case design was appropriate to answer the “how” and “why” questions (Rowley, 2002). A single intrinsic case study design was followed in this research to determine how quality 4.0 can be achieved in a tertiary institution context, the case being University of Venda as a selected institution. Furthermore, the purpose of adopting a case study design was to explain issues related to the implementation of 4IR technologies in tertiary institutions. The goal was to determine the relationships or factors which led to a particular behaviour being studied (Inaam, 2016). For instance, to determine why 4IR based quality is accepted or rejected in service delivery by the unit of the study or why are the subjects of the study not aware of the 4IR based teaching and learning technologies? (Zaidah, 2007). Figure 4.1 illustrated the study's research process.

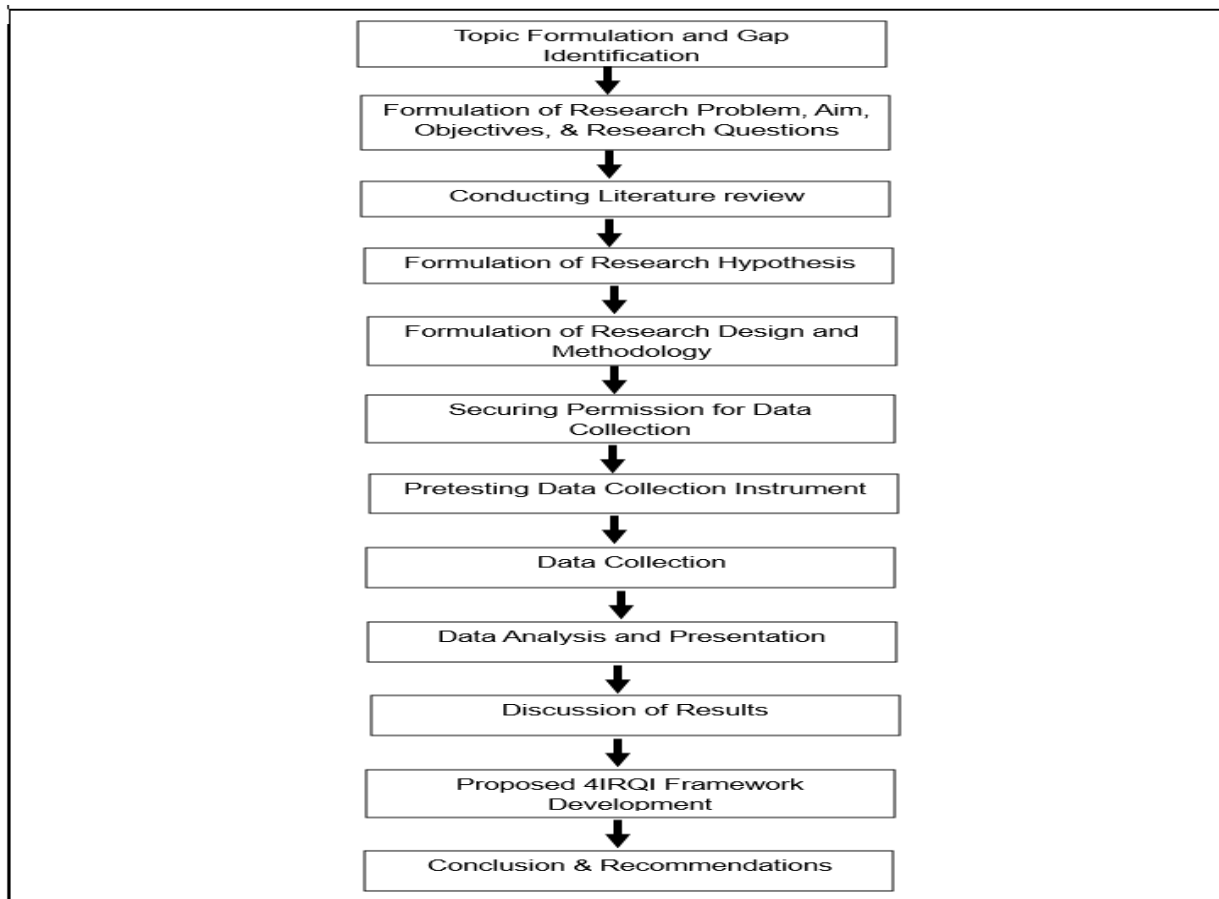


Figure 4.1: The Research Process. Source: Researchers Own

4.4. The Research Approach (Methodology)

Research methodology is referred to the approaches used in conducting the study determining how the research inquiries should proceed (Tashakkori & Teddlie, 2016). It is also defined by (Creswell, W. John & Creswell, 2018) as a research plan and procedure that ranges from wider assumptions to precise data collection and analysis methods which requires intersecting the philosophical assumptions, designs, and particular methods. The study followed a quantitative research approach for directing the data collection and sampling procedures. Quantitative approaches allowed the researcher to produce stronger empirical inferences with divergent and complementary views of 4IR in tertiary education context in fulfilling the research aim. That is to study the determinants of the successful application of 4IR in tertiary institutions.

4.4.1. Rationale for Quantitative Approach

The purpose of a quantitative approach is to observe the social phenomenon with more scientific precision and robustness in producing greater knowledge. According to (Leedy & Ormrod, 2013), quantitative research approach involves the collection and analysis of

numeric data through statistical calculations. This approach facilitated the researcher to produce more accurate and valid data that could be sorted, classified, and generalized to a larger audience reliably (Leal Filho & Kovaleva, 2015). Through this approach, the researcher aimed to collect numeric data pertaining to the role of 4IR in tertiary institutions together with the challenges and benefits of adopting 4IR based technologies in tertiary institutions. This method supported the researcher to link the relationship between challenges, benefits, and perceptions with service quality improvement. Furthermore, information on the current practices in relation to Quality 4.0 in improving service quality at tertiary institutions was collected. This included gathering data on the various policies, standards and quality assurance methods currently implemented at tertiary institutions through a survey questionnaire.

Additionally, (J. W. Creswell, 2014) stated that researchers can use **inductive** or **deductive** approaches to reasoning. For this study, the explanation of the arguments based on laws and rules were expressed deductively (Tenuche, 2018). To be clearer, the researcher used existing theories to generate research questions and then built broader themes through participants views. With deductive approach, the researcher pursued obtaining data about subjects' perspectives on 4IR and its importance within the University in applying the concept of Quality 4.0 for enhancing overall services. The researcher sought to understand the position of the tertiary institution in operating via a 4IR platform, that is to introduce a smart campus with increased value creation towards the stakeholders. The results of this process guided the researcher in producing knowledge for developing the 4IR application framework for improving the service quality.

In comparison, it is reported by (Venkatesh et al., 2016) that, qualitative research approach is more focused on collecting and analysing narrative data. Therefore, data is a resultant of meanings extracted from words and images to capture experiences and perspectives in a natural setting (Leal Filho & Kovaleva, 2015). Researchers use this approach with the aim of gaining an in-depth knowledge by interacting with the participants. (J. W. Creswell, 2013) identified five types of qualitative research designs namely grounded theory, ethnography, phenomenological study, case study and action research. Usually, qualitative researchers study documents with records in gathering contextual information regarding the phenomena of study.

While in a mixed method context, researchers can use both inductive and deductive reasoning with the aim of developing reliable knowledge. Pragmatism advocates for the use of **abductive** reasoning which involves both inductive and deductive reasoning in generating knowledge (Gregory & Muntermann, 2011). Abduction refers to guessing a concept theory that enables to understand an unusual phenomenon in reality (Gregory & Muntermann, 2011). Abductive reasoning has a characteristic of developing better ideas over time. According to (Soiferman, 2010), inductive reasoning involves beginning with specific arguments which are then moved to general arguments, while deductive reasoning involves moving from general arguments which are then ended with specific arguments. This study did not implement mixed-methods as emphasis is given to quantitative data.

However, Table 4.2 presented a comparison of advantages and disadvantages of Quantitative and Qualitative approaches.

Table 4.2: The Advantages and Disadvantages of Qualitative and Quantitative Research Approaches. Source: (Eyisi, 2016; Rahman, 2017; Tenuche, 2018).

Approach	Advantages	Disadvantages
Qualitative	<ul style="list-style-type: none"> - Analysis is inexpensive and cheap - it is not confined to a limited perspective - data collection is not required to follow specific questions, rather can be adjusted throughout the process. - human experience brings more power to the data gathered - assists researcher with a clear vision on what to expect in order to paint a bigger picture 	<ul style="list-style-type: none"> - data can be skewed towards the subjective nature of the research - the responses can be directly influenced by the researcher - findings can be difficult to present visually - the quality of research is based on the skills and experience of the researcher which can be affected by personal ideologies.
Quantitative	<ul style="list-style-type: none"> - Quick short time frame for administered survey - Inexpensive means of data collection - efficient compared to qualitative - statistical significance - generalizability - accurate for measuring large samples 	<ul style="list-style-type: none"> - valuable findings may be difficult to present as no in-depth descriptions occurs - it requires balancing the changing number to remain consistent - researchers creates an artificial environment to control variables - findings can be biased - analysis requires greater experience and advanced tools - respondents may not be honest with conflicting answers - may lack resources for large scale research

4.5. Unit of Analysis

Unit of analysis is referred to the subject or entity from whom data will be collected and analysed in a scientific study (A. Khan, 2021; Kumar, 2018). It is focused on depicting who must be studied and what has to be researched from which conclusions could be

made (Sedgwick, 2014). In other words, it is the level of analysis at which data is collected. According to (Serkan, 2010), there are limitless varieties of possible unit of analysis classified in categories or levels. Hence, it includes categories such as individuals (students, employees, citizens, staff); groups (departments, teams, families, neighbourhoods; organisations (corporates, universities, societies, supermarkets) and social artifacts/social interactions (objects, books, constitutions, technological devices, machines). As alluded by (R. R. Margaret & Paul, 2015), it is important to obtain a well-defined and clear unit of analysis to retain context required to reach meaningful conclusions. This is supported by (Kumar, 2018) who indicated that, the unit of analysis is important for the researcher to accurately define the research problem and methodology.

For this research, the unit of analysis is the application of 4IR in tertiary institutions and therefore, the subjects of the study will participate to represent the organizations. The organization consisted of students and staff to whom questionnaires were distributed and interviews were conducted to determine how quality of teaching and learning can be improved through 4IR.

4.6. The Target Population

According to (Daniel, 2011; Levy & Lemeshow, 1999), population is defined as a complete set of persons, events and objects whose shared attributes are to be measured for the study interest. Target population is defined as an aggregation of those elements meeting specific inclusion criteria from which sample will be drawn (J. W. Creswell & Clark, 2018). A target population was required to be selected in this study as it was not feasible to measure all the units of the population due to time and resource constraints (Babbie, 2007). The population of this study was all the 26 public tertiary institutions in South Africa. However, the target population of the study consisted of selected ICT staff, students, and lecturers at the University of Venda. It was of significance to study the views of these selected individuals regarding the use of 4IR in improving service quality within a rural-based tertiary institution. The students, staff and lecturers are the potential users of advanced technology and hence, considered as vital stakeholders. The IT staff can provide sufficient knowledge on the current and future plans pertaining the implementation of 4IR technologies and its significance towards service quality.

4.6.1. Sampling Technique

According to (Leedy & Ormrod, 2013), a sample is a subgroup of the population from which inferences will be made of which findings will be generalized to the population as a whole. Sampling is referred to the processes of selecting a suitable subgroup of the population. There are two broad categories of sampling as discussed by (Babbie, 2010), known as probability and non-probability sampling. Probability sampling is highlighted as a method for selecting the sample randomly, whereby each participant of the population has an equal known chance of being present (Ilker & Kabiru, 2017). Probability sampling includes the following forms: simple random, stratified random, cluster and systematic sampling. While non-probability sampling plans does not guarantee whether every member of the universe will have an equal chance to represent the sample (Daniel, 2011). Non-probability sampling consists of the following forms: convenience, quota, purposive, and snowball sampling.

The study adopted a quantitative sampling technique to accommodate the quantitative components of the study (Venkatesh et al., 2016). It is recommended by (J. W. Creswell, 2013) that, to achieve the objectives of a quantitative survey, probability sampling procedures be followed. However, a non-probability sampling was followed to select IT staff samples.

4.6.1.1. Quantitative sampling approach

Simple random sampling was implemented for participant selection which are the students and academics at the tertiary institution (Babbie, 2010). This technique allowed all the students and staff to have a similar amount of probability of inclusion in the sample. With the fast-paced introduction of advanced technologies, traditional methods of operations are causing tertiary institutions to lag, thereby affecting the quality-of-service delivery. Therefore, this study aimed to gain a better understanding from the staff and students on their perceptions regarding the existing quality of services and the vision of integrating innovative technologies such as artificial intelligence, IoT, and a smart campus model. The implementation of such technologies will enhance digital interaction among the tertiary institution with the students and staff making service available always when required. Therefore, students and staff were randomly selected from different faculties. A complete list of the number of students and staff within each faculty was acquired from the university's information head. The simple random technique was selected to ensure

the sample is free from bias and would be readily available for participation (Leedy & Ormrod, 2013).

Convenience sampling was used to select the targeted tertiary institution as a case because the researcher is working and studying there, hence it became convenient to avail participants in terms of access, location, time, and willingness of participation (Etikan et al., 2016). However, Purposive/judgemental sampling was followed to obtain data from the staff in IT. With this technique, the respondents were intentionally selected for their knowledge, experience and expertise that could significantly contribute towards achieving the aim of the study (Daniel, 2011). The researcher believed that the respondents could add value in the development of the 4IR service quality framework. Therefore, the inclusion criteria for participation were those members who understood 4IR in a tertiary institution setting.

4.6.2. Sample size and frame.

A significant phase in the sampling process is to determine an appropriate sample size to avoid sampling errors and draw valid conclusions that could be accurately generalized (Mujere, 2016). The sampling frame is referred as a list of population from which the study units are selected. For any statistical analysis, a relatively small sample selection affects the accuracy of representing the realities of the population because valid findings would not be yielded (Singh, Ajay & Masuku, 2014). On the other hand, a very large sample selection would have to be balanced against the researcher's resources such as time and budget which can be unnecessary if same results could be obtained with a smaller sample size (Taherdoost, 2017). Therefore, the selection of sample size is dependent on the nature of the investigation and the characteristics of the population (Daniel, 2011). Furthermore, factors such as the effect size, statistical power, significance level, and estimated measurement variability were considered.

Quantitative sample size: the target institution currently entails four faculties (science, engineering, and agriculture; management, commerce, and law; humanities, social sciences, and education; health sciences). To estimate the sample size for this population, the Cochran formula was used (Cochran, 1977).

Cochran formula for sample size:

$$n_0 = Z^2 pq / e^2$$

Based on this formula, n_0 is the size of the sample, z is the desired confidence level, p is the estimated proportion of an attribute present in the population, q is $1 - p$ and lastly e is the desired level of precision. Since the degree of variability was unknown, the researcher assumed maximum variability of 50%, hence $p = 0.5$. Therefore, $q = (1 - 0.5)$ that is 0.5. Furthermore, a 95% confidence level was assumed arriving to z value of 1.96 with a precision of $\pm 5\%$ making the e value to be 0.05.

The calculation resulted in the sample size of

$$n_0 = (1.96)^2(0.5)(0.5) / (0.05)^2 = 384.16 = 384.$$

However, for this study the population was finite and known. Therefore, the formula was corrected as suggested by Cochran. Hence, the formula below was used.

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

The calculation resulted in the following sample size of:

$N = 14949$, $n_0 = 384$; therefore

$$n = \frac{384}{1 + \frac{(384-1)}{14949}} = \frac{384}{1 + \frac{(383)}{14949}} = \frac{384}{1 + \frac{(383)}{14949}} = \frac{384}{1+0.02} = \frac{384}{1.02} = 376,47 = 377.$$

A total of 377 questionnaires were distributed to the student population. For the academics' population, a total of 60 questionnaires were be distributed across the four faculties. A total of 20 questionnaires were distributed to the IT staff members.

4.7. Data Collection

Data collection refers to the process of obtaining information from various sources to answer the research questions in a systematic and unbiased manner (Grove et al., 2015). The process of data collection starts after the researcher has identified the research design (Thakur, n.d.). It is recommended that data collection be a smooth process for yielding quality and timely data through which credible evidence can be built (Sapthami, 2020). This is because the data collection process influences the research instrument, sampling techniques and research evaluation. It is mentioned by (Kabir, 2016), that obtaining accurate data is significant in achieving research integrity and reducing errors.

Data is classified into two broad sources namely primary data and secondary data. The current study collected data from both primary and secondary sources.

4.7.1. Sources of Data Collection

The basis of data collection arises from two sources. The **primary** data is referred to data that is fresh, has original character and has been collected for the first-time through first-hand experience to address a particular problem through systematic procedures (Hox & Boeije, 2005). This type of data is then added as a contribution to the existing body of knowledge to be reused by other researchers. (C. H. Margaret & Melissa, 2009) iterates that primary data collection is a significant aspect of a research study. For this study, primary data was obtained from data gathered through questionnaires. On the other hand, **secondary** data is referred to data that has already been collected, statistically processed or transcribed, analysed, and used for a purpose by somebody at a different time historically (Unachukwu et al., 2018). This type of data is used to review literature as it is not appropriate to collect new data adequately without understanding historic events and developments as well as having an insight in terms of the current state-of-art information on the research phenomenon (Kabir, 2016). The significance of secondary data was to assist in creating a baseline for collecting primary data (Martins et al., 2018). For this study, secondary data was obtained from available literature sources concerned with the topic of 4IR, Quality 4.0, service improvements, and tertiary education sourced from various journal articles, books, conference proceedings, websites, databases and reports. (Jilcha Sileyew, 2020). Furthermore, the researcher also consulted 4IR documents, 4IR plans in government gazette, existing frameworks, policy, and regulatory data to support in understanding the research objectives.

4.7.2. Data Collection Methods

According to (Thakur, n.d.), the data collection method(s) is regarded as the “heart” of research. It holds an importance in the research methodology since it determines how the data will be used and explained through the selected approaches (Paradis et al., 2016). A method of data collection is any technique or tool a researcher can use to physically obtain data needed to be analysed in for research. (Johnson & Christensen, 2017). The researchers can carefully select from various methods of data collection categorised as the qualitative, quantitative, and mixed methods considering the strengths and weaknesses of each. It is suggested that the data collection methods be

standardised to make it easier for visualising and analysing relevant data (Sapthami, 2020). Additionally, in selecting an adequate research method for data collection, the researcher considered elements such as the research objectives, nature of data, field of investigation, time, costs, and resources available. In this study, it had to be determined how the researcher will interact with the research participants to gather perceptions on the 4IR research phenomenon. The researcher therefore implemented a quantitative method of data collection since it allowed to expand the scope of the study and capture various dimensions of the phenomenon (Sandelowski, 2000).

4.7.2.1. Quantitative data collection

In this phase, the researcher collects data focused on particular variables recognised in relation to the study objectives often from a large sample (Leedy & Ormrod, 2013). Quantitative data is that which can be mathematically processed and analysed (Kabir, 2016). With quantitative methods, a random sampling method and structured instrument is relied upon. It is iterated that a survey method be used for gathering quantitative data (J. W. Creswell, 2014). Using a survey method, the researcher was able to estimate opinions, attitudes, and characteristics of individuals on a large scale. (Paradis et al., 2016). Quantitative data backed the researcher in summarising, comparing, and generalising the findings. The researcher selected questionnaires as a method of collecting quantitative data as briefly discussed below.

Quantitative Data Collection Instrument

a) Structured Questionnaires

The current study used questionnaires as an instrument for data collection. A questionnaire is a tool that guides researchers to gather information from the research subjects through a set of pre-arranged and written questions addressing the research objectives (McMillan & Schumacher, 2014). This method required dividing questions into groups and arranging them logically. Through questionnaires, the researcher obtained facts pertaining the respondent's behaviour, attitudes, beliefs, perceptions, and knowledge regarding the research enquiry (Grove et al., 2015). Using this method, researcher experienced advantages such as low costs, access to larger samples, standardised answers, and a controlled data collection environment (Nigel & Amanda, 2009). Also, the questionnaire format was that of closed-ended questions, meaning that a set of answers were provided to the respondents to choose from. This was because of

the belief that closed ended questionnaires are more efficient due to its ease of analysis. Since educational institutions may lack transparency and a high level of interaction between students and educators when implementing new technologies, questionnaires were suitable for interacting with these students and educators in obtaining their views on implementing the trending 4IR technologies. Futurists are predicting the most technological changes in between the year 2022 – 2026. It was therefore significant to investigate the progress of changes that has been implemented at the tertiary institution in between this period from the perspectives of students and lecturers.

The design of the questionnaire was guided from the theoretical model adopted to understand the challenges and opportunities presented by 4IR at Univen. The study applied a closed-ended questionnaire format divided into sections and included a combination of Likert scale, dichotomous and multiple-choice question format to simplify respondents understanding of the questions and reducing errors (Mazhar et al., 2021). The questionnaires were used to understand the level of acceptance that the respondents had towards participating in 4IR initiatives focused on improving quality of service delivery. Also, to understand the gaps identified concerning 4IR implementation from the participant's perspective, data regarding their awareness and expectations from tertiary institutions was collected through the questionnaire. Therefore, measures for quality improvement were proposed accordingly.

On the other hand, **qualitative** researchers may adopt interviews and document analysis as a data collection method (Canals, 2017; J. W. Creswell, 2009; Kabir, 2016). Interviews are valuable and resourceful for collecting subjective and in-depth perceptions with an assumption that respondents have unique knowledge about the research phenomena (Johnson & Christensen, 2017). Interviews can be conducted face-to-face or telephonically, with an individual or groups of individuals (Sapthami, 2020). Interviews were not suitable for this study because of its highly standardised nature. Using this technique, the researcher would not be able to obtain elaborated responses and would not have provision for follow-up questions (Johnson & Christensen, 2017). Researchers with qualitative research nature could also rely on document analysis, which would collect textual information/written materials to provide context and supplement other research data (Busetto et al., 2020). In some studies, document analysis is used to extract meanings, obtain understandings and developing empirical knowledge (Bowen, 2009).

In some studies, document analysis is used to extract meanings, obtain understandings and developing empirical knowledge (Bowen, 2009). For this study, the researcher did not want to limit collecting data from a few participants, while developing empirical knowledge was reliant on primary data collected, and therefore did not require document analysis.

4.8. Data Analysis

Data analysis refers to the process of scrutinizing, cleaning, arranging, and transforming data to extract meaningful information (Grove et al., 2015). The aim of analysing data is for presenting data in a manner that supports the research arguments to obtain convincing conclusions (Walliman, 2006). Also, it assists the researcher in breaking down or categorising the phenomenon for it to become understandable. A quantitative analysis approach was employed to analyse quantitative and qualitative data separately leading to two datasets (J. W. Creswell & Clark, 2018).

4.8.1. Quantitative analysis

Quantitative data analysis utilises numbers and statistical approaches to understand and make sense of data (Boswell, C., and Cannon, 2018). Various statistical techniques were used to identify patterns, present tabulated and graphical summaries of data properties, and forecast future trends (Leedy & Ormrod, 2015). The data collected from questionnaires was reviewed and inspected for any omissions and inconsistencies. Thereafter, data was analysed using the latest version of IBM SPSS (Statistical Package for the Social Sciences). According to (Lutabingwa & Auriacombe, 2007), quantitative data analysis process should begin by preparing raw data into a computer readable format, hence the researcher followed the following steps (Saunders et al., 2019):

- Data editing: this stage involved identifying errors and omissions, as well as checking if the survey data was complete. The aim here was to ensure quality control.
- Data coding: to conduct statistical analysis, data must be transformed into a numeric format that will be recognised by the computer software which in this is SPSS. The researcher assigned numeric codes to the answers of the questionnaire as well as any missing data.
- Data entry: this stage involved entering numeric codes into the computer software for further processing.

- Data cleaning: this stage involved eliminating any errors that may have occurred while coding and entering data.

Statistical analysis is divided into two broad categories, that is parametric tests (suitable for normal sample distribution usually with a sample size greater than 60 and non-parametric tests (suitable for small sample sizes where sample is not normally distributed) (Saunders et al., 2019). Both descriptive and inferential statistics were adopted to analyse data. However, it is important for the researcher to know what type of data is being collected. It is recommended by (Jen & Shannon, 2016), that the researcher must distinguish between four types of quantitative data being collected: 1) Nominal/categorical – data values cannot be associated with numbers but can be classified into sets as there is no concept or degree of order such as race or ethnicity; 2) Ordinal/rank – data values cannot be measured in numbers but contains a particular order to the data in which a relative position is known such as Likert scale questions; 3) Interval – contains an order to the data with equal and fixed measurable distances between that data points, meaning that a difference can be stated between the data values for a variable for which a relative difference cannot be measured such as scores on a test; and 4) Ratio/Scale – contains order and a fixed interval between data values meaning an interval and relative difference for data values for a variable can be specified such as temperature, height. .

Descriptive statistics were aimed at describing the sample including tests such as measures of central tendency (mean, median, mode), frequency distribution (standard deviation), and measures of dispersion (range, variance) (Stapor, 2020); which in this research were conducted to study the demographic characteristics, 4IR usability and factors influencing the implementation of 4IR. Conversely, **inferential statistics** was aimed at making predictions about the population using the data from the sample drawn (Chanoknath & Louangrath, 2015; Thompson et al., 1996); hence the following inferential statistical tests were performed:

- Pearson's Chi-square: was conducted to test the relationship between variables.
- Factor analysis: was used to test the validity of the constructs and measure the degree of correlation. It enabled to correlate groups of variables which could be reduced to a specific factor. It includes two types – confirmatory factor analysis which was

conducted using structural equation model analysis; and explanatory factor analysis via latest version of IBM AMOS.

- Reliability analysis: to test the degree to which the questionnaire had consistent findings. It was also conducted on data collected from the pilot study.
- Measures of variance: the ANOVA was conducted to calculate a value that reflects on the degree of differences in the means of the population groups. For instance, to study if there was a difference among people's age group and the perceptions of 4IR usage.
- Regression analysis: was conducted to measure how accurately one or more independent variable allowed predictions to be made concerning the values of dependent variables.

Alternatively, **qualitative** studies involve analysing data through observational methods, meaning that data is examined without conversion to numbers (Boswell, C., and Cannon, 2018). It involves identifying specific patterns, researcher's judgement to describe the outcomes, and develop research theories. Inductive approach could be used to analyse data from open interview questions, and it allows to focus more on impacts and consequences. According to (Lester et al., 2020), there are multiple methods of analysing qualitative data including thematic analysis, content analysis, framework analysis, narrative analysis, interpretive analysis, and discourse analysis. As suggested by (Braun & Victoria, 2021; Braun & Clarke, 2013), qualitative researchers could implement certain stages/process of qualitative analysis such as Familiarising with data, Generation of initial codes, Search for themes, Review of themes, Define and name the themes, and Compilation the report/ write-up (Lacey & Luff, 2007; Lester et al., 2020; Liamputtong, 2009; Mattimoe et al., 2021; Vinitha, 2019). The ATLAS.ti qualitative analysis tool can be used for the generation of codes, in other words, electronic memos were attached directly to a particular segment. Memos can be used to capture the initial understandings of the data and establishing connections with other parts of study such as the theoretical framework and literature review (Lester et al., 2020). This study did not focus on qualitative analysis due to limited generalisability challenges and possible overload of data generation.

4.9. Reliability and Validity

To evaluate the quality of the research, it is vital to address the concepts of reliability and validity (H. K. Mohajan, 2017a). Reliability and validity are the two techniques mostly adopted by researchers in the social sciences to measure precision and accuracy (Babbie, 2007). Therefore, performing validity and reliability on the measurement instruments allowed the researcher to determine the extent of statistical significance of the data analysis and inferences made from the analysis (Leedy & Ormrod, 2015). The subsequent sections addressed the reliability and validity processes maintained in this study.

4.9.1. Reliability

According to (Heale & Twycross, 2015), reliability refers to the extent to which the findings of measurement are similar. Therefore, it measures stability and consistency to ensure the measurement is free from any error or bias which would increase the chance of making the right decisions (McMillan & Schumacher, 2014). In this case, the questionnaire used to collect data would be considered reliable if it produced similar results when the test was repeated under similar circumstances and group of respondents. It is highlighted by (Dros, 2011; Leedy & Ormrod, 2015) that, reliability can be measured using five methods namely test/retest, internal consistency, split half, parallel form, and inter-rater reliability. For the current study, quantitative reliability was measured using the following criteria:

- Test retest: to measure stability, a test-retest conducted to estimate the degree to which the questionnaire yielded similar results for the same respondents on different occurrences. A pilot study was conducted using the same instrument.
- Internal consistency: to measure homogeneity, an internal consistency test was conducted to estimate the degree to which the items on the scale measured one construct. The Cronbach's Alpha was used to test the correlations whereby the values ranging from 0.80 and 0.96 are considered strong reliability.
- The researcher conducted a literature review in order to confirm the research problem, since the research problem had to be in line with certain theoretical background.
- The study documented the research methods employed, and detailed the research design, sampling approaches and sources of data. For comprehensive data usage,

the study also relied on publicly available secondary data sources published by authentic bodies and government regulatory pertaining to 4IR in tertiary institutions.

Qualitative studies usually maintain reliability by thoroughly checking transcripts to eliminate any errors or mistakes in transcribing the interview data, researchers constantly compare data to verify the accuracy of data collected with the context of the study to ensure that there were no shifts in the meaning of codes throughout the coding process, and cross check codes to determine the level of consistency in coding (Leung, 2015). This process was not employed since no qualitative data was collected in this research.

4.9.2. Validity

According to (Dros, 2011), quantitative validity determines the extent to which the instrument measures what it envisioned to measure. In other words, it measures the truthfulness of the findings and the extent of which those findings are meaningful (H. K. Mohajan, 2017a). However, qualitative validity depends on the procedures employed by the researcher to measure accuracy of the responses. For the current study, the following criteria was used to measure quantitative validity:

- Internal validity: is concerned with how true the study is. It relates to the degree to which the research design is suitable for the research questions. Therefore, focus is on determining if the inferences regarding causal relationships are precise. Hence, the researcher should be confident in conceptualising the extent of cause-and-effect claims made between the study variables. The researcher eliminated threats to internal validity by for instance randomly selecting the right sample of participants. Attempting to eliminate confounding or extraneous variables may result in high validity. In this way, any other likely explanations of the findings can be eliminated. The researcher adopted existing questionnaires, and considerable theoretical framework.
- External validity – is concerned with how well the results of the study can be applicable to the real world. Th researcher must demonstrate that the study sample is representative of a larger population. Also, the researcher must be confident that the investigation can be repeated in other studies with similar context. The researcher believed that threats to external validity can be reduced as extensive literature review was conducted, adequate sample size was selected, quality of data collected was reviewed. The study examined the relationship between 4IR and service quality

improvement using quantitative for statistical analysis which enhanced the generalizability of the overall research.

- Measurement validities – refers to the extent of which a measurement scale measures the research concepts. It describes “how well the indicator and the conceptual and operational definitions of the construct fit together” (Neuman, 2007).
 - *Content validity* relates to how well the instrument covers the content to represent the sample. In other words, how well do the questions in the scale and the scores achieved represents all possible questions regarding the content of the study. Content validity consists of three types namely face validity, factorial validity, and sample validity. Face validity refers to the degree to which the questionnaire truly measures what it anticipates measuring. Therefore, the researcher checked if the questionnaire looked logical at first glance for a respondent to complete it and conducted a pilot test with a small sample to verify the relevance and representativeness of the questionnaire items. Sample validity refers to how well the test covers the areas it intends to cover. The researcher consulted the supervisors to judge how well the items in the questionnaire represents the content. Factorial validity relates to empirically determining the extent of “fit” between the theoretical structure and actual structure of the test. The researcher adopted the technique of factor analysis to load items in the correct dimension.
 - *Criterion validity* – relates to how well the instrument correlates with other standard criteria. Criterion validity consists of two types of namely concurrent validity and predictive validity.
 - *Construct validity* – relates to testing a scale on basis of theoretical underpinnings. In other words, the researcher should establish logical relationships amongst the variables. For this study, the items in the questionnaire were developed on basis of theoretical underpinnings concerning quality improvement in tertiary institutions.

Alternatively, in qualitative studies, validity is all about maintaining appropriateness of the research instrument, procedures, and data. The concept of trustworthiness is employed by researchers to determine the validity of: 1) the research questions in line with the expected results, the design and methodology for answering those questions, 2) the sampling, and 3) data analysis approaches as well as the inferences obtained in line with the context of the study. According to (J. Creswell & Poth, 2018), there are four criteria to measure the trustworthiness of qualitative data as identified by Lincon and Guba

(1985), which are Credibility, Transferability, Dependability, and Confirmability. *Credibility* measure truthfulness and ensure confidence in the results, that is to interpret and report results in a manner that matches the respondent's original views. *Transferability* determines the extent to which the findings can be applied in another context. *Dependability* determines the extent to which the results can be replicated or repeated in the same context. It should be determined if the analysis is consistent with the study design. Techniques such as rich description and audit trails assists in producing dependable research. *Confirmability* determines the extent to which the characteristics of data is neutral and free of researchers bias and own assumptions. These procedures were not required in this study as no in-depth interviews was conducted.

4.9.3. Pilot Study

A pilot study is referred to a small study carried out with a small number of respondents which are similar to participants who will be recruited in the study at a later stage on a larger scale. According to (Wadood et al., 2021), a pilot test is significant in increasing the reliability and validity of the research instrument. It assists in analysing the feasibility prior to the main study (Junyong, 2017). Hence, the researcher conducted the pilot study to test the questionnaires from a small number of participants. This assisted the researcher to check if the wording or the questions were proper and understandable, to check if the constructs were stable, to look for any questions that could discomfort the participants, and to identify flaws in the research techniques and strategies.

4.10. Ethical Considerations

Information systems research entails an array of ethical principles that must be considered for ensuring the safety of the research subjects (Fleming & Zegwaard, 2018). Ethical considerations in research are significant to ensure integrity, dignify human rights and enable the science and society to collaborate (Pritha, 2021). Acknowledging the ethical issues assisted the researcher in understanding the rights and wrongs of research behaviour, that is to understand what is appropriate and inappropriate in conducting a scientific inquiry. The study was guided by the ethics code of conduct as stipulated by the University of Venda Research and Ethics Committee. To overcome various ethical issues, the researcher used the checklists provided by (Saunders et al., 2019) under various sections of their book chapter: "negotiating access and research ethics". The ethical consideration relevant to this study are outlined as follows:

Permission to conduct the study: The researcher presented the research proposal to the Department of Business Information Systems, then to the Faculty of Management, Commerce and Law after which it was also presented to the University of Venda Higher Degrees Committee. This enabled the researcher to obtain permission for conducting the research and comply with the ethical guidelines of the University of Venda. An application for ethical clearance was sent to the ethics committee which enabled to collect data.

Informed consent and Voluntary participation: the value attached with informed consent lies in the researcher providing enough information to participants enabling them to understand the impact their contribution will make (Saunders et al., 2019). Therefore, the participants were issued with an informed consent letter clearly stating the purpose of the academic research and notify them of no financial gains or incentive to be provisioned. Also, the consent letter served as an agreement between the researcher and the participants, clarifying the boundaries of permission and assisted complying with data protection acts. It is unacceptable for researchers to force their targeted respondents to participate and allow them to practice their right of being protected from harassment (Saunders et al., 2019). As such, it included granting the respondents an option to not answer any question(s) forcibly. According to (Babbie, 2007), it is important to note that the respondent's voluntary involvement in any research study ought to be based on their acknowledgement of the probable risks associated with the research. Hence, the participants were informed about the potential benefits and risks (if any raised at the time of data collection) behind the study prior to their participation. With this reasoning, the participants were requested to read, understand, and sign the informed consent letter. The consent letter also informed the participants of their rights to withdraw at any stage and that their participation is completely voluntary and thereby no force or pressure was practiced. The researcher indicated the approximate time it might take a participant to complete the survey before they could commit to the participation. The participants were also informed that they were welcome to ask any questions during their participation. Lastly, the informed consent letter included contact details such as the name of the researcher and email address to cater for any concerns raised.

Confidentiality, anonymity, and privacy: it is significant to maintain anonymity and confidentiality of the participants in order to protect the respondents' interests and identity. Anonymity in research is referred as not being able to identify a specific response

with a specific respondent (Babbie, 2007). The researcher informed the research subjects of the anonymous nature of the study and that their personal details such as names, addresses and contact details were not required. Confidentiality in research is referred as being able to identify a particular response with a particular respondent but ensuring not disclosing it in public (Babbie, 2007). For ensuring confidentiality, the respondents were advised that the information they provided was only accessible to the researcher, the research assistant, and the research supervisors. Maintaining confidentiality and anonymity enabled the researcher to enhance the reliability of data as participants freely expressed their views. Privacy ensured participants protection from any form of stigma.

Protection from harm: The researcher will ensure that the study does not harm the participants in any form or manner and protect their physical, emotional, and psychological well-being. The study will not be biased and will ensure any gender, race, religious discrimination will be guarded against. The respondents will not be embarrassed and violated in any form during their participation in the survey. However, should the respondents feel anxious or uncomfortable, they will be informed about it and directed to the counselling service offered by the University of Venda.

Communication of results: To ensure protection from penalties, conflict of interest and lawsuits, the researcher avoided plagiarism and acknowledged information sourced from other researchers. **Research misconduct:** For the research to be reliable and credible, the results of the study require to be transparent. Therefore, the researcher ensured the research report presented was submitted with utmost honesty, and that the data was not falsified and fabricated. Also, the intentional misinterpretation of the findings was avoided so to not mislead the study and reach biased conclusions. Lastly, the researcher did use deception by lying to participants in order to lure them to participate.

4.11. Summary

This chapter covered the aspects concerning the research paradigms, design, and approaches. The researcher justified the use of quantitative methods for conducting the study. It addressed the procedures for selection of sample and data collection techniques and instruments. The researcher also outlined the measures for obtaining reliability and validity in order to address the quality of the research. Lastly, the research also determined the ethical aspects to be implemented in maintaining integrity of the research.

CHAPTER FIVE: QUANTITATIVE DATA PRESENTATION, ANALYSIS, AND INTERPRETATION

5.1. Introduction

Chapter three concluded with a detailed explanation of the research design and methodology for the study. This chapter focuses on the analysis and presentation of the data collected from the survey. It aims at collecting data which would inform the current state of 4IR technologies in the selected tertiary institution. The questionnaires were administered to the students, lecturers, and IT staff participants. The nature of the questionnaire for each sect was different to some extent. The questionnaire was sectioned into six parts, beginning with demographics moving to 4IR components and key activities; to 4IR key resources, capabilities, and funding; to 4IR challenges, benefits, and critical success factors; to 4IR role in quality management; and lastly 4IR perceptions, expectations, and awareness. All the target participants qualified in responding to all the sections of the questionnaire since the study was based on determining the views and perceptions of 4IR technologies regardless of their use. The findings are presented through tables and graphs for the purpose of identifying patterns and comparisons. This chapter also highlights the lessons learnt from the pilot study and informs the findings of the main study. The analysis begins with descriptive statistics including frequency, standard deviations, measures of central tendency and distribution ranges together with the univariate, bivariate and multivariate analysis. Thereafter, inferential analysis is performed to assess and predict the causal relationships between the variables. This includes conducting factor analysis, chis-square tests, t-tests, analysis of variance (ANOVA), regression analysis and structural equation modelling.

5.2. Data Collection Challenges

The researcher faced some inevitable challenges due to a lack of control over the participants. These challenges include some respondents being reluctant in participating despite assurance of the ethical procedures maintained throughout the study. Some respondents indicated a lack of interest in participation as no direct benefits were offered such as financial gains or rewards for their time. Some respondents highlighted that the survey could be time consuming for their busy schedules and refused to participate. A few respondents withdrew from the processes highlighting their lack of understanding and fear of providing misleading responses. The lecturer participants were not easily

available and took the longest period to complete the questionnaires. In terms of the IT staff, constant reminders had to be sent for them to complete the questionnaires. These resulted a delay in completing the data collection process. A small proportion of the respondents did not fully complete the questionnaires and a few questionnaires were not returned which affected the study's response rate.

5.3. Data preparation

This section focused on evaluating the data collected against the population of the study to determine the extent to which the sample data can be represented in the study population. This stage was completed by cleaning and screening data, detecting outliers, and checking for normality and linearity.

5.3.1. Data screening and cleaning

It was significant to ensure that the process of data analysis has not been influenced by inaccurate and missing data, as this could mislead the reporting of the findings obtained. Therefore, the questionnaire items were coded in numeric values using the SPSS v26 software which was later updated to v29. The items which did not have any responses were assigned a missing value code of "999" to filter out any inaccurate analysis. According to (Dong & Peng, 2013; Rahm & Do, 2000), it is significant to analyse the data files for inspecting any missing values. For this study, to detect any missing value, frequency tests for each variable were performed. Questionnaires with missing values of more than 4 responses were not considered for analysis. The "Exclude case pairwise" method was implemented, which excluded the consideration of that case only for the data of that specific question; the case was still considered for analysis for which responses were available. The questionnaires were separated in terms of students, academics, and IT staff to obtain a clear representation of 4IR perceptions and expectations from each sect. Table 5.1 illustrated missing data from three data sets of the study. The frequency analysis performed depicted that all responses were received from the IT staff sect, while the academic and students' respondents had some missing data.

Table 5.1: Missing numbers across the three data sets

Question missing	Number of missing responses	Questions missing	Number of responses	Questions missing	Number of responses	Questions missing	Number of responses
Students		students		students		Academics	
Q2	7	Q8.3	3	Q13.5	1	Q1.	1
Q3	2	Q8.4	3	Q15	1	Q3	3
Q4	5	Q8.6	2	Q16.3	2	Q6	1
Q5	10	Q8.7	2	Q18.4	2	Q7	2
Q6	6	Q10.7	1	Q18.11	1	Q17	1

5.3.2. Univariate, Bivariate and Multivariate Assumptions

There was significance in establishing interrelatedness of variables through bivariate and multivariate analysis as the extended Servqual model and TRAM Model contained additional variables proposed to achieve the goal of the study. Hence, to test assumptions of normality, linearity, multi-collinearity and homoscedasticity, the likert scale variables were transformed to continuous variables in the form of composite means.

5.3.2.1. Data outliers

Outliers are referred as those data points (patterns) which are distinct from other responses in the observed data as it is ideal to determine normal distribution of data (Bengal, 2005). Hence, data that does not conform to normal behaviour has to be dealt with accordingly by either accommodating them, removing them, or retaining them with justification. It was significant to conduct outlier analysis before moving to advanced statistical analysis to eliminate any errors, bias, inconsistencies, and negative consequence on the findings (Muthukrishnan & Poonkuzhali, 2017). It was also necessary to observe outliers to remove any misspecification in the research model. Outliers could be univariate, meaning a single dimension could outlay an extreme value (Tabachnick & Fidell, 2013). Data variables were transformed to composite mean variables for easy readability, hence a total of 65 variables were reduced to 24 variables. Univariate outliers were detected by checking the z-score frequencies (standard deviation statistic) (Mowbray et al., 2019). The value of acceptable z score must not exceed + 3.29 or must not be lower than -3.29.

Furthermore, the box plots were used as a visual illustrative to identify the possible outliers marked in either a circle or asterisks. The cases which observed circles in the box plot were cross-checked for any error in the data value. For any errors identified, data was recoded. However, if no error was identified, then the z- scores were observed both in ascending and descending order. The outcome of conducting z-score tests revealed that no score exceeded the absolute score of the standard value +3.29 or dropped below the standard value of -3.29. Table 5.2. depicted the outcome of standard deviations scores performed to identify univariate outliers which implied that no outliers existed since all cases fell in the acceptable range.

Outliers could also be multivariate, which contains extreme values when multiple dimensions are taken into consideration (Tabachnick, 2007). Multivariate outliers were

detected using the Mahalanobis distance (MD) test as it is ideal for measuring the distance among a data point and a distribution, which indicates how many standard deviations further is a data point from the mean of distribution (Ghorbani, 2019). According to (Leys et al., 2019), the MD test identifies those subjects who are outliers in multiple variables. Standardized residuals with values higher than 3.3 are identified as outliers. Once the MD test was calculated using the criterion of $\alpha = .001$ (significance level) with degree of freedom equal to 24 variables, the chi-square distribution table was consulted to interpret the values. The analysis revealed that any value above 51.18 is considered a critical value. Only 11 cases were found to have a value lower than $\alpha < .001$, where the critical p value ranged between 0.00006 – 0.00065 and MD ranged between 52.660237 – 60.13216, with a standardized residuals ranged between 2.99717 and - 1.36660. These cases were deleted when conducting advanced inferential analysis.

Table 5.2: Identification of UNIVARIATE outliers

Scale Items	N	Mean	Std. Dev.	Scale Items	N	Mean	Std Dev.	Scale Items	N	Mean	Std. Dev.
Opt	334	1,76	1,067	PUC	334	1,09	,933	EE	334	,98	,920
Inn	334	1,88	1,151	QPR	334	1,40	,756	PRL	334	,81	,779
Ins	334	1,82	1,221	QAR	334	1,43	,707	PE	334	,98	,790
Dis	334	1,86	1,257	QCR	334	1,50	,793	PRS	334	1,04	,847
SS	334	1,17	,879	ET	334	,82	,874	PAS	334	,83	,823
SZ	334	1,14	,924	ERL	334	,88	,806	PT	334	1,02	,955
TS	334	1,23	,986	ERS	334	,90	,843	AWS	334	1,34	,832
I	334	,89	,881	EAS	334	,83	,823	QI	334	,88	,802

5.3.3. Data Normality

The assumption of normality was tested to determine whether data has been symmetrically distributed before proceeding to inferential statistics such as Structural Equation Modelling (SEM). This test also assisted in deciding the suitability of parametric or non-parametric analysis to assure validity. A normal distribution suggests a bell-shaped curve (Frey, 2018; Sainani, 2012). It is highlighted by (Ghasemi & Zahediasl, 2012) that, parametric tests assume normal distribution, indicating that the population within which the sample was extracted from is normally distributed. Whilst non-parametric tests do not give much attention towards data distribution. It has been warned by (Rani Das & Rahmatullah, 2016) that, violated assumptions of normality may jeopardize the validity of the outcomes and produce inaccurate predictions. Both statistical and graphical methods were employed for testing normality assumption. This study looked at the descriptives of Skewness (symmetry) and Kurtosis (peakedness), box

plots (histograms), QQ plots, PP plots, the Shapiro-Wilk test (SW), and the Kolmogorov-Smirnov (KS) test (Orcan, 2020). However, according to (Mishra et al., 2019), the SW and KS tests (see Annexure I,) were unreliable since sample for this study was greater than 300 for student data. Also, academic data was known to have a non-normal distribution based on the SW and KS tests (Annexure I). For the IT staff data, some variables indicated a normal distribution whilst some indicated otherwise (Annexure I).

Table 5.3: Normality assessment for Student data

Scale Items	Skewness		Kurtosis		Scale Items	Skewness		Kurtosis		Scale Items	Skewness		Kurtosis	
	statistic	Std error	statistic	Std error		statistic	Std error	statistic	Std error		statistic	Std error	statistic	Std error
Opt	,178	,133	-,634	,266	PUC	,948	,133	,594	,266	EE	,955	,133	,608	,266
Inn	,076	,133	-,784	,266	QPR	,311	,133	-,219	,266	PRL	1,211	,133	1,721	,266
Ins	,154	,133	-,974	,266	QAR	,214	,133	-,213	,266	PE	,628	,133	,332	,266
Dis	,105	,133	-1,050	,266	QCR	,390	,133	-,127	,266	PRS	,788	,133	,726	,266
SS	1,029	,133	1,310	,266	ET	1,303	,133	1,813	,266	PAS	,988	,133	,667	,266
SZ	,953	,133	,953	,266	ERL	,942	,133	,988	,266	PT	,701	,133	-,134	,266
TS	,800	,133	,349	,266	ERS	,942	,133	,615	,266	AWS	,537	,133	,021	,266
I	1,485	,133	2,374	,266	EAS	,988	,133	,667	,266	QI	,871	133	,362	,266

N= 334

Nonetheless, Table 5.3 presented the outcomes of the normality tests performed based on the skewness and kurtosis for the student's sample. The absolute skew statistic values were within the threshold values of -2 and 2 respectively, indicating acceptable normality (Hair et al., 2010). Furthermore, the kurtosis statistics ranged in between the suggested critical values of -7 and 7, considering data to be normal. Accordingly, the Z score values of the skewness and kurtosis statistic for academic data ranged between the threshold values of -3.29 and +3.29 for most of the variables except for variable ET1; ET2; EAS1; EEM1 (see Annexure I) as the sample was between 50 and 300. Alternatively, the Z score values calculated as $\left(\frac{\text{Skewness statistic}}{\text{std. error}}\right)$, indicated a normal distribution of most of the variables with critical values ranging between -1.96 and 1.96 for IT staff data, except for variables O2; INN1; INS2; SS1; I1; I2; and PRL2 (see Annexure I) since the sample was less than 50. Furthermore, the histograms were consulted to conduct a visual inspection of the shape of the distribution (see Figure 5.1) which suggested adequate normality margins with positive skewness established in some variables. In terms of the Q-Q plots, Figure 5.1 indicated a straight line moving across most of the data confirming the normal distribution of data with large samples. For the distribution assumptions of academic data

and IT staff data were normal with only a few variables positively skewed and negatively skewed (Annexure I).

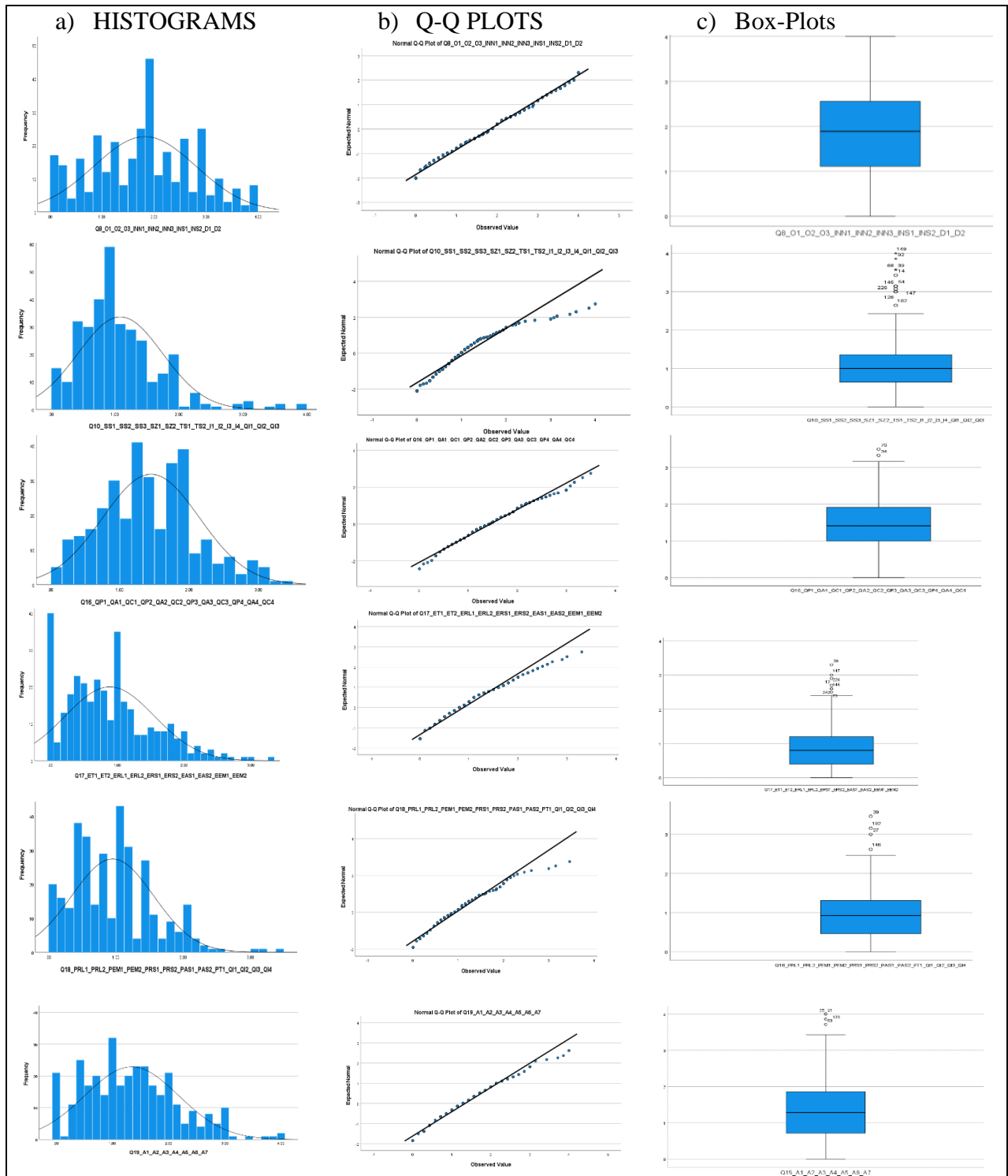


Figure 5.1: Visual representation of normality tests of variables in the student sample (Histogram, QQ Plots, Box Plots).

5.3.4. Linearity Assumptions

Bivariate linearity assumptions

The assumption of bivariate linearity was tested to determine if there were any linear or curvilinear relationships identified amongst dependent variable and independent variables (Ho, 2013; Moore & Notz, 2021). A matrix of scatterplots was used to visually assist in identifying non-linear relationships since the number of variables were extensive, which also affected the visibility (clearness) of the scatterplot shape (Mindrila & Phoebe, 2017). Therefore, a fit line was generated in SPSS for the scatter matrix. Annexure J presented the scatter plots depicting linearity assumptions (positive relationship) being met between various variable pairs of data.

Bivariate multicollinearity assumptions

Multicollinearity refers to the presence of a strong linear correlation (interdependence) between independent variables within a regression model making it a challenge to assess the influence each independent variable has on the dependent variable; hence the coefficients being estimated tends to be unpredictable (Ho, 2013). The bivariate multicollinearity assumptions were assessed using the Pearson's correlation test. This test ensured that the discriminant/divergent validity is not violated. Annexure J illustrated how predictor variables are associated with the outcome variables. The results showed positive relationships amongst the predictor variables at a significance level of $p < 0.01$, besides four relationships which showed significance at $p < 0.05$ (SS1 < -- > I3: $r = 0.114$, $p = 0.38$; SS2 < -- > I1: $r = 0.113$, $p = 0.40$; TS1 < -- > I3: $r = 0.129$, $p = 0.19$; TS2 < -- > I3: $r = 0.116$, $p = 0.034$). However, the correlation coefficients of the variables did not exceed 0.7 (Peat & Barton, 2014) for most of the variables which indicates no multicollinearity problems except for the relationship between I3 < -- > I4: $r = 0.741$, $p < 0.001$; QC1 < -- > QP2: $r = 0.711$, $p < 0.001$; T1 < -- > T2: $r = 0.781$, $p < 0.001$; ERS1 < -- > ERS2: $r = 0.703$, $p < 0.001$; A2 < -- > A3: $r = 0.747$, $p < 0.001$ (Annexure J). According to (Berry & Feldman, 1985; Cheung et al., 2023; Kim, 2019), the correlation becomes a problem if the r value exceeds 0.8. the Pearson's correlations in Annexure J indicated that the strongest correlation was among the variables I2 < -- > I3: $r = 0.693$, $p = 0.001$ with a coefficient of determination (r^2) of 0.480 indicating a shared variance of 48.0%.

Table 5.4: Pearson Correlation between the predictor variables and the outcome variable.

Correlations		Opt	Inn	Ins	Dis	SS	SZ	TS	I	PUC	QpR	QAR	QCR	ETang	ERL	ERS	EAS	IEE	PRL	PEE	PRS	PAS	PT	AWS	QI
QI	Pearson correlation	-,049	-,041	,017	-,041	0,1	,115*	,064	,215**	,325**	,091	,155**	,099	,357**	,448**	,463**	,472**	,447**	,355**	,292**	,397**	,472**	,528**	,210**	1
	Sig (2 tailed)	,377	,458	,752	,456	,067	,035	,247	,000	,000	,096	,005	,071	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	
	N	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334

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

* Correlation is Significant at the 0.05 level (2 - tailed)

In terms of the correlations between predictor variables (Composite means) with the dependent variables, a total of 15 out of 23 predictor variables had a significant association with the outcome variable at a significance level of $p < 0.01$ and $p < 0.05$ (Table 5.4). Multicollinearity assumptions were further discussed in regression analysis.

5.3.5. Assumptions of Multivariate Analysis

The most significant assumptions for consideration under multivariate analysis are normality, homoscedasticity, and linearity (Alexopoulos, 2010; Randolph & Myers, 2013; Timm Springer, 2002). These were measured using scatterplots, P-P plots, and regression standardised residuals for the outcome variable. The findings observed from the plots indicated multivariate assumptions being met. It is evident from Figure 5.2a in which the normality of the residuals was not violated as the standard residuals had a normal curve in the histogram. Furthermore, the P-P plots for the QI variable indicated that the variables were closely following the straight line, therefore, indicating linearity (see Figure 5.2b). Also, the scatter plot of the residuals in Figure 5.2c formed a rectangular shape with all the points falling within the critical values of -3 and 3, hence meeting the assumptions of homoscedasticity. See Annexure K for these tests on regression models for academic data also indicating a non-violation of the multivariate assumptions.

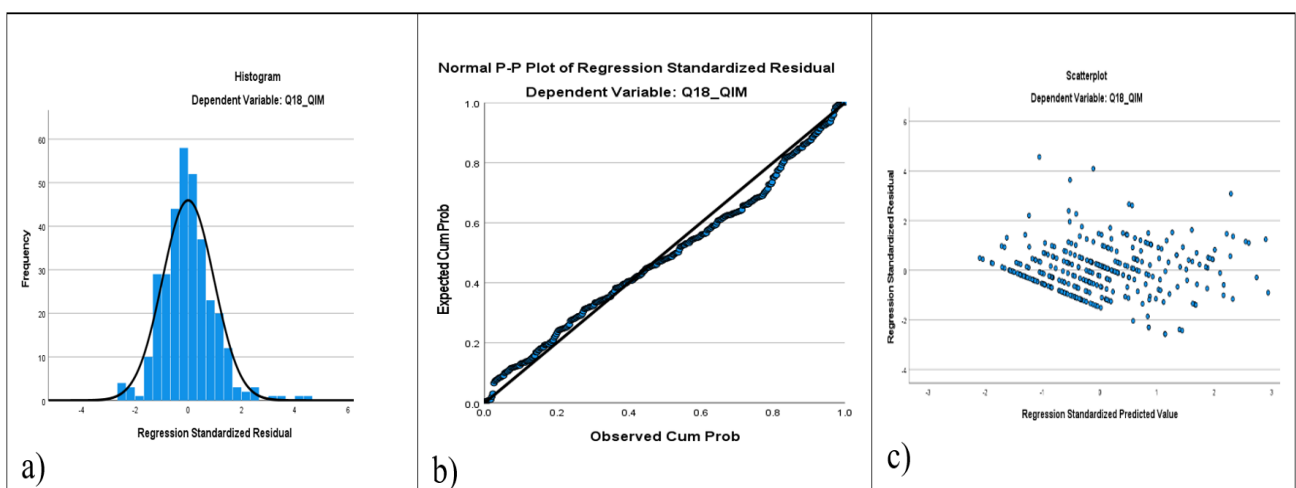


Figure 5.2: Normality, Linearity and Homoscedasticity Assumptions tested for multivariate analysis of the QIM model (student data).

terms of the QI regression model for IT staff data, a data reduction technique was used to eliminate the challenges associated with high dimensional data since the sample size of this group was only 17 (Holmes & Henandez, 2017). The data was therefore reduced

by transforming predictor variables into a smaller linear combination (see Annexure K). It was observed that the residuals were normally distributed (frequency vs regression standardised residuals) together with a straight-line curve maintaining linearity between variables. Accordingly, homoscedasticity was not violated as the scatter plot residuals fell between -2 and 2.

5.4. Quality of the scale instrument

It was significant to assess the validity of the content in the instrument before distributing the questionnaires. This step assisted in determining the degree to which the items of the content are adequately represented in the instrument. The researcher consulted the supervisors and experts in the field to determine the accuracy of the questions in measuring the study content, particularly in obtaining the research objectives. At this stage, face validity and item validity were evaluated by reviewing the suitability of each question drafted in the questionnaires as the scale items were borrowed from other studies in literature. It was suggested that a series of questions be grouped in each section particularly directed at answering a specific objective. Some of the questions were rephrased to increase the respondent's ability to understand the questions. Some questionnaire items which appeared to be repetitive were removed. Some of the errors were concerning incorrect spellings and omission of words. Modifications were accommodated prior conducting the pilot study.

5.5. Pilot study findings

To test the research instrument of the study, a small study was conducted with 35 participants. The aim of the pilot study was to determine the level of understanding and clarity gained by the respondents prior to the actual administration of the survey. The pilot study also assisted in determining if the design and methodology selected was suitable to be used on a large scale in addressing the suitability of 4IR technologies for service quality improvement. It was realised that the best approach for distributing the questionnaires to students was face-to-face distribution than online, telephonic, or emailed surveys. This was because the participants indicated having connectivity challenges due to power outages. Some participants did not have smartphones or devices which could enable them to access the survey electronically. In terms of academic participants, it was realised that some preferred to have the questionnaires electronically but indicated that the survey would retain a higher response rate in a non-

electronic format. The language, format, and grammatical errors in the questionnaires were identified and fixed. It was also verified that the respondents understood the terminologies used in the questionnaires by asking them if there were any confusing words. Positive feedback regarding the order of the questionnaire items was received. However, for multiple-choice questions, the researcher had overlooked including the option of “None” which had to be added.

Initially, the participants were given 15 minutes to complete the survey, however, it was realised that the respondents needed more time to understand and complete the survey. Hence, the time was increased to 25 minutes and additional time was provided for those who requested. It should be noted that the data collected from the pilot study was not included in the main findings nor the questionnaires were distributed to the same participants. A total of 35 questionnaires were distributed amongst the sample, of which 27 were returned, giving a response rate of 77%. The responses constituted of 74% students, 19% of academics and only 7% of IT staff. It was learned from Table 5.5 that, the female participants surpassed the male respondents by 4%. A highly represented age group of 15-25 had a contribution of 67% with majority of race group being African/Black (96%). Most of the participants were familiar with the presence of 4IR but were not engaged in any 4IR projects associated with 4IR. Moreover, the reliability of the scale for all the items was above 0.7% in terms of the Cronbach’s alpha.

Table 5.5: Demographic and background information (Pilot study)

Characteristic		Students		Academics		IT staff		Total	
		F	P	F	P	F	P	F	P
Gender	Male	10	50%	2	40%	1	50%	13	48%
	Female	10	50%	3	60%	1	50%	14	52%
Age	15-25	17	85%	-	-	1	50%	18	67%
	26-35	2	10%	1	20%	-	-	3	11%
	36 to 45	-	-	3	60%	1	50%	4	15%
	46 and above	-	-	1	20%	-	-	1	4%
Race	African/Black	19	95%	5	100%	2	100%	26	96%
	Indian/Asian	1	5%	-	-	-	-	1	4%
Heard of 4IR	Yes	15	75%	3	60%	2	100%	20	74%
	No	4	20%	2	40%	-	-	6	22%
4IR project Awareness	Yes	5	25%	1	20%	1	50%	7	4%
	No	15	75%	4	80%	1	50%	20	74%

5.6. Main study Findings

Once the matters identified from the pilot study were rectified, the questionnaires were administered to a total of 457 participants including 377 students, 60 academics and 20

IT staff to gather data on different aspects of 4IR and quality improvement through 4IR as reported in the proceeding sections of this chapter. It is reminded that the questionnaires were divided into 6 subsections and therefore data is presented accordingly.

5.6.1. Response rate

Of the 457 questionnaires distributed, 402 usable questionnaires were received of which 83% (334) constituted students, 13% (51) academics and 4% (17) IT staff. This indicates that the research obtained a response rate of 88% which is considered adequate for conducting analysis in many literature studies as it sufficiently represents the population (Draugalis et al., 2008; Fincham, 2008). Amongst the entire sample, 27 student respondents, 33 academics and 6 IT staff refused to participate which had to be replaced. A 12% deficiency in response rate was due to incomplete discarded questionnaires and a few unreturned questionnaires. The response rate was more than the response rate established in the pilot study indicating that the participants were interested in participating the research.

5.6.2. Demographic profile and background information

The demographic characteristics were built up of gender, age, race, study level, work experience, and profession. Additionally, background information on participant's 4IR familiarity, Quality 4.0 familiarity and 4IR project(s) engagement was obtained. These characteristics significantly influences the findings as it assists in determining the variances in participants responses concerning the influence of 4IR on quality improvement. The findings presented in Table 5.6 showed that in terms of gender, more females (64.3%) represented the population than males (35.7%) among the students and academic participants. The proportion of student enrolments in HEIs nationwide were predominated by 61.4% of females with only 38.6% males (Department of Higher Education and Training, 2023).

According to the target institution's enrolment statistics as of 2022, more female students were enrolled than males. This also indicates that more females are granted the opportunity to acquire their tertiary education than males. This could be due to their historical status of previously disadvantaged background in education. However, the IT staff respondents were significantly male dominating. This is because the IT department entailed more male (76.5%) employees than females (23.5%). Table 5.6 also indicated

that more than 87% of participants were aged between 15-35 years. Findings revealed that the most represented age group was of 15-25 years (77.9%). The age of range of 46 and above was only represented by the Academics and IT staff only contributing to 5.8% combined. This implies that most of the students were young and aged below 46. It could also be deduced that majority of the participants were tech savvy and might be familiar with 4IR.

Table 5.6: Participants demographic and Background information

Demographics & Background	Category	Students		Academics		IT staff		Total	
		F	%	F	%	F	%	F	%
Gender	Male	109	32.6%	21	41.2%	13	76.5%	143	35.7%
	Female	225	67.4%	29	56.9%	4	23.5%	258	64.3%
Age	15-25	303	90.7%	1	2%	4	23.5%	308	77.9%
	26-35	23	6.9%	11	21.6%	5	29.4%	39	9.9%
	36-45	1	0.3%	18	35.3%	6	35.3%	25	6.3%
	46 & above	--	--	21	41.2%	2	11.8%	23	5.8%
Race	African/Black	317	94.9%	47	92.2%	17	100%	381	95.9%
	Coloured	6	1.8%	--	--	--	--	6	1.5%
	Asian/Indian	9	2.7%	--	--	--	--	9	2.3%
	White	--	--	1	2%	--	--	1	0.3%
Study Level	1 st Year	209	62.6%	Not applicable		Not Applicable		209	63.5%
	2 nd Year	41	12.3%					41	12.5%
	3 rd Year	60	18%					60	18.2%
	4 th Year	13	3.9%					13	4.0%
	Honours	6	1.8%					6	1.8%
Work experience	< 1 Year	Not applicable		--	--	8	47.1%	8	11.9%
	1 – 5 Years			10	19.6%	1	5.9%	11	16.4%
	6 – 10 Years			10	19.6%	1	5.9%	11	16.4%
	> 10 Years			30	58.8%	7	41.2%	37	55.2%
Heard of 4IR	Yes	226	67.7%	40	78.4%	17	100%	283	72.2%
	No	98	29.3%	11	21.6%	--	--	109	27.8%
4IR project Engagement	Yes	77	23.1%	15	29.4%	15	88.2%	107	27%
	No	251	75.1%	36	70.6%	2	11.8%	289	73%
Heard of quality 4.0	Yes	97	29%	9	17.6%	11	64.7%	117	29.2%
	No	236	70.7	41	80.4%	6	35.3%	283	70.8%
Drafted 4IR implementation policies	Yes	Not Applicable				10	58.8%	10	58.8%
	No					7	41.2%	7	41.2%
Familiar with national 4IR regulations & legal compliances	Yes					13	76.5%	13	76.5%
	No					4	23.5%	4	23.5%
Incorporated 4IR frameworks to govern 4IR technology use	Yes					12	70.6%	12	70.6%
	No					5	29.4%	5	29.4%

As shown in Table 5.6, the distribution of Race/Ethnicity indicated that majority of the respondents were African/Blacks (95.9%). The remaining race classification contributed a total of 4.1% with 2.3% Asian/Indian, 1.5% coloured and 0.3 % white. This is a result of the population entailing more African/Blacks than other racial groups. According to

(Statista, 2023), of the 1.03 million students enrolled for higher education as of 2021, 76.4% entailed Black Africans. The questionnaire also collected data on participants study level/status from students. The findings depicted that more than 60% of students were on entry level followed 18.2 % at third year level, and 12.5% at second year level. The least represented group was at honours level (1.8%). This is because the enrolment statistics of postgraduates are relatively lower (17,9%) than undergraduates (88.1%) (Department of Higher Education and Training, 2023).

Furthermore, out of 402 participants, 283 (72.2%) indicated to have heard of 4IR which implies that the students and staff are equipped to be 4IR ready as it positively influences their preparedness towards the 4IR era. This finding resonates with another study conducted by (Cele et al., 2023) revealing that 74.4% of students at the researched institution knew what 4IR is. In comparison, 27.8% have not heard of 4IR. This could be due to a presence of digital divide, poor socioeconomic background, and lack of technological infrastructure. Similarly, to determine the role of 4IR in quality improvement, the participants were also requested to indicate if they were familiar with the term Quality 4.0. It was revealed that an aggregate of only 29.2% had heard of Quality 4.0. compared to the 70.8% who were unfamiliar. This could be due to stakeholders at the institution not being habitual of digital service quality management processes and a lack of Quality 4.0 culture (Lodi et al., 2022).

Additionally, in terms of identifying any 4IR trends at the institution, the respondents were asked to indicate if they were aware of any 4IR projects withing their institution. The responses determined a 73% of no involvement in any 4IR-based projects. This included 75.1% of students and 70.6% of academics implying that the institution might not have initiated any 4IR-projects requiring participation from students and academics. However, 88.2% of IT staff were associated with certain 4IR projects. This is justifiable as 4IR is a significant field of IT. In comparison, only 27% of students and academics combined have engaged with 4IR-technologies. This could be due to an absence of capacity in skills, investments and infrastructure required in preparing students and academics towards participating in 4IR (Kayembe & Nel, 2019).

The academics indicated their teaching positions (Figure 5.3) ranging from professors (11.8%), senior lecturers (19.6% (60.8%), lecturers (60.8%), junior lecturers (5.9%), and teaching assistants (2%). About 58.8% of academics had more than 10 years of teaching

experience, whilst 39.2% had between 1-10 years of experience. Academics have witnessed numerous transitions in terms of technological advancements in their academic journey. This implies that academics have been compelled to shift their teaching methodologies to accommodate recent technological trends to which 4IR is no different. One such case was during the covid-19 pandemic (Cronje, 2021; Marivate et al., 2021). It is worth noting that that the highest represented faculty was Management, Commerce and Law with 49% of respondents (Figure 5.4). This is because more academics from this faculty agreed to participate compared to the rest. Lastly, the IT staff positions as outlined in Table 5.7 indicated a wide range of representatives formulating the IT department. Out the 17 members who agreed to participate, 41.2% had more than 10 years of work experience. The IT department must play a significant role in policymaking and assisting both students and academics in familiarising with 4IR technologies by means of organising trainings and awareness campaigns.

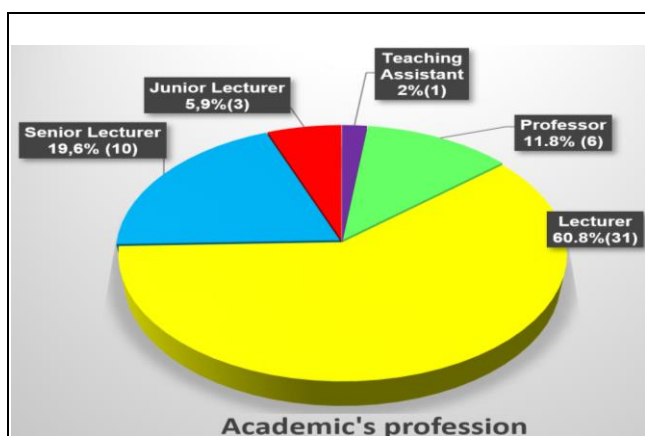


Figure 5.3: Distribution of academic positions.

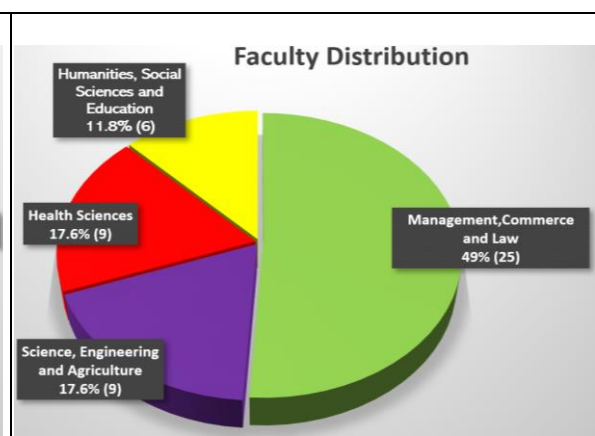


Figure 5.4: Academics faculty distribution.

Table 5.7: Distribution of IT positions

Layout of IT Department Positions					
Position	F	%	Position	F	%
Audio Visual Technician	1	5.9%	Senior Network Engineer	1	5.9%
Business Analyst	1	5.9%	Senior Server Engineer	1	5.9%
Head: ICT Support Services	1	5.9%	Student Assistant	1	5.9%
Help Desk support officer	1	5.9%	Student Assistant	3	17.6%
IT Intern	3	17.6%	Student technician	1	5.9%
IT Lab Technician	1	5.9%	System Analyst	1	5.9%
IT Specialist	1	5.9%	Technician	1	5.9%
TOTAL: 17 (100%)					

5.6.3. 4IR components and key readiness activities (4IR Readiness Levels)

To obtain an understanding of the institution's 4IR readiness behaviour, the respondents were expected to indicate which 4IR technologies they had previously heard of. A total of

3749 responses were received from 402 respondents concerning the eleven 4IR technologies as depicted in Table 5.8. Awareness of various 4IR technologies may have an influence on its usage and ultimately result in its adoption. The highest level of familiarity was found to have been associated with augmented reality containing a large total of 96.1% of case responses. This implies that majority of respondents have heard of augmented reality and could be willing to adopt given the necessary support and facilities. Followed by augmented reality, 375 (189 students, 19 academics and 2 IT staff) respondents indicated to have heard of blockchain technology. This could be due a rise in demand of and awareness pertaining crypto transactions among the youth.

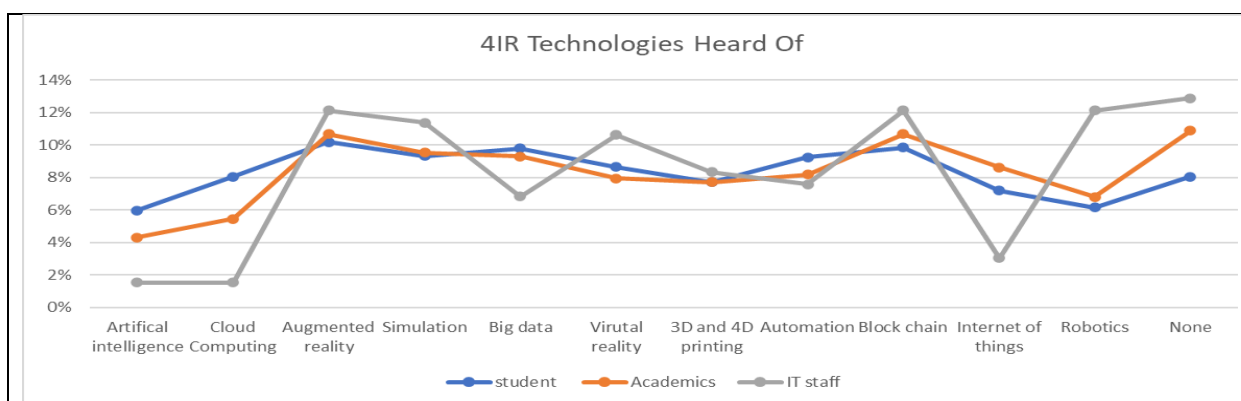


Figure 5.5: 4IR technologies heard of: a comparison.

Table 5.8: 4IR technologies heard of

4IR TECHNOLOGIES											
	F	%	% of cases		F	%	% of cases		F	%	% of cases
Artificial intelligence	210	5.6%	52.2%	Big data	361	9.6%	89.8%	Block chain	375	10.0%	93.3%
Cloud Computing	281	7.5%	69.9%	Virtual reality	323	9.3%	80.3%	Internet of things	270	7.2%	67.2%
Augmented reality	386	10.3%	96.0%	3D and 4D printing	290	7.7%	72.1%	Robotics	241	6.4%	59.9%
Simulation	353	9.4%	87.8%	Automation	339	9.0%	84.3%	None	320	8.5%	79.6%
TOTAL: 3749 (100%); 932.5% of cases											

On the contrary, artificial intelligence (5.6%) and robotics (6.4%) were the least recognised 4IR components. This could be due to the participants being less known to or familiar with the essence of artificial intelligence and robotics. Additionally, virtual reality which received upmost recognition during the covid19 pandemic, was moderately familiar by respondents with 80.3% of cases. Lastly, Figure 5.5 demonstrated that at least 8.5% of respondents were not aware of any 4IR technologies, falling in the 25-45 age group. This implies that a few participants may not have any access or knowledge of 4IR which could in turn affect their preference and usage of it.

To ascertain the influence of 4IR on service quality improvement, it was significant to establish the extent to which the tertiary institution was believed to be ready for the 4IR environment. The readiness extent was measured based on a series of activities or processes initiated to provide attention towards the 4IR using a Likert-scale of 1-5 with nine items ranging from Great Extent to No Extent. The results as illustrated in Figure 5.6 reads the graph from the top showing great extent of readiness. Therefore, the highest extent of readiness believe was associated with the tertiary institution having programs to quickly adapt to the culture of change required by the 4IR (21.4%), followed by having strategies in place for embracing 4IR initiatives (19.7%). The highest extent of belief towards 4IR unpreparedness was linked to the tertiary institution not having effective processes for 4IR-based service management (19.4%). Conversely, majority (28.4%) of participants remained neutral towards the institution having established any partnerships with the government, industries, and other tertiary institutions in promoting 4IR projects.

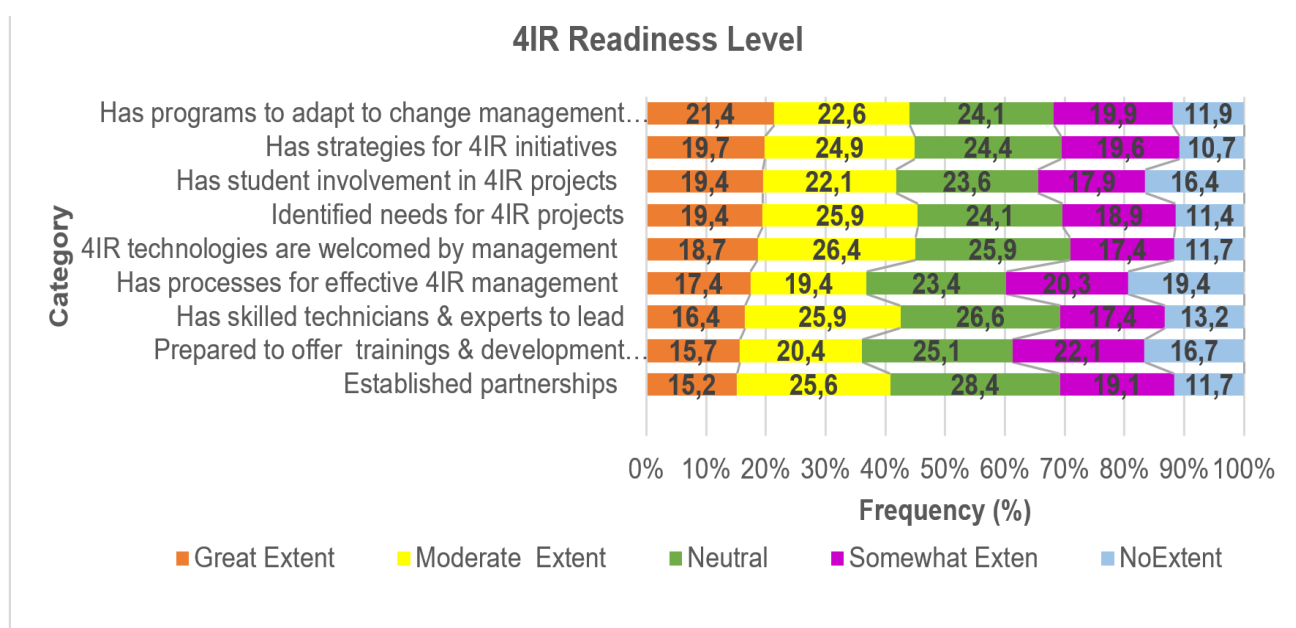


Figure 5.6: Readiness level of 4IR activities.

5.6.4. 4IR key resources, capabilities, and funding

In order to determine the applicability of 4IR within tertiary institutions service quality improvement programs, it was worthy to discover the resources required according to the respondents for the effective use of 4IR from a selection of options provided. With 1921 response cases, the findings from Figure 5.7 showed that the participants indicated 4IR support clubs (students:74.5% of cases), 4IR labs (academics:66.7% of cases), and ICT support (lecturers:35.3% of cases) as the most required resources respectively. This

implies that the significance for tertiary institutions in establishing labs dedicated towards 4IR learning and student clubs for establishing 4IR initiatives/projects is highly in demand. Furthermore, mentor support was required by more than 50% of case responses. This could be due to an absence of trained personnel available to guide members of the institution towards 4IR adoption. While smart computers (39% of cases) and highspeed internet were the least of the required resources implying that the respondents may have access to smart computers and high bandwidth connectivity provided by their tertiary institutions. Consequently, additional resources for the IT staff required advanced technology infrastructure and datacentres (17.6% of cases each) to obtain an effective 4IR technology use (not included in Figure 5.7).



Figure 5.7: 4IR Resources Required

The respondent's beliefs were sought in order to determine the extent of the selected tertiary institution's capabilities in initiating a range of 4IR activities required for promoting quality improvement. By simply identifying capabilities, each faculty at the tertiary institution can make significant contributions towards adequate service delivery. The participants were tasked to rate their level of agreement on a scale of 1 to 5 with five variables (sensing, seizing, transferring, investment, perceived usefulness) containing a total of eighteen items. The outcome as illustrated in Figure 5.8 showcased that the strongest level of agreement (58.8%) was towards the institutions capability in monitoring the effectiveness of service quality through 4IR.

It is assumed that the participants believe tertiary institutions could be able to adequately observe service delivery outcomes through 4IR use. Thereafter, an aggregate of 47.1% and 23.5% of participants strongly agreed and agreed that the tertiary institutions have

the capability of taking risks towards establishing 4IR-based project revenue streams. This implies that the respondent's believes that the institution is strongly able to sustain itself through 4IR making them more financially feasible. Majority of the respondents (47% and 33.6%) were also of the opinion that their institution has the capability to secure fundings for various 4IR initiatives. This could be due to the availability of multiple funding options and opportunities provided to public tertiary institutions by the government and external partners.

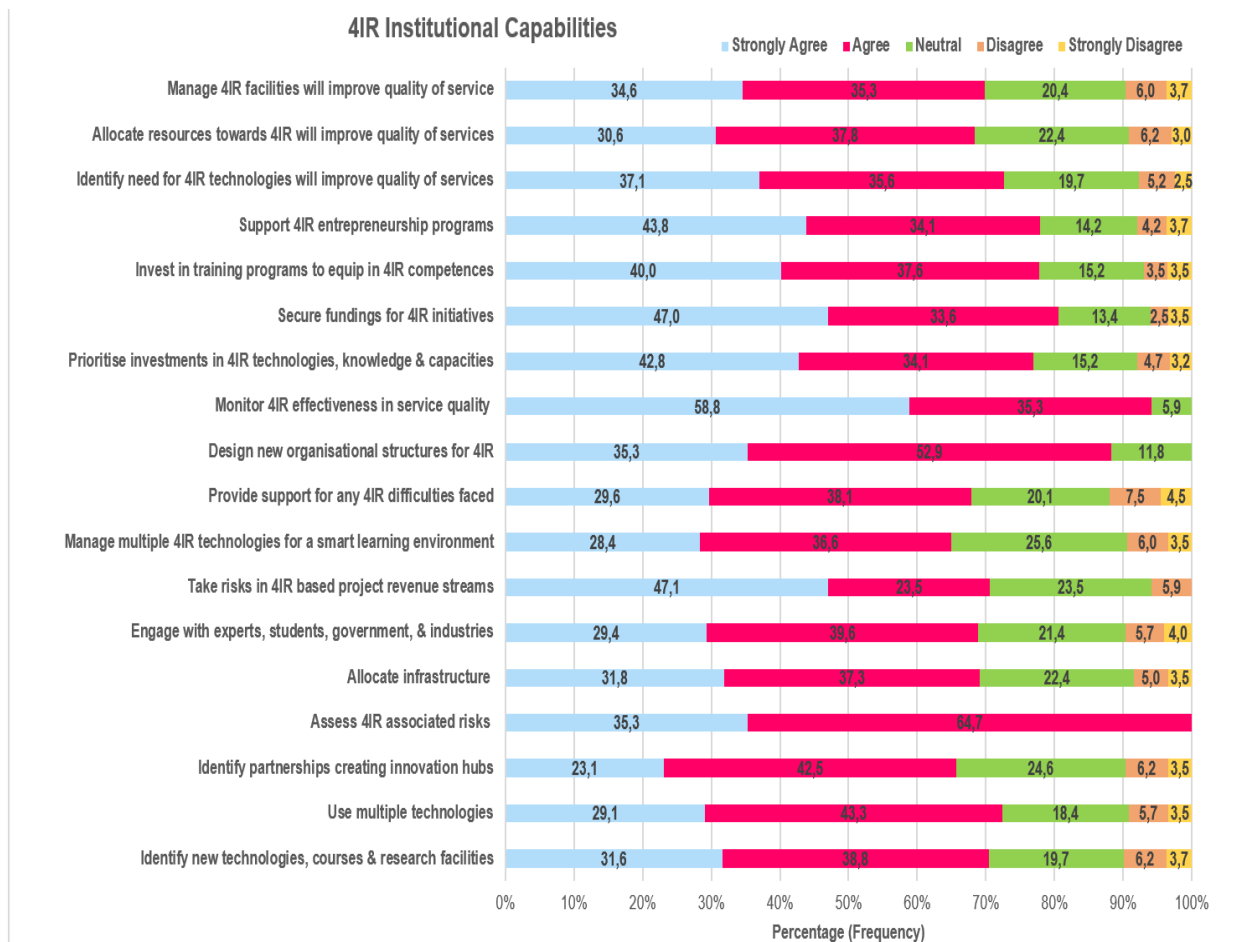


Figure 5.8: 4IR institutional capabilities.

However, an aggregate of 12% of respondents disagreed in terms of the institutional ability of providing support for any 4IR difficulties faced. This could mean that a small proportion of participants have a strong doubt concerning support facilities offered by the institutions. On the other hand, participants remained largely neutral regarding the institutional capability in managing multiple 4IR technologies for creating a smart learning environment. This indicates that the respondents could be unsure of the institutions ability in fitting multiple technologies supporting a university 4.0 structure. Overall, it can be

deduced that majority of the respondents agreed with the statements and believed their institution has adequate capabilities of initiating successful 4IR engagements.

In order to eliminate room for technical inabilities in implementing 4IR projects, the IT staff were requested to highlight from a multiple series of options certain service quality capabilities needing improvement and additional support (Figure 5.9). 34% of the respondents specified none of the existing service quality capabilities required improvements while 16% of respondents reported for an improvement in creation of 4IR service-oriented culture. This could be due a lack in 4IR-based service delivery methods being established. It is assumed that very little is done to incorporate service provision through 4IR technologies, yet IT personnel showing interest in the latter. However, the capability for assessing 4IR user needs (12%) and 4IR-based service monitoring (12%) could become more advanced to suit recent trends. Therefore, the findings suggest that IT personnel are willing to accommodate changes required by the introduction of 4IR.



Figure 5.9: Service quality capabilities requiring improvements.

5.6.5. 4IR challenges, Benefits, and Critical Success Factors

To successfully implement 4IR technologies, an organisation must recognise the benefits it will obtain and resolve any issues that could hinder its success. To achieve this information, participants were requested to emphasise on the possible benefits and challenges of 4IR based on their knowledge and experiences. It was also necessary to determine what could drive the institution in embracing 4IR and factors contributing towards its successful initiation. The results are presented in the subsequent sections.

5.6.5.1. Benefits

This multiple-choice response received an aggregate of 1976 responses of the 24 options from the three groups of respondents. The findings presented in Table 5.9 revealed that gaining hands on experience-based learning (12.8%) and personalized teaching experience (13%) were highlighted as major educational benefits of 4IR whilst improved user experience (13.3%) was represented as a major technical benefit. The findings portrayed the significance of experience-based service delivery as valuable in this digital era. This may also imply that the participants have an urge of seeking individual attention in their respective fields for boosting their teaching, learning and user-service experiences. In addition, a greater percentage of 11.6% showed that 4IR provides a creation of repetitive learning experiences for improved performance and 12.6% believes in receiving real-time feedback through 4IR. This could be due to the automated nature of 4IR systems in generating instant feedback, hence resolving communication barriers among students, academics, and support staff. Lastly, fairly 90 (5.3%) responses owed towards improved access to resources with 19 (7.3%) responses showing improved teaching efficiency and 3 (10%) responses of increased agility as a benefit.

Table 5.9: 4IR benefits in Tertiary Institutions

Educational benefits			Technical benefits					
students	N	%	Academics	N	%	IT Staff	N	%
Personalized learning experience	166	9.9	Personalized teaching experience	34	13.0	Improve decision making	1	3.3
Improved research opportunity	93	5.5	Improved research facilities	22	8.4	Increase agility	3	10.0
Improved access to education & resources	90	5.3	Improved access to educational resources	28	10.7	Improve user experiences	4	13.3
Become career ready for future jobs	112	6.6	Easy to collaborate & network	28	10.7	Improve security management	2	6.7
Flexible and remote learning	157	9.3	Enhanced student engagement	25	9.6	Improve communication	2	6.7
Hands on experience-based learning	216	12.8	Remote learning availability	22	8.4	Improve productivity	1	3.3
Better communication with lecturers	150	8.9	Improved teaching efficiency	19	7.3	None	17	56.7
Improvised student services	180	10.7	Real-time feedback	33	12.6			
Creation of repetitive learning experiences for improved performance	195	11.6	None	50	19.2			
None	326	19.3						
TOTAL	1685	100	TOTAL	261	100	TOTAL	30	100

5.6.5.2. Challenges

Encountering challenges may have a negative influence towards 4IR technology use and could hinder its applicability in service quality improvement. The response cases revealed that an aggregate of 13% (13.5% of students, 10.1% of academics) participants believed lack of trust in technology contributes as a major challenge of using 4IR, followed by inability to adapt new technologies (12.1%). It can be seen from the results that respondents are finding it difficult in trusting the capabilities of the new technologies, while a high amount of unacceptance could be owing to the participants lack in experiences towards adapting advanced technologies due to an absence of a 4IR-based cultural environment. Included among the technical challenges are data privacy/security risks (58.8%) and technical complexities (47.1%). This implies that IT experts believed advanced technologies comes along with increased risks of harmful activities and difficulties which could slow down embracing 4IR systems. Consequently, it emerged that majority of the participants (14.7%) indicated to be not affected by any of the challenges when using 4IR technologies as depicted in Table 5.10.

Table 5.10: 4IR challenges in Tertiary institutions

students/Academics	N	%	% of cases	IT Staff	N	%	% of Cases
It can be costly	165	6,4	42,9	expensive to maintain	4	7.8	23.5
No training and support	177	6,9	46,0	technical complexities	8	15.7	47.1
No ability to adapt new technology	310	12,1	80,5	data privacy/security risks	10	19.6	58.8
Fear of change towards current learning	270	10,5	70,1	difficult to integrate	6	11.8	35.3
technical difficulties	31	1,2	8,1	Need highly skilled staff	2	3.9	11.8
No infrastructure and devices	211	8,2	54,8	resistance to change	4	7.8	23.5
Lack of trust in technology	333	13,0	86,5	None	17	33.3	100
No skills & knowledge to use new technology	263	10,3	68,3				
No internet connectivity	181	7,1	47,0				
Data Privacy and security concerns	255	9,9	66,2				
None	368	14,4	95,6				
TOTAL	2564	100	666%	TOTAL	51	100	300%

5.6.5.3. Drivers

Based on the respondent's knowledge and views, the drivers of 4IR assisted in highlighting those significant factors which could highly motivate tertiary institutions in supporting the use of 4IR for the delivery of educational, academic, and IT services. The outcome as shown in Figure 5.10 revealed that 51.2% of case responses contributed towards the use of 4IR to support future sustainability. This implies that respondents believe with 4IR, service delivery could improve and be available as and when needed. This also implies that universities could generate an extra stream of income by

commercializing 4IR projects which can be aligned with strategic objective 7 of the institution. Furthermore, driving innovation (194,13.7%) and gaining competitive advantage (157,11.1%) were followed as fairly significant drivers. This finding suggests that respondents may want their institution to introduce a smart campus environment with innovative teaching and learning and other improved service delivery methods which may attract more members to associate.

Consequently, the respondents believed compliance with regulations (0.4% & 1.5% of cases) and attraction of funding opportunities (1.8% & 6.5% of cases) could make the least contribution in driving 4IR support. This could be as a result of 4IR technology adoption being a matter of choice and not an obligation by tertiary institutions regulations. Also, an absence of proper 4IR regulatory frameworks could demotivate 4IR use restricting its contribution in service quality improvement. In terms funding opportunities, the respondents may believe tertiary institutions may not need to attract additional funding due to the availability of many existing grants, donations, and support from government and third parties.

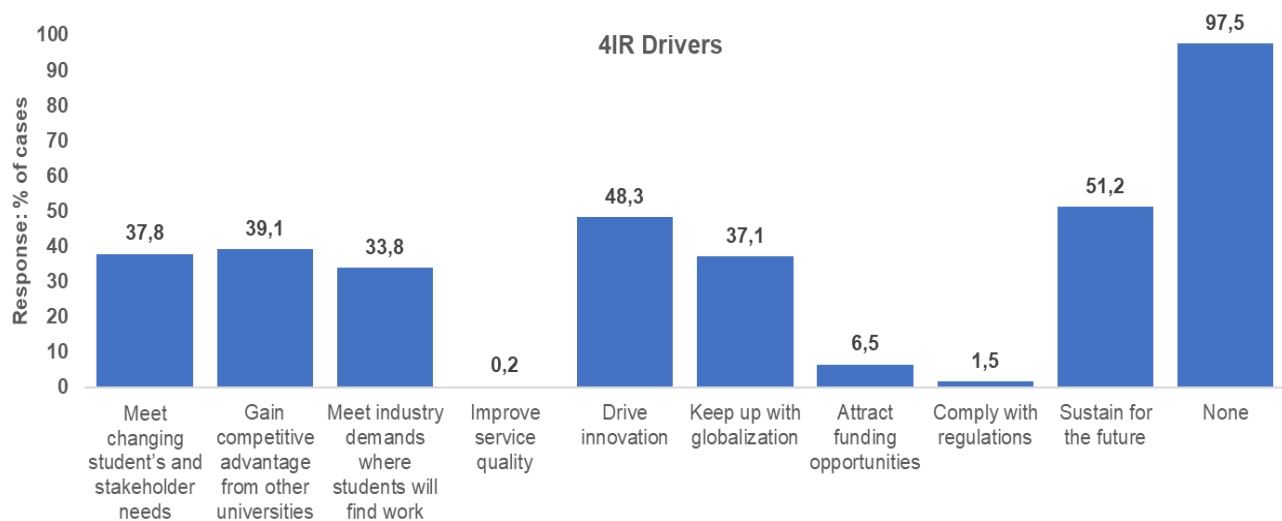


Figure 5.10: Drivers motivating the support of 4IR use in tertiary institutions.

5.6.5.4. Critical success factors

The critical success factors assisted in establishing the need for tertiary institutions in utilising 4IR for service quality support. Given a wide range of critical success factors to choose from, 1322 responses were received of which 395 responses combined largely held an opinion that none of the factors were significantly required by their institution for implementing 4IR. It could be directed that for these respondents, no existing changes were required in the current service quality structure of the institution. Nevertheless,

Figure 5.11 demonstrated that 45% of case responses thought their institution will be able to implement 4IR if partnerships were established with the industries. It can be deduced from this finding that each category of respondents was willing to put efforts in acquiring linkages with industries and establish networks for guiding as many members of the institution as possible towards 4IR. Adding to that, support from leaders (experts) in the field was advocated by 42.3% of responses. It could be assumed that in the absence of support from key role players, respondents may be strained without any supervision. At least 7.2% realised the need for policy frameworks encouraging for the adoption of 4IR systems and related technologies. The participants may have felt the frameworks may provide some assurance in terms of 4IR governance in institution. The skilled staff and experts with funding and resources factors were each represented lower than 35% of the responses.

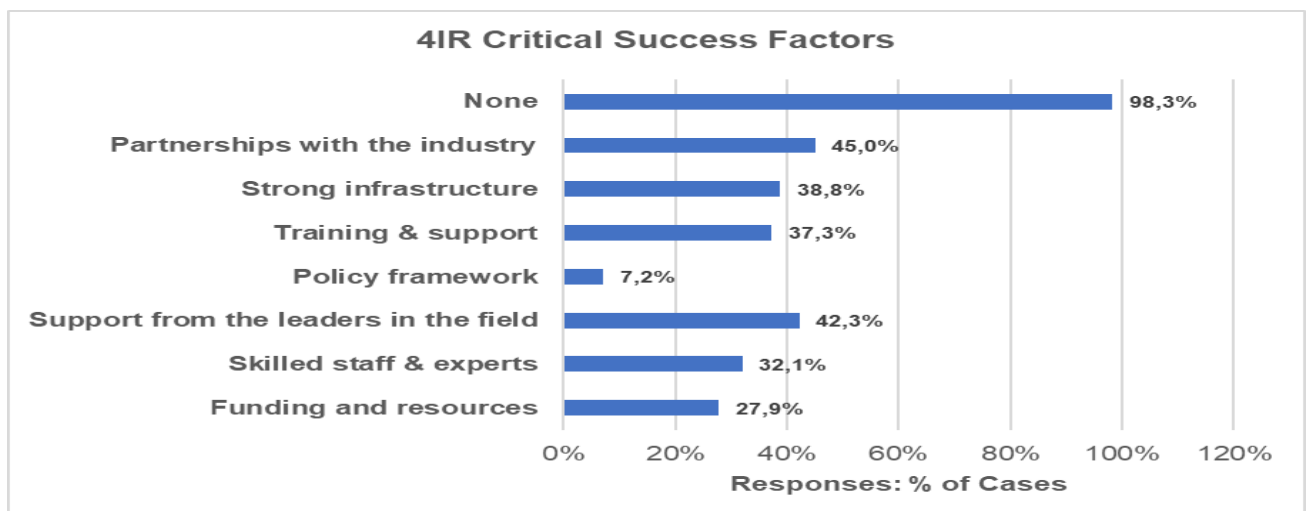


Figure 5.11: Critical success factors for implementing 4IR in tertiary institutions.

5.6.6. 4IR Role in Quality Management, Perceptions, and Expectations

It was significant to establish the role 4IR plays in the context of a tertiary institution's service quality improvement process. The participants view on these were expressed on a scale of 1-5 ranging from strongly agree to strongly disagree as illustrated in Table 5.11. This section also covered the respondents' expectations and perceptions of 4IR towards quality improvement.

4IR role in quality management

The role of 4IR in quality management was established based on three factors namely quality planning, quality assurance and quality control. The study found that 25.4% (102) of respondents strongly believed 4IR could play a significant role in promoting sustainable

technologies for creating an optimistic quality enhanced environment. This implies that participants believe the adoption of eco-friendly and energy-efficient green technologies may positively influence service delivery in their immediate environment. Next, a greater percentage of 57.9% respondents believed with 4IR, the standards of online services would remain as valuable as physical services while only 1.5% strongly disagreed. This perception might have been influenced based on the covid-19 pandemic driven shift towards online services being excellently managed. Of the 57.9%, 56.9% were students, 57.4% were academics, 70.6% were IT personnel. Additionally, with 4IR based quality-controlled measures, 59.7% believe corrective actions could be taken via online feedback; 52.7% believe service expectations could be met via stakeholders' online presence evaluations; while 52.5% believe service performance could improve via a quick adoption of on-demand technologies. It can be assumed that participants might be comfortable in experiencing digital transformation initiatives in multiple aspects of education including quality management and service improvement. Overall, it can be deduced that 4IR-based quality measures may increase the value of tertiary institutions.

4IR Expectations

This sub-section served to determine the respondent's expectations from their institution concerning 4IR technologies. The expectations were measured based on five factors namely tangibility, reliability, responsiveness, assurance, and empathy as shown in Table 5.11. The researcher wanted to determine which 4IR facilities were majorly expected by respondents from their institution in hope of elevating quality. The consolidated percentage of respondent's agreement scores contributed 81.7% towards modern technology equipment (count:338) and modern facilities (count:319) such as university 4.0 platforms. This means a large number of participants expects tangible services with 4IR support. It is assumed that the participants may expect the presence of smart buildings, smart classrooms, smart offices, and smart parking systems within their campuses. Approximately 40.3% have an expectation of 24/7 availability of 4IR technologies with 42.3% strongly expecting helpful support staff to assist with user difficulties. This means that respondents expect their institution to offer real-time support and timeliness assistance also catering for emergencies, hence increasing the reliability of 4IR technologies.

It assumed that with reliable 4IR based service delivery, user experiences could be upgraded. Furthermore, 38.1% strongly agreed for tertiary institutions to be more flexible

in keeping up with the changing needs and demands of 4IR while 42.5% strongly agreed for institutions in providing feedback and guidance to enquiries concerning 4IR use. Consequently, 5.2% and 5.7% disagreed whilst 16.2% and 14.9% remained neutral respectively. This implies that the participants may highly expect tertiary institutions to regularly review and update their terms of service quality in order to remain responsive towards emerging trends.

Only an aggregate of 3.5% did not expect their institution to employ skilled staff to assist with 4IR operations whereas 5.7% did not expect for any policies to be drafted guiding the safety measures for 4IR technology use. The low assurance level could be due a lack in awareness or limited understanding of 4IR risks and experience. Lastly, 39.1% and 35.3% of respondents strongly agreed and agreed to expecting individual 4IR needs of stakeholders to be accommodated for by their institution, as well as 39.8% and 35.6% strongly agreed and agreed expecting stakeholders feedback towards 4IR technology preference to be valued. The respondents may have a belief that meeting diverse stakeholder needs may foster a supportive culture through which quality of services could improve. The overall findings suggested that most of the participants who agreed than those who disagreed had a gap of over 70% indicating high expectations from 4IR.

4IR Perceptions

This section presented the findings on the respondent's perceptions towards 4IR technologies within tertiary institutions. The measures of perceptions were based on 4IR technological tangibility, reliability, responsiveness, assurance, and empathy. The data garnered in Table 5.11 revealed that most of the participants (87.1%) believed 4IR technologies to be accurate for improving the standards of service operations in tertiary institutions. It can be assumed that respondents might not want to be dependent on only manual efforts of service delivery hence indicating a positive perception of technological progress. More than 70% of each participant category of student (count: 258), academics (count:42) and IT personnel (count:15) were in agreement with 4IR technologies being more reliant in terms of accessing digital tools. The respondents might have agreed owing to factors such as enhanced research capabilities, digital learning and remote work environments creating a changing landscape of reliable service delivery.

Moreover, a sum of 3.5% and 1.5% disagreed and strongly disagreed believing that 4IR technologies are irrelevant for offering personalized services. The result could possibly

be due to a presence of digital divide, limited understanding and varied cultural backgrounds showing a lack of empathy. However, an aggregate of 20.4% neither agreed nor disagreed. Whilst 34.3% strongly agreed viewing 4IR technologies in automatically capturing feedback and interest of stakeholder needs. This finding may suggest that respondents might be willing for their requirements and queries to be captured via automated interconnected systems, hence trusting in its responsiveness. Only 0.7% strongly disagreed with 20.2% students, 9.8% academics and 17.6% IT personal who remained neutral. Nevertheless, an aggregate of close to 77% were assured that 4IR technologies would be more competent than sole reliance on human knowledge and more trustworthy/secure means of service delivery. This could be owing to the intelligent nature of 4IR technologies causing a reduction in possibility of errors. Also, at least 75% in each category claimed that 4IR tools may add more value toward their daily activities. Overall results implied that most of the participants agreed with various measures of 4IR technology use. However, reliability and empathy were most dominating factors compared to others.

4IR quality improvement contributors

This part served to determine how 4IR service quality satisfaction contributes towards service quality improvement. The respondents were requested to determine if they intend to use 4IR technologies upon access given to which 45% strongly agreed and 33.8% agreed (see Table 5.11). A greater percentage of 80.3% participants also indicated to encourage other people in using 4IR technologies. While approximately 78.8% highly committed in staying up to date with latest technology developments. This could be due a fear of missing out with recent trends. However, less than 10% of respondents indicated to disagree to all the three factors. Regardless, 76.1% believed 4IR would improve quality of service within their respective environments. Of the 76.1%, 72.7% (243) constituted students, 87% (47) academics and 94% (16) IT personnel.

Table 5.11: 4IR Quality Management Role, Expectations, Perceptions

			SA	A	N	D	SD
			%	%	%	%	%
Quality Planning	QP1	Offer personalised services for behaviour analysis	20,6	37,3	30,6	8,0	3,5
	QP2	Promote use online automated systems for growth of the institution	25,4	39,3	22,1	11,2	2,0
	QP3	Promote sustainable technology use creating positive teaching, learning, and working environment	21,6	32,6	32,6	10,0	3,2
	QP4	Create visible changes in quality of services to enhance stakeholder experiences with new technology	17,9	36,3	28,9	13,7	3,2
Quality Assurance	QA1	Aligns personalized services to institutional mission and values	16,9	42,3	30,1	8,5	2,2

	QA2	Ensures standards of online services are as valuable as physical to comply with quality regulations	20,6	37,3	28,6	11,9	1,5
	QA3	Ensure compliance with global sustainability goals towards technological innovations	15,9	34,3	35,6	10,9	3,2
	QA4	Using 4IR technologies is supported by institutional mission and vision of driving innovation	21,4	35,6	28,1	11,7	3,2
Quality control	QC1	Ensure service evaluation via online feedback for corrective actions	18,7	41,0	28,9	7,7	3,2
	QC2	Continuously evaluate stakeholders' online presence to meet service expectations	19,2	33,6	30,6	12,7	4,0
	QC3	Share technological sustainability reports on the institutional website	16,2	37,8	28,6	13,9	3,5
	QC4	Ensure agile adaption of on-demand technologies to improve service performance	17,9	34,6	25,9	14,9	6,7
	QC5	Assess quality of technology through benchmarking	1,2	1,5	1,5	0,0	0,0
Tangibility	ET1	Modern technology equipment to support 4IR	50,5	33,6	11,7	2,7	1,5
	ET2	Modern technology facilities to govern a university 4.0 platform	40,0	39,3	15,4	3,7	1,5
Reliability	ERL1	24/7 availability of user friendly 4IR technologies	40,3	38,8	15,9	4,2	0,7
	ERL2	Presence of sincerely helpful staff to solve user problem through 4IR technologies	42,3	36,6	17,2	2,7	1,2
Responsiveness	ERS1	Flexibility to accommodate change with stakeholder interests & demands of 4IR	38,1	40,5	16,2	4,5	0,7
	ERS2	Provision of guidance and feedback to enquiries concerning 4IR use	42,5	36,8	14,9	4,7	1,0
Assurance	EAS1	Employment of skilled staff to assist with 4IR operations	50,5	30,6	15,4	2,7	0,7
	EAS2	Policies drafting appropriate safety measures for 4IR use	39,6	37,3	17,4	4,5	1,2
Empathy	EEM1	Accommodate for individual 4IR needs for every stakeholder	39,1	35,3	18,9	5,0	1,7
	EEM2	Value stakeholders feedback towards preference of 4IR technologies, equipment, and facilities	39,8	35,6	16,9	5,7	2,0
Reliability	PRL1	Is accurate for improving standards of service operations	49,0	38,1	9,5	2,5	1,0
	RPL2	Are more dependable in accessing digital tools	32,8	45,5	16,4	4,2	0,7
Empathy	PEM1	Are more relevant for personalization of services	33,1	41,5	20,4	3,5	1,5
	PEM2	Automatically captures feedback and interests of stakeholder needs	34,3	43,0	18,7	2,7	0,7
Responsiveness	PRS1	Are more responsive in providing assistance	35,1	39,8	20,4	2,7	2,0
	PRS2	Are available in answering individual queries	32,6	40,3	22,1	3,7	1,2
Assurance	PAS1	Are more competent than reliance on human knowledge	32,6	37,8	23,4	5,2	1,0
	PAS2	Are more trustworthy and secure means of service delivery	32,8	38,1	21,4	5,5	2,2
Tangibility	PT	Provides access to tools and platforms which adds more value towards daily activities	34,8	40,8	17,7	6,0	0,7
Quality improvement	QI1	Will improve quality of services	40,0	36,1	17,9	5,2	0,7
	QI2	Intend to use when provided access	45,0	33,8	15,9	4,0	0,7
	QI3	Encourage others to use 4IR technologies	42,8	37,6	15,9	2,7	1,0
	QI4	Will remain committed to updated 4IR technologies	44,5	34,3	16,4	3,7	1,0

5.6.7. 4IR Awareness

4IR technologies may highly remain underutilised within tertiary institutions due to a lack of awareness. Hence to increase the level of usage, the level of awareness must improve. To establish 4IR awareness levels among tertiary institution's stakeholders, the respondents were requested to rank their level of agreement ranging from strongly agree to strongly disagree via eight awareness indicators (Figure 5.11). The findings suggested that 25,9% and 32,6% of participants strongly agreed and agreed, leading to a total of 58,5% of participants being aware of the 4IR facilities available at the tertiary institution. It can be assumed that these participants could have established an association with the IT department through which awareness on 4IR facilities was sought.

Furthermore, only 15.4% of respondents were unaware of the risks and negative implications of 4IR technologies which received the highest rank of disagreement. It is assumed that that these participants may not be directly impacted by 4IR risks within their immediate environment. On contrary, 51.4% indicated to be aware, which could be due an increased efforts from the tertiary institution in educating its members on the downsides of technology use.

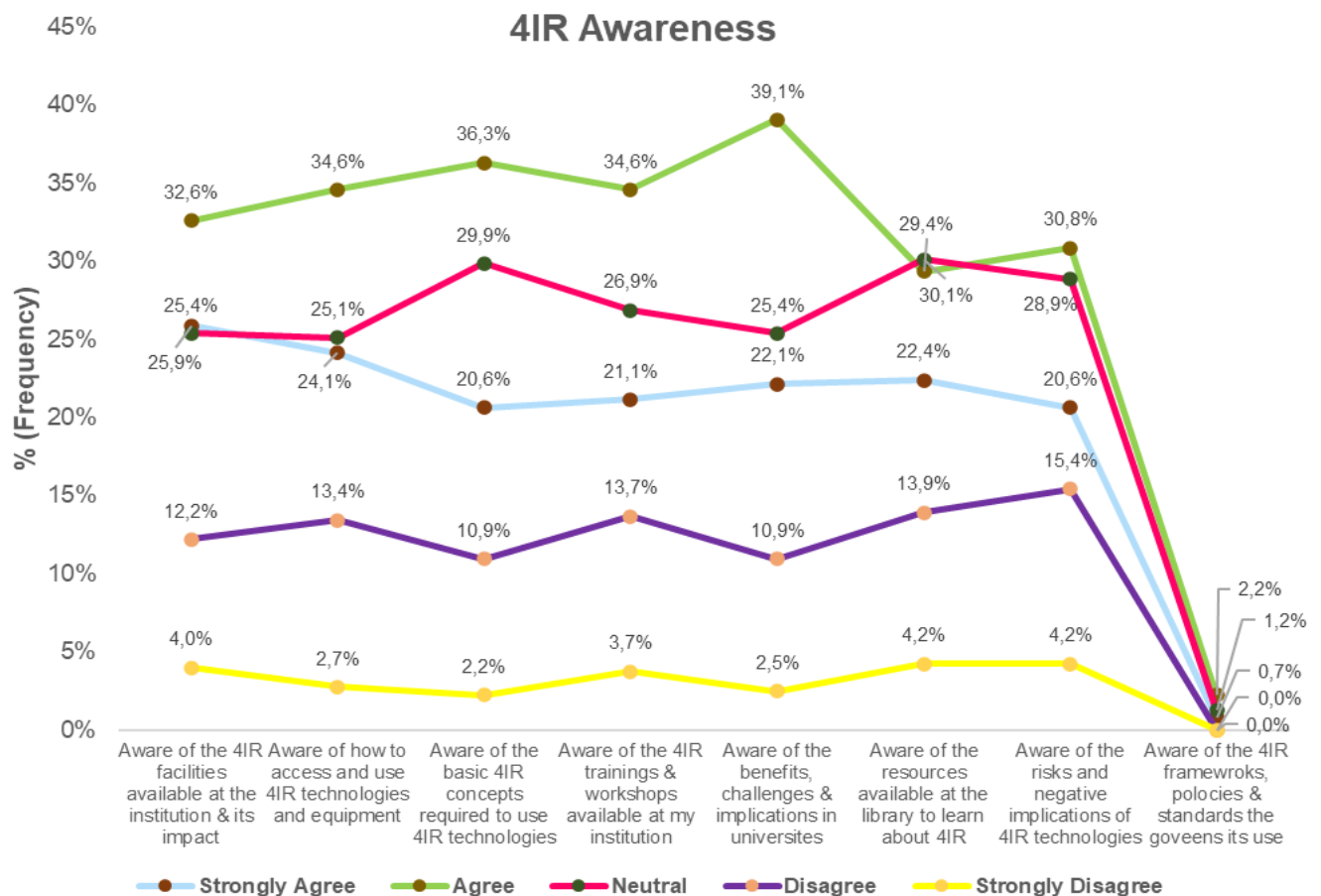


Figure 5.12: 4IR Awareness factors.

In addition, 25.1% of students, 5.9% of academics and 17.6% of IT personnel strongly agreed (count: 90) to be aware of the library resources available to learn about 4IR while an aggregate of 30.1% remained unsure. The respondent's indication towards awareness of trainings and workshops availability was greatly high since a consolidated number of 224 (55.7%) agreed. This could be due to social media engagements and information sessions or seminars and guest lectures organised by the institution. Over 50% of participants were in agreement with the 4IR awareness factors; with accessibility and usability at 58.7%, basic concepts understanding 56.9%, benefits and challenges at 61.2%. Less 5% of respondents strongly disagreed for each category indicating a complete lack of awareness. The awareness of IT personnel was shown to be the highest.

Over 35% of respondents remained neutral. It could be that those respondents were unsure of these 4IR aspects.

5.7. Reliability Analysis

It is a requirement of quantitative studies to evaluate the measurement instrument for its reliability (Zaki et al., 2013). This is to ensure that inefficiencies and possible errors could be identified and minimised to obtain accuracy (Ursachi et al., 2015). Reliability in this study was to assist in determining if the instrument and findings thereof could be interpreted similarly across various settings using similar methodologies. For this study, Cronbach's Alpha (α) test was used to measure internal consistency reliability of the scale items based on mean inter-correlations to determine the applicability of 4IR in service quality improvement (Taber, 2018). The scale contained a total of 65 items across 6 constructs which were measured on a 5-point Likert scale.

Several studies in literature highlighted acceptable Cronbach's alpha coefficients ranging between 0 (no relationship significance) to 1 (absolute relationship significance) (Tavakol & Dennick, 2011). It should be noted that generally, scholars have interpreted minimum alpha values 0.7 and maximum alpha values of 0.95 to be considered acceptable (H. K. Mohajan, 2017b). The various levels of reliability assume alpha coefficient less than 0.6 to be low, between 0.6 to 0.7 to be moderate, between 0.7 to 0.8 to be good, between 0.8 to 0.9 to be high, whilst above 0.9 to be excellent (Gliem & Gliem, 2003; Mat Nawi et al., 2020; Schrepp, 2020). For the current study, the acceptable alpha (α) coefficients were between the range of 0.75 to 0.95 as some variables contained less than 10 items (Pallant, 2020). The data in Table 5.12 presented the findings of reliability of the study from the three sets of questionnaires namely students, academics, and IT personnel. The results showed the instrument being internally consistent, as alpha values fell between the desirable range. The Cronbach's alpha values for the student scale can be explained as follows: $\alpha = .902$ (Readiness levels); $\alpha = .884$ (4IR Capabilities); $\alpha = .890$ (4IR role quality in management); $\alpha = .891$ (4IR Quality expectations); $\alpha = .859$ (4IR Quality Perceptions); $\alpha = .860$ (4IR Quality improvement); and $\alpha = .896$ (4IR Awareness).

Additionally, the means of every scale was shown to be closer to one another. The reliability of the academic scale ranged between .759 to .959 whilst the IT Personnel scale ranged between .797 to .936. The high alpha values indicated that the constructs were internally consistent, meaning the higher the alpha coefficient, the higher the

reliability of the scale measuring the same construct. Hence, all the constructs were used for performing further analysis.

Table 5.12: Internal Reliability Statistics

Question No.	N	Scale	No. of Scale Items	Inter-Item Means	Mean		Cronbach's Alpha (α) Based on Standardized Items	Type
					minimum	maximum		
Student Scale								
Q8	313	4IR_RL	9	1.819	1.700	2.019	.902	Excellent
Q10	320	4IR_CQI	14	1.065	.794	1.291	.884	High
Q16	319	4IR_RQM	12	1.442	1.313	1.583	.890	High
Q17	321	4IR_E	10	.862	.698	.972	.891	High
Q18	318	4IR_P	9	.967	.664	1.066	.859	High
Q18	321	4IR_QI	4	.821	.784	.900	.860	High
Q19	321	4IR_A	7	1.333	1.231	1.433	.896	High
Academics Scale								
Q10	51	4IR_RL	9	1.678	1.549	1.804	.953	Excellent
Q12	51	4IR_CQI	14	1.084	.961	1.235	.959	Excellent
Q18	51	4IR_RQM	12	1.395	1.039	1.686	.932	Excellent
Q19	51	4IR_E	10	.720	.588	.804	.944	Excellent
Q20	51	4IR_P	9	.850	.725	1.039	.899	High
Q20	51	4IR_QI	4	.608	.471	.784	.759	Good
Q21	51	4IR_A	7	1.992	1.804	2.078	.934	Excellent
IT Personnel Scale								
Q9	17	4IR_RL	9	2.732	2.529	3.000	.922	Excellent
Q12	17	4IR_CQI	18	.663	.353	.882	.892	High
Q19	17	4IR_RQM	13	.964	.824	1.176	.900	Excellent
Q20	17	4IR_E	10	.647	.294	.941	.936	Excellent
Q21	17	4IR_P	9	.686	.529	.824	.871	High
Q21	16	4IR_QI	4	.578	.438	.688	.797	Good
Q22	17	4IR_A	8	.985	.824	1.118	.826	High

5.8. Validity Analysis

Although the data collected may be classified as reliable, weak validity may indicate the study failing to measure what it intended to. For determining the extent to which the scale items measured the constructs of the study, validity tests were performed. Construct validity tests were run to confirm the trustworthiness of the inferences from the findings. For this study, construct validity entailed performing discriminant and convergent validity tests. While convergent validity assisted in determining the commonness among the construct items, the discriminant validity assisted in determining the uniqueness of each construct in a model. Common methods for running validity tests are via exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) (Orçan, 2018; Plucker, 2003; D. D. Suhr, 2006a). Hence, dimensionality reduction techniques and correlation matrix were used to confirm the construct validity of this research.

The principal component analysis (PCA) procedure was used as a dimensionality reduction technique with the purpose of transforming the dimensionality of the large dataset into a smaller set without compromising much data (Jolliffe & Cadima, 2016). PCA was useful for putting various 4IR quality improvement factors into significant categories. Therefore, maximum variability can be preserved in an interpretable manner. It should be noted that the sample size (321) for this analysis was large enough to generalise the factors retained. Also, the ratio of variable items to respondents was 65:1, higher than recommended ratio of at least 10:1. Therefore, in the PCA test performed for each scale, the retained components within the Total Variance Explained (TVE) were verified through the scree plots. Before conducting the PCA test, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity were taken to assess sampling size adequacy of respondent data for each variable (B. Williams et al., 2010).

The measures of index of the KMO test are typically ranged between 0 to 1 whereby index closer to one is more desirable. Whilst the Bartlett's Test of Sphericity should be significant at $p < .05$ for the PCA to be suitable for the dataset. It is highlighted by (Shrestha, 2021) that KMO indexes greater than a minimum of 0.6 implies good sampling adequacy. Additionally, for the factor analysis to be considered for this research, the coefficients from the correlation matrix are expected to be greater than 0.3. The study also considered the KMO-MSA via the anti-image correlation matrix for every item requiring to be >0.5 . Furthermore, communality analysis established the degree to which each variable correlated with the other variables in the model. Correlations with values $>.4$ are acceptable while values lower than $.4$ are required to be dropped. It is also recommended for the extraction factors with a value less than $.3$ to be cut-off. The eigen values were extracted to explain the total variance, factors needing to be retained were identified based on eigen values equal to or higher than 1. The subsequent sections presented the results from the PCA tests for each scale.

4IR Readiness (4IR_R)

The outcome of PCA test for the 4IR_R scale is shown in Table 5.13. The analysis confirmed that the Pearson correlations of the items within the model were above 0.3 and below 0.9. The correlations ranged between $.393$ (lowest) to $.686$ (highest). The factorability of items depicted through the anti-image correlations was found to be reasonable since the correlation values displayed diagonally varied between $.847$ and $.920$, which were all above the recommended value of $.05$. Furthermore, the KMO-MSA

test was assessed, resulting in a meritorious value of .893 with the significance of Bartlett's test of Sphericity being $p < .001$, lower than the acceptable value of $p < 0.05$. The test was favourable in performing factor analysis on the 9 items since at least a pair of items shared a common variance. It was found through the Total Variance Explained table that the items in the correlation matrix could be reduced to one dimension. This was because only the first component had an eigenvalue greater than 1 ($e_1 = 5.042$). The component retained explained 56.017% of variance. Additionally, all the factor loadings were significant in the retained component since values were above 0.3. The communalities highlighted in table 5.13 showed that all the variables were extracted at values greater than 0.4 explaining sufficient one factor solution. The convergent validity was achieved at 0.560 (AVE), therefore internal reliability was maintained at .902.

Table 5.13: The principal component analysis for 4IR Readiness

4IR_R Items	CORRELATION MATRIX									FL	COMM
	1	2	3	4	5	6	7	8	9		
4IR technologies are welcomed by management (1)	.920^b									.699	.488
Established partnerships (2)	,568	.883^b								.728	.529
Has strategies for 4IR initiatives (3)	,521	,547	.902^b							.739	.545
Identified needs for 4IR projects (4)	,491	,425	,573	.893^b						.723	.522
Prepared to offer trainings & development programs (5)	,405	,462	,500	,523	.916^b					.750	.563
Has skilled technicians & experts to lead (6)	,400	,435	,526	,488	,585	.918^b				.768	.590
Has student involvement in 4IR projects (7)	,516	,604	,487	,488	,611	,644	.895^b			.830	.689
Has programs to adapt to change management culture (8)	,415	,393	,421	,505	,442	,531	,595	.847^b		.742	.551
Has processes for effective 4IR management (9)	,431	,479	,417	,397	,507	,532	,595	,686	.868^b	.751	.564
a. Determinant= .009 ; b. KMO-MSA for each item; AVE= 56.03 . Extraction Method: Principal Component Analysis											

Institutional Capabilities for quality improvement (IC)

The PCA for the IC scale revealed that all the component correlations were above the threshold value of 0.3 and less than the maximum threshold value of 0.9 ranging from 0.316 to 0.657. The anti-image correlation matrix depicted diagonally in table 5.14, showed that the leading correlations ranged between 0.763 to 0.915 (> 0.5) contributing to a sufficient factorability. The KMO measure for sampling adequacy (0.838) was also above 0.5, while the Bartlett's test of sphericity was significant at $p < 0.001$ being lower than 0.05 indicating that the items in the IC scale were eligible for EFA. The Total Variance Table (see Annexure M) showed that the correlation in this model were reduced

to a two-factor solution, with the first component explaining 54.432% ($e_1=3.810$) and second component explaining 15.072% ($e_1=1.055$) of total variance (69.50%). The scree plot in Annexure M also confirmed a maximum of two components being retained. The communalities were fairly acceptable for all the items (0.580 to 803). The first component was aligned with the tertiary institutions ability in providing support for using 4IR by means of infrastructure allocation, engagement with experts and management of multiple technologies. Therefore, the component was renamed as adaptation capability (AC). The second component was relating to the tertiary institution's capability in sensing innovation of 4IR by means of new technology identification, use and partnership creation. Therefore, the component was renamed to sensing capability (SC). Hence, the convergent validity was attained at 0.624 and 0.631 respectively ($AVE>0.5$).

Table 5.14: The principal component analysis for Institutional capabilities for quality improvement

4IR_IC	CORRELATION MATRIX							Factor loading		comm
	1	2	3	4	5	6	7	1	2	
Identify new technologies, courses & research facilities (1)	,832^b								.766	.624
Use multiple technologies (2)	,588	,763^b							.863	.803
Identify partnerships creating innovation hubs (3)	,398	,615	,819^b						.750	.633
Allocate infrastructure (4)	,361	,484	,434	,915^b					.644	.580
Engage with experts, students, government, & industries (5)	,316	,400	,409	,557	,864^b				.837	.748
Manage multiple 4IR technologies for a smart learning environment (6)	,378	,379	,424	,537	,647	,837^b			.831	.750
Provide support for any 4IR difficulties faced (7)	,364	,400	,318	,492	,631	,657	,842^b		.831	.728
b. Determinant= .046 ; c. KMO-MSA for each item Extraction Method: Principal Component Analysis										

Investment Capabilities and Perceived usefulness (IPU)

The PCA test for IPU (see Table 5.15) scale showed that the Pearson correlation coefficients and anti-image correlations were higher than 0.5. The KMO-MSA test resulted in a value of 0.861 also higher than 0.5. The Bartlett's Test of Sphericity being significant at $p<0.001$ indicated that the correlation matrix of the items in the IPU scale was not comparable to an identity matrix. Based on the Total Variance Table, it was confirmed that the items were best represented by a two-factor solution, with item communalities above 0.4 and factor loadings above 0.3. The highest factor loading in component one accounted in a value of 0.830, while component two accounted for a value in 0.858. The eigenvalue ($e_1=4.161$) of the first component (investment capability)

implied that the first factor explained a variance of 59.443% and the second component's (usefulness capability) eigenvalue ($e_2=1.101$) explained a variance of 15.732% accounting for a collective of % (75.175%) of total variance (Annexure M). The Cronbach's alpha value was maintained since no items were removed. The convergent validity of 0.643 and 0.713 implied that the construct validity criterion was met.

Table 5.15: The principal component analysis for investment capabilities and 4IR perceived usefulness

4IR_IPU	CORRELATION MATRIX							Factor loading		comm
	1	2	3	4	5	6	7	1	2	
Prioritise investments in 4IR technologies, knowledge & capacities (8)	,877^b							.815		,675
Secure fundings for 4IR initiatives (9)	,639	,864^b						.830		,777
Invest in training programs to equip in 4IR competences (10)	,530	,666	,850^b					.806		,738
Support 4IR entrepreneurship programs (11)	,516	,675	,737	,868^b				.755		,741
Identify need for 4IR technologies will improve quality of services (12)	,329	,475	,429	,506	,876^b				.833	,759
Allocate resources towards 4IR will improve quality of services (13)	,324	,433	,464	,503	,670	,841^b			.858	,793
Manage 4IR facilities will improve quality of service (14)	,321	,472	,426	,526	,655	,693	,856^b		.843	,778
a. Determinant= .019 ; b. KMO-MSA for each item Extraction Method: Principal Component Analysis										

4IR Role in Quality Management (RQM)

Table 5.16 showed the findings of the PCA analysis for the RQM scale. The principal component analysis of 4IR role in quality management initially suggested that although most of the items correlated significantly (>0.3), some pair of items had correlations above 0.2 and less than 0.3. Hence, three items with majority of correlations less than 0.3 were deleted before conducting factor analysis to eliminate ambiguity (See Annexure M). The PCA test was performed again with the remaining items. However, the anti-image correlations were ranged between 0.844 - 0.895 displaying reasonable factorability. The KMO-MSA was higher than 0.5 at 0.860, and the BART test was significant at $p < 0.001$ ($\chi^2=1188,152$, $DF=36$). The findings from the Total Variance Explained table (see Annexure M) revealed that the RQM items were best supported for a two-dimension solution with all factor loadings being above 0.5 (0.568 - 0.835). The scree plot also supported the findings of retaining two factors with the eigen value of first component at $e_1=5.405$, and second component at $e_2=1.517$. The two components were renamed as Quality planning role (QPR) and Quality control role (QCR). All the RQM item loadings showed significant explanations for a two-factor solution with communalities greater 0.5.

The convergent validity satisfied the construct validity at 0.531 and 0.571 (AVE>0.5). Hence, the new Cronbach alpha for internal reliability was 0.869.

Table 5.16: The principal component Analysis for 4IR role in Quality Management.

4IR_RQM	CORRELATION MATRIX												Factor loading		Comm
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
Offer personalised services for behaviour analysis (1)	.885 ^b												.726		.562
Aligns personalized services to institutional mission and values (2)	.588	.866 ^b											.721		.564
Ensure service evaluation via online feedback for corrective actions (3)	.530	.573	.846 ^b										.835		.723
Promote use of online automated systems for growth of the institution (4)	.436	.504	.689	.844 ^b									.783		.660
Ensures standards of online services are as valuable as physical to comply with quality regulations (5)	.470	.425	.511	.593	.866 ^b								.713		.591
Continuously evaluate stakeholders' online presence to meet service expectations (6)	.435	.363	.508	.471	.606	.871 ^b							.568		.565
Promote sustainable technology use creating positive teaching, learning, and working environment (7)	.334	.309	.392	.397	.423	.523	.876 ^b							.710	.603
Ensure compliance with global sustainability goals towards technological innovations (8)	.272	.341	.246	.299	.246	.330	.480	.791 ^b						.831	.700
Share technological sustainability reports on the institutional website (9)	.318	.350	.332	.331	.356	.423	.386	.463	.895 ^b					.720	.575
a. Determinant= .023 b. KMO-MSA for each item. - Extraction Method: Principal Component Analysis - Rotation converged in 3 iterations															

4IR Technology Expectations on Quality Improvement (EQI)

The Pearson correlations coefficients of the EQI items were below 0.9 with most of the items above 0.3. The anti-image correlations fell between 0.812 and 0.929 (>0.5) confirming acceptable factorability. The KMO was found to be 0.872 highly above the suggested 0.5. The BART test was significant at $p < 0.001$ ($\chi^2 = 1795,27$; $DF = 45$; $p < 0.05$) showing eligibility for proceeding with factor analysis. Dependent on the total Variance Explained Table and the scree plot, two components with eigen values greater than one were retained. Hence, the dimensionality of two factors was suggested. The first component resulted in a variance of 51.22% ($e_1 = 5.122$), while the second component had a variance of ($e_2 = 1.520$) 15.19% explaining a total variance of 66.419% post Varimax rotation. The largest factor loading equalled 0.860 while lowest equalled 0.533 among the two components. Since the first factor was aligned with respondents' expectations from tertiary institutions in modernising the institutional environment by accommodating for changes and providing guidance via experts to achieve service improvement, it was renamed as 4IR Institutional responsiveness expectancy (IRE). While second factor was renamed as 4IR institutional empathy expectancy (IEE). The communalities are summarised in Table 5.17. Upon the calculation of Average Variance Extracted (AVE),

the convergent validity was established at 0.527 and 0.661, which is fairly higher than 0.5 meeting the construct validity criterion. The reliability remained at 0.860.

Table 5.17: the principal component analysis for 4IR technology Expectations on quality improvement

4IR_EQI	CORRELATION MATRIX										Factor Loadings		Comm
	1	2	3	4	5	6	7	8	9	10	1	2	
Modern technology equipment to support 4IR (1)	.827 ^b										.849		.734
Modern technology facilities to govern a university 4.0 platform (2)	.767	.812 ^b									.860		.752
24/7 availability of user friendly 4IR technologies (3)	.577	.578	.893 ^b								.775		.643
Presence of sincerely helpful staff to solve user problem through 4IR technologies (4)	.483	.514	.594	.914 ^b							.665		.570
Flexibility to accommodate change with stakeholder interests & demands (5)	.457	.468	.498	.511	.870 ^b						.614		.579
Provision of guidance and feedback to enquiries concerning 4IR use (6)	.437	.443	.406	.450	.698	.878 ^b					.533		.548
Employment of skilled staff to assist with 4IR operations (7)	.317	.295	.312	.408	.437	.461	.929 ^b					.752	.617
Policies drafting appropriate safety measures for 4IR use (8)	.345	.359	.329	.362	.453	.488	.618	.879 ^b				.828	.736
Accommodate for individual 4IR needs for every stakeholder (9)	.263	.272	.286	.400	.360	.418	.553	.680	.860 ^b			.848	.735
Value stakeholders feedback towards preference of 4IR technologies, equipment, and facilities (10)	.297	.275	.425	.460	.465	.463	.547	.659	.691	.876 ^b		.821	.727
a. Determinant= .004 b. KMO-MSA for each item. - Extraction Method: Principal Component Analysis - Rotation converged in 3 iterations													

4IR Technology Perceptions on Quality Improvement (PQI)

The results of the PCA for the PQI scale are represented in Table 5.18. The findings from the Pearson correlations indicated most of items correlated with coefficients greater than 0.3 except for item number 9. However, the item was retained as it loaded successfully when conducting factor analysis resulting in a communality of 0.608 and obtained a factor loading of 0.777. The anti-matrix correlations were all above 0.8 determining a satisfactory factorability. The KMO measure of sampling adequacy was shown to be 0.851 being fairly higher than 0.5. Hence, it is evident that some pair of items were sharing common variance. The BART Test was significant at $p < .001$ with an approximate Chi-square=1207,401 with degree of freedom (DF) = 36. It was confirmed that the PQI items were significant for factor analysis. A total of two components were suggested to be kept as the component loadings were statistically significant. The factor loading for each component varied between 0.556 to 0.813, being greater than 0.5. The two components (institutional reliability and institutional assurance of 4IR use) had a total variance of 62.741% with factor one accounting for 48.11% and factor two accounting for 14.330%. This indicates that a two-dimensional solution was best fitted with $e_1=4.357$ and $e_2=1.290$.

The communality of each item was greater 0.5, explaining the two factors adequately. Convergent validity was realised at 0.602 and 0.513 (AVE>0.5). The Cronbach's alpha value for internal consistency remained unchanged.

Table 5.18: the principal component analysis for 4IR technology perception on Quality Improvement

4IR_PQI	CORRELATION MATRIX									Factor Loadings		Comm	
	1	2	3	4	5	6	7	8	9	1	2		
Is accurate for improving standards of service operations (1)	,861 ^b										,775		,653
Are more dependable in accessing digital tools (2)	,631	,828 ^b									,813		,682
Are more relevant for personalization of services (3)	,492	,587	,846 ^b								,781		,638
Automatically captures feedback and interests of stakeholder needs (4)	,531	,474	,532	,861 ^b							,735		,611
Are more responsive in providing assistance (5)	,448	,385	,368	,560	,845 ^b							,556	,560
Are available in answering individual queries (6)	,411	,340	,401	,396	,607	,870 ^b						,651	,575
Are more competent than reliance on human knowledge (7)	,320	,322	,331	,369	,496	,519	,881 ^b					,769	,646
Are more trustworthy and secure means of service delivery (8)	,331	,332	,346	,309	,385	,463	,588	,824 ^b				,800	,673
Provides access to tools and platforms which adds more value towards daily activities (9)	,312	,233	,191	,269	,362	,392	,438	,566	,841 ^b			,777	,608
a. Determinant= .022 b. KMO-MSA for each item. - Extraction Method: Principal Component Analysis - Rotation converged in 3 iterations													

4IR Awareness (AWS)

The PCA test for 4IR awareness was illustrated in Table 5.19, the results of which showed significant correlations among the items (>0.3). The anti-image correlations were above 0.8 for KMO-MSA values of each item, while the KMO-MSA for all the items in total was observed to be 0.872. The significance of further conducting factor analysis was confirmed by the Bartlett's test of sphericity realised at p<0.001. With some pairs of items sharing variance, the Total Variance Explained table presented a one-dimension solution for the AWS items resulting in a variance of 60.858%. All the items loaded successfully with a loading above 0.7 ranging between 0.722 and 0.825. The communalities above 0.5 gave an indication that the AWS items were reasonably sufficient for a one-dimension solution. This finding satisfied the construct validity criterion as convergent validity calculation was found to be at 0.608 of average variance extracted (AVE= 60.852%). The internal reliability was sustained at 0.896.

Table 5.19: the principal component analysis for 4RI Awareness

4IR_AWS	CORRELATION MATRIX	FL	COMM
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	1	2	3	4	5	6	7	1	
Aware of the 4IR facilities available at the institution & its impact (1)	,888 ^b							,722	,521
Aware of how to access and use 4IR technologies and equipment (2)	,662	,816 ^b						,790	,624
Aware of the basic 4IR concepts required to use 4IR technologies (3)	,593	,749	,862 ^b					,825	,681
Aware of the 4IR trainings & workshops available at my institution (4)	,506	,565	,604	,932 ^b				,809	,654
Aware of the benefits, challenges & implications in universities (5)	,398	,497	,549	,600	,881 ^b			,794	,631
Aware of the resources available at the library to learn about 4IR (6)	,411	,396	,444	,558	,588	,888 ^b		,734	,539
Aware of the risks and negative implications of 4IR technologies (7)	,401	,430	,538	,563	,692	,640	,851 ^b	,781	,610
a. Determinant= ,019 b. KMO-MSA for each item									

4IR Quality Improvement (QI)

The PCA test for quality improvement provided the Pearson correlations of the QI items to be greater than 0.3 and less than 0.9 (see Table 5.20). The diagonal correlations being above 0.7 endorsed sufficient factorability from the anti-image correlations of the items. The findings from the KMO-MSA (0.798) and Bartlett's test of Sphericity ($p < 0.001$) justified performing factor analysis on the QI scale. The Total Variance Explained Table showed a one factor solution with an eigen value $e_1 = 2.891$ explaining a total variance of 72.269%. The highest factor was loaded at 0.897. The communalities were ranged between 0.561 to 0.562. The only eigen value of the retained component was found to be $e_1 = 2.89$ (also confirmed through the scree plot). Sufficient explanation was sourced from the squares of the factor loadings resulting in an AVE of 0.722 ($AVE > 0.5$). Hence, the convergent validity was achieved, and internal consistency was upheld at 0.860.

Table 5.20: the principal component analysis for Quality improvement

4IR_QI	CORRELATION MATRIX				FL	COMM
	1	2	3	4		
Will improve quality of services	,885 ^b				0.749	,561
Intend to use when provided access	,560	,851 ^b			0.860	,740
Encourage others to use 4IR technologies	,540	,680	,752 ^b		0.897	,804
Will remain committed to updated 4IR technologies	,509	,674	,797	,754 ^b	0.886	,786
a. Determinant= ,019 b. KMO-MSA for each item, - Extraction Method: Principal Component Analysis						

5.9. Correlation analysis

The strength of the association and directions between the constructs retained post factor analysis was assessed through bivariate Pearson's correlations. The analysis revealed a series of positive, negative, and unrelated correlations. Table 5.21 presented the findings of correlations analysis conducted. The results indicated that the correlation between Quality improvement and other predictor variables were mostly positive, while the correlation between predictor variables were all less than 0.6 indicating no multicollinearity. Therefore, divergent validity was achieved among the independent variables. The analysis revealed that there was a largely positive significant relationship of assurance ($r=.563$), reliability ($r=.454$), empathy ($r=.484$), responsiveness ($r=.494$) with quality improvement at $P<0.01$. With a significance of ($.000$), the probability that this could have happened by chance is low. Therefore, the more assurance stakeholders at tertiary institutions obtain in terms of 4IR use, the more positive influence it will have on service quality. Similarly, the more reliable 4IR technologies become, the better the impact it creates on quality improvement. It should also be noted that the higher the expectations of stakeholders in receiving empathy and responsiveness from tertiary institutions by means of accessing modern and user-friendly equipment, and facilities with a presence of skilled staff, guidance, policies, and appropriate feedback, the higher the chances of service quality improvement.

Table 5.21: correlation coefficients between the constructs of the study.

Correlations		1	2	3	4	5	6	7	8	9	10	11	12	13
Readiness (4IR_R) (1)	Pearson Correlation	1												
	Sig. (2-tailed)													
Adaptation Capability (AC) (2)	Pearson Correlation	-,186**	1											
	Sig. (2-tailed)	,001												
Sensing capability (SC) (3)	Pearson Correlation	-,149**	,562**	1										
	Sig. (2-tailed)	,008	,000											
investment capability (IC) (4)	Pearson Correlation	,026	,336**	,216**	1									
	Sig. (2-tailed)	,641	,000	,000										
Perceived usefulness capability (PUC) (5)	Pearson Correlation	,006	,422**	,274**	,580**	1								
	Sig. (2-tailed)	,915	,000	,000	,000									
quality planning role (QPR) (6)	Pearson Correlation	-,138*	,263**	,286**	,025	,156**	1							
	Sig. (2-tailed)	,013	,000	,000	,657	,005								
quality control role (QCR) (7)	Pearson Correlation	-,227**	,251**	,225**	,125*	,267**	,559**	1						
	Sig. (2-tailed)	,000	,000	,000	,025	,000	,000							
Institutional Responsiveness	Pearson Correlation	-,033	,192**	,184**	,313**	,272**	,078	,188**	1					
	Sig. (2-tailed)	,552	,001	,001	,000	,000	,165	,001						

Expectancy (IRE) (8)															
Institutional Empathy Expectancy (IEE) (9)	Pearson Correlation	,044	,099	,137*	,319**	,302**	,032	,185**	,559**	1					
	Sig. (2-tailed)	,432	,078	,014	,000	,000	,562	,001	,000						
Institutional reliability (IR) (10)	Pearson Correlation	-,060	,032	,038	,126*	,116*	,114*	,213**	,392**	,436**	1				
	Sig. (2-tailed)	,287	,563	,493	,024	,037	,042	,000	,000	,000					
Institutional assurance (IA) (11)	Pearson Correlation	-,003	,017	,062	,195**	,247**	,031	,217**	,297**	,433**	,576**	1			
	Sig. (2-tailed)	,959	,758	,268	,000	,000	,580	,000	,000	,000	,000				
4IR Awareness (4IR_AWS) (12)	Pearson Correlation	-,116*	,083	,041	-,060	,068	,318**	,278**	,042	,165**	,268**	,261**	1		
	Sig. (2-tailed)	,038	,137	,460	,285	,222	,000	,000	,455	,003	,000	,000			
Quality Improvement (QI) (13)	Pearson Correlation	-,087	,142*	,071	,167**	,275**	-,009	,147**	,494**	,484**	,454**	,563**	,220**	1	
	Sig. (2-tailed)	,121	,011	,206	,003	,000	,877	,008	,000	,000	,000	,000	,000		
**. Correlation is significant at the 0.01 level (2-tailed).															
*. Correlation is significant at the 0.05 level (2-tailed).															

Additionally, there was a moderate strength association of 4IR awareness ($r=.220$) and 4IR perceived usefulness ($.275$) with the dependent variable at significance of $P<0.01$. This implies that with an increase in tertiary institutions capability of recognising the usefulness of 4IR technologies (by providing 4IR-based curriculums, research facilities, labs, 4IR programs and management), there will be a likely chance in enhancing service quality. Consequently, an increase in awareness of 4IR in terms of its facilities, accessibility, skills, and knowledge, would lead to an increase in stakeholders urge of its usage; successively promoting increase in service quality of teaching and learning, research, IT, and other services. However, there was a weak significant correlation between the role of 4IR in quality control process ($r=.147$, $P<0.01$), institutional capability of 4IR investment ($r=.176$, $P<0.01$), and adaptation capability ($=.142$, $P<0.05$) with the outcome variable. Therefore, there was no sufficient evidence to support that these correlations might have occurred by chance as significance was 0.008, 0.003 and respectively. 0.011. The findings suggested that although there was a presence of low positive association, an increase in each of those predictors will increase to some extent when quality improvement value increases. It can be implied that as more investments, adaptation and quality control processes emerge, the more stakeholders would want service quality to increase.

Amongst the predictor variables, all the positive correlations were significant at $P<0.01$ except for the five associations which were significant at $p<0.05$ (IC $< -- >$ QCR: $r=.125$, $p=.025$; SC $< -- >$ IEE: $r=.137$, $p=.014$; IC $< -- >$ IR: $r=.126$, $p=.024$; PUC $< -- >$ IR: $r=.116$, $p=.037$; QPR $< -- >$ IR: $r=.126$, $p=.042$). Whilst 4IR_R was shown to have a negative

significant correlation with AC, SC, QPR, QCR, 4IR_AWS (see Table 5.21). Additionally, the highest correlation strength between predictor variables was shown between investment capability and perceived usefulness capability ($r < 0.6$). The results suggested that stakeholders within the tertiary institutions environment seemed to have higher expectations of 4IR which are required to be managed to create a valuable service quality management system.

5.10. Regression Analysis

Regression analysis assisted in determining how significant were the predictor variables towards the independent variables (Sykes, 1993). That is to evaluate the effect or relationship of each predictor variable in predicting the dependent variable. The research model was revised based on the PCA analysis which eliminated the insignificant items from the research model. Therefore, to estimate the hypothesis, multiple linear regression analysis was adopted at 95% confidence intervals to determine the significance of a 4IR-based quality improvement model (Chatterjee & Ali S. Hadi, 2013). The extent to which 4IR readiness levels, adaptation capabilities, sensing capabilities, investment capabilities, usefulness capabilities, quality planning role, quality control role, responsiveness, empathy, reliability, assurance, and awareness determined the applicability of 4IR in service quality improvement was assessed.

The assumption of linearity, multicollinearity, homoscedasticity, and normality were rerun after eliminating insignificant items. The MD test was calculated using the criterion of $\alpha = .001$ (significance level) with degree of freedom equal to 13 variables, the chi-square distribution table was consulted to interpret the values. The analysis revealed that any value above 34.528 is considered a critical value. About 15 cases were identified as outliers and were removed prior conducting PCA analysis since those cases were found to have a value lower than $\alpha < .001$, where the critical p value ranged between 0.00000 to 0.00090 and MD ranged between 34.83169 to 52,62355. The following criteria was followed to interpret the multiple regression analysis illustrated in Table 5.22: variance inflation factor should be less than 10, while tolerance should be more than 0.1.

Table 5.22: 4IR-Based Service Quality Improvement (model Summary)

Model Summary ^b										ANOVA					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				Durbin-Watson	Model	Sum of Squares	df	Mean Square	F	Sig.
					R Square Change	F Change	df1	df2							
	1,699 ^a	0,489	0,469	0,52322	0,489	24,55	12	308	0	1,908	Regression	80,651	12	6,721	24,55<,001 ^b
a. Predictors: (Constant), Q19_AWS_Factor, sensing capability, readiness level, institutional responsiveness expectancy, usefulness capability, assurance of 4IR use, quality planning role, investment capability, quality control role, reliability of 4IR use, adaptation capability, institutional Empathy expectancy. b. Dependent Variable: Q18.3_QI_Factor										Residual	84,318	308	0,274		
										Total	164,969	320			

Based on the model summary and ANOVA table, the quality improvement model was found to be significant in terms of its variability, showing a good model fit: $F(13,308) = 24.550$, $P < 0.01$, $Adj R^2 = 0.469$ which indicated that the overall of twelve variables under this research have a significant impact on service quality improvement. Furthermore, the model explained that the predictor variables accounted for almost 50% of the variability in 4IR-based service quality improvement ($R^2 = 0.489$). Also, the influence of each independent variable (factors) on the dependent variable (criterion) was assessed based on the coefficients presented in Table 5.23.

It should be noted that the multiple regression analysis for the 4IR-Based Quality Improvement Model showed that the multicollinearity assumptions were not violated since the tolerance value ranged between 0.555 to 0.898, which did not exceed the maximum acceptable value of 1. This means that a minimum of 55.5% of variance in predictor variables was not explained by other predictor variables. Moreover, the value inflation factor (VIF) did not exceed the critical value of 10, with the highest coefficient being 1.801 and the lowest being 1.113. This means that there were no residuals being identified as outliers. Additionally, the Durbin Watson (DW) test was used to check the independence of the residuals by assessing their autocorrelation, the score of 1.908 confirmed that the residuals had a positive correlation.

To determine the significance of the coefficients in the model, the t statistic and alpha values were looked at. The analysis of which revealed that adaptation capability ($\beta = 0,109$, $t(308) = 2,006$, $p = 0,046$), usefulness capability ($\beta = 0,126$, $t(308) = 2,298$, $p = 0,022$), and empathy expectancy ($\beta = 0,139$, $t(308) = 2,552$, $p = 0,011$) had a significant positive effect on quality improvement at $P < 0.05$. However, responsiveness expectancy ($\beta = 0,290$, $t(308) = 5,598$, $p = 0,000$) and assurance ($\beta = 0,369$, $t(308) = 6,890$, $p = 0,000$)

significantly predicted 4IR-based service quality improvement at $P < 0.001$; while awareness ($\beta = 0,081$, $t(308) = 1,767$, $p = 0,078$) positively influenced quality improvement at a significance of $P < 0.1$. The results also found that 4IR readiness ($\beta = -0,080$, $t(308) = -1,860$, $p = 0,064$) and 4IR quality planning role ($\beta = -0,089$, $t(308) = -1,698$, $p = 0,090$) coefficients were negatively significant at $P < 0.1$ in influencing quality improvement, while 4IR investment capability ($\beta = -0,127$, $t(308) = -2,411$, $p = 0,016$) had a negative influence at $p < 0.05$. This implied that respondents may have a belief that their institutions did not show any effort in introducing 4IR-technologies and neither established any quality planning processes of integrating 4IR for quality management as well may not have the capability to invest in 4IR initiatives for service quality improvement. Although institutional reliability had a positive relationship with quality improvement, a lack in predictive power was found ($p = 0.251$). However, institutional 4IR sensing capability, and quality control processes did not have any significant effect on quality improvement. Hence, it can be deduced that a significant change in each one of these independent variables may not cause a change in the dependent variable. Overall, tertiary institutions should pay more attention improving their capabilities of recognising new technologies and introduce technology-based quality planning processes with reasonable investments.

Table 5.23: Regression analysis results for the 4IR-based quality improvement model

Coefficients ^a											
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	0,144	0,113		1,279	0,202					
	4IR Readiness (4IR_R) H1	-0,059	0,032	-0,080	-1,860	0,064	-0,087	-0,105	-0,076	0,898	1,113
	adaptation capability (4IR_AC) H2a	0,090	0,045	0,109	2,006	0,046	0,142	0,114	0,082	0,563	1,775
	sensing capability (4IR_SC) H2b	-0,064	0,043	-0,075	-1,477	0,141	0,071	-0,084	-0,060	0,647	1,546
	investment capability (4IR_IC) H3a	-0,108	0,045	-0,127	-2,411	0,016	0,167	-0,136	-0,098	0,602	1,662
	usefulness capability (4IR_PUC) H3b	0,102	0,044	0,126	2,298	0,022	0,275	0,130	0,094	0,555	1,801
	4IR quality planning Role (QP_R) H4a	-0,083	0,049	-0,089	-1,698	0,090	-0,009	-0,096	-0,069	0,602	1,661
	4IR quality control Role (QC_R) H4b	-0,040	0,046	-0,046	-0,870	0,385	0,147	-0,050	-0,035	0,596	1,677

institutional responsiveness expectancy (IRE)H5a	0,301	0,054	0,290	5,598	0,000	0,494	0,304	0,228	0,617	1,620
Institutional Empathy expectancy (IEE)H5b	0,129	0,050	0,139	2,552	0,011	0,484	0,144	0,104	0,561	1,784
Institutional Reliability (IRP) H6a	0,066	0,058	0,062	1,151	0,251	0,454	0,065	0,047	0,573	1,744
Institutional Assurance (IAP)H6b	0,375	0,054	0,369	6,890	0,000	0,563	0,365	0,281	0,579	1,726
4IR Awareness (4IR_AWS) H7	0,070	0,040	0,081	1,767	0,078	0,220	0,100	0,072	0,781	1,280
a. Dependent Variable: Quality Improvement (QI)										

The hypothesis analysed resulted as follows:

Majority of the hypothesis (75%) were accepted at a significant level varying between $P < 0.1$; $P < 0.05$, $P < 0.001$ based on the regression results. However, the moderators (age, gender, study level) did not indicate any significant influence on service quality improvement. Table 5.28 depicts a summary of the regression model.

Table 5.24: Summary of Regression Model

Hypothesis	Independent variable	Significance level	Result
H1	4IR_R	< 0.1	Accepted
H2a	4IR_AC	< 0.05	Accepted
H2b	4IR_SC	-	Not Accepted
H3a	4IR_IC	<0.05	Accepted
H3b	4IR_PUC	<0.05	Accepted
H4a	QP_R	<0.1	Accepted
H4b	QC_R	-	Not Accepted
H5a	IRE	<0.001	Accepted
H5b	IEE	<0.05	Accepted
H6a	IRP	-	Not Accepted
H6b	IAP	<0.001	Accepted
H7	4IR_AWS	<0.05	Accepted
DV: QI			

5.11. Structural Equation modelling (SEM)

SEM approach was used to examine the structural relationship between the constructs of the study (Hair et al., 2021; D. Suhr, 2006). In other words, the multivariate causal relationships were analysed to confirm the hypothesis (Fan et al., 2016).

Model fit indices of the measurement model.

At this stage, the CFA was run for the entire model to establish the model's fitness (Brown, 2015). All the relationships between the latent variables were assessed for it to confirm the regression analysis. The model contained sixty-two items explaining thirteen latent variables. Analysis of Moment of Structures (Amos) in SPSS version 29 software was used for computing the CFA. The goodness-of-fit-measures were determined by inspecting the absolute fit and incremental fit measures. The absolute fit indices were determined by the Chi-Square (χ^2), goodness-of-fit index (GFI), adjusted goodness of fit index (AGFI), the Root mean square residual (RMSR) and Root mean square error of approximation (RMSEA). Whilst the incremental fit measures were determined by the Tucker Lewes index (TLI), comparative fit index (CFI), and incremental fit index (ILI). Concerning the goodness of fit indices, literature suggests that a value closer to 0.1 for GFI and AGFI indicates a good fit while a value closer to zero indicates a badness of fit.

The initial run of the CFA resulted in an inadequate measurement model fit. Therefore, modifications were performed to improve the fit indices by inspecting the factor loadings, standardised residual matrixes, and modification indices. All factor loadings were above 0.5. However, factor loading of 14 items had a weak squared correlation (< 0.2) which were deleted. The CFA of the modified measurement model was rerun and resulted in a successful model fit as depicted in Table 5.25. It should be noted that although the chi-square is expected to have an insignificant value preferably ≥ 0.05 , it is sensitive to a large sample size, therefore alternative index of Parsimonial Fit (CMIN/DF or χ^2/df) was consulted. The GFI (0.848) and AGFI (0.817) were closer to one respectively. The rest of the indices met the minimum threshold of acceptable fit. The AVE of each loaded construct was greater than 0.5. While the composite reliability varied between 0.809 – 0.896. Therefore, the model was fitted for the SEM.

Table 5.25: measurement model fit indices (source: D. D. Suhr, 2006b)

N	Measure	Suggested cut-off indices	Value
1	X^2	$P \geq 0.05$; $df \geq 0$	1485.0; $p=000$; $df=979$
2	X^2/df	< 5	1.517
3	CFI	≥ 0.90	0.936
4	TLI	≥ 0.90	0.927
5	RMSEA	< 0.05 or between 0.05-0.08	0.040
6	SRMR	< 0.10	0.446

Model fit indices of the SEM.

The SEM approach was equipped to examine the overall fit of the structural model as part of the confirmatory factor analysis. The findings revealed that some of the fit indices did not meet the minimum acceptable criteria, showing that the model had a close fit. The parsimonious fit index (CMIN:DF) was acceptable having a value of 1.865 which is less than the critical value of 5. The CFI being 0.891 and TLI being 0.877 were not acceptable but were close to 0.95. The absolute fit index in terms of RMSEA indicated a fair fit model as it was found to be 0.052 (<0.08) (LO 90: 0.048; HI 90: 0.056), while SRMR was 0.1209 being a little above 0.10. The structural model with the estimations (factor loadings, communalities, and correlations) is depicted in Figure 5.13. The model explained 44% of variance in quality improvement through 4IR in tertiary institutions from the stakeholder's viewpoints. The findings indicated six positive significant predictors: awareness, institutional empathy, institutional responsiveness, institutional assurance, adaptation capability and perceived usefulness capability. While three predictors were negatively significant: investment capability, readiness level and quality planning role. On the contrary, three relationships were not significant: sensing capability, quality control role and institutional reliability.

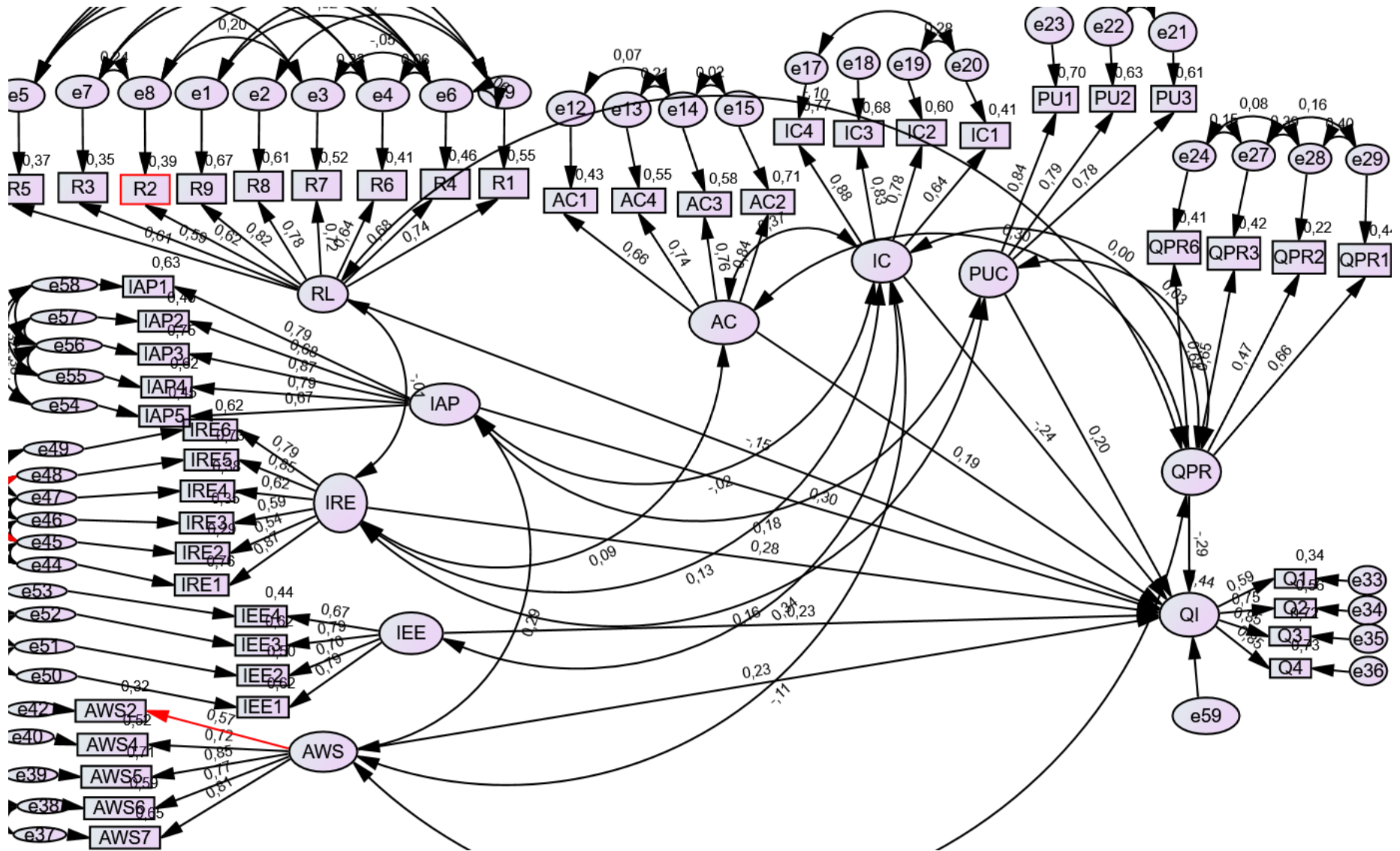


Figure 5.13: The structural model with factor loadings and variances.

The path analysis illustrated the various paths being significant at $p < 0.001$, $P < 0.005$, and $p < 0.05$. The estimates of the paths between the hypothetical variables are presented in Table 5.26. In comparison to regression output, majority of hypothesis were significant at $P < 0.005$ except for H_{2a} which was significant at $p < 0.05$. The C.R values presented in table 5.26 were higher than ± 1.96 , indicating normality.

Table 5.26: Standardised and unstandardised.

Hypothesis	Path		B	β	S.E	C.R	p	Supported
H1	QI	<--- 4ir_R	-0.069	-0.150	0.024	-2.850	0.004**	YES
H2a	QI	<--- 4ir_AC	0.126	0.193	0.046	2.725	0.006*	YES
H3a	QI	<--- 4IR_IC	-0.147	-0.239	0.043	-3.388	***	YES
H3b	QI	<--- 4ir_PUC	0.133	0.202	0.040	3.305	***	YES
H4a	QI	<--- QPR	-0.223	-0.286	0.069	-3.234	0.001**	YES
H5a	QI	<--- IRE	0.198	0.284	0.045	4.392	***	YES
H5b	QI	<--- IEE	0.183	0.231	0.057	3.219	0.001**	YES
H6b	QI	<--- IAP	0.260	0.304	0.055	4.701	***	YES
H7	QI	<--- 4ir_AWS	0.138	0.230	0.042	3.320	***	YES
*** Significant $P < 0.001$ ** Significant at $P < 0.005$ * Significant at $P < 0.05$								

5.12. Chapter summary

This chapter highlighted through various sections the quantitative findings collected from the three sets of participants compiled through SPSS and AMOS and examined the key factors of 4IR technologies in improving service quality at tertiary institutions. It began with descriptive analysis of the survey data, then assessed the assumptions of inferential statistics (i.e. screening missing data, outliers, linearity, and normality). The reliability and validity of the research constructs were assessed to establish significant association between the dependent variable and independent variables. Methods such as factor analysis (principal component analysis) and regression analysis were employed. Three constructs initially included in the conceptual framework were eliminated as no significance was established. The remaining constructs met the reliability and validity criteria. The process of structural equation modelling revealed an adequate fit model satisfying most of the critical indices. The path analysis assisted in verifying the hypothesis of nine path relationships.

CHAPTER SIX: DISCUSSION AND PROPOSED FRAMEWORK

6.1. Introduction

The previous chapter presented the findings of the study, where in the research model for a 4IR based service quality improvement was validated. After obtaining the analysis, this chapter seek to discuss the key results affecting the applicability of 4IR among stakeholders at the selected tertiary institution. This chapter will also determine if the research questions as presented in the first chapter of the study were answered. A descriptive method will be used to provide clarity of the study results and synthesize them with relevant literature. The various explanations emerged in this chapter may assist in eliminating challenges towards understanding the key findings. Thereafter, a research framework is proposed to assist in improving service quality via 4IR technologies based on findings gathered.

6.2. Discussion of the Findings

As highlighted in chapter one, the main aim of this research was to investigate the applicability of 4IR in service quality improvement within the context of tertiary institutions (with the University of Venda as a case) and propose a framework to implement 4IR in teaching, learning and research. The subsequent sections addressed the main findings in line with the research questions.

6.2.1. 4IR Capabilities Required for Service Quality Improvement.

RQ1: What are the 4IR capabilities tertiary institutions need to develop for enhancing quality of service?

This research question was answered by identifying the various institutional capabilities highlighted by the respondents to be required for the successful improvement of service quality through 4IR. The institutional capabilities were classified into four categories namely: 1) adaptation capabilities, 2) sensing capabilities, 3) investment capabilities and 4) perceived usefulness capabilities. The four independent variables resulted in the following hypotheses being tested:

H2a: There is significant relationship between the tertiary institution's capability to adapt 4IR and service quality improvement.

H2b: There is significant relationship between the tertiary institution's capability to sense new 4IR technologies and service quality improvement.

H3a: There is a significant relationship between the tertiary institution's capability to invest in 4IR technologies and service quality improvement.

H3b: There is a significant relationship between the tertiary institution's capability to use 4IR technologies and service quality improvement.

The findings revealed that three variables were found to be significantly influencing service quality improvement. With adaptation capability being significant at $P < 0.05$, while investment capability and perceived usefulness capability being significant at $P < 0.001$.

Adaptation capability for this study refers to the tertiary institutions' ability to identify and capitalize on new technology. It can be asserted that for any new technology to be implemented successfully within a specific environment, its users ought to be capable of adapting it. The requirement of highly adaptive methods for the effective implementation of 4IR technologies is also highlighted by (Tassiopoulos & Gastrow, 2018) in their report. As also noted by (Sinxadi et al., 2021), it can be implied that strengthened adaptive capabilities results in a faster pace of adaptation which in turn leads to a high chance of sustainable survival. (Oliver, 2022) have recognized the essence of willingness of tertiary institutions in adapting newer models for inclusivity in the 4IR environment in collaboration with government and industry partnerships. The concept of adaptive performance has been highlighted by the study of (Adekanmbi & Ukpere, 2022) as a critical factor in addressing the changing roles of employees raised by the demands of new technologies. (Xing et al., 2018) identified adaptive approaches such as accessible environment, accessible curriculum, digital fluency, digital literacy, accelerated learning and professional development, transformation, and inclusiveness, for tertiary institutions to quickly adapt to 4IR. It is therefore suggested that tertiary institutions ought to reinforce institutional capabilities to enable a 4IR support environment for quality service delivery.

Additionally, with the ability to make adequate investments in 4IR implementation, significant changes in service delivery could occur. This directs tertiary institutions to reliably estimate sustainable investments in 4IR projects. This study found that technology investments, government fundings, training programs investments, and 4IR entrepreneurship investments were determinants of 4IR investments in the selected institution. Similarly, in the study of (Benassi et al., 2020), the association between 4IR investment capabilities and firm performance pointed that although technological

investments are significant, it could only benefit process efficiency with little economic benefits.

Furthermore, it is possible that newer technologies have been implemented within some organizations without any relevant use of it. Therefore, the finding indicated that recognizing the usefulness of a particular 4IR technology prior to implementation could positively enhance service quality. Perceived usefulness has been investigated in previous studies (Al-Hattami, 2023; Almaiah, Alfaisal, Salloum, Al-Otaibi, et al., 2022; Alyoussef, 2023; Edumadze et al., 2022; Kampa, 2023b; Panday, 2018) resulting as a significant factor contributing to the acceptance of numerous emerging technologies. As also indicated by (Adarkwa & Oppong, 2023), perceived usefulness has been relevant in ICT for education from the perspectives of stakeholders, and as such, have been shown to be relevant for 4IR technologies within tertiary institutions through the current study. Agreeing to the study of (A. Oke & Fernandes, 2020), establishing perceived usefulness within tertiary institutions is required to predict the attitudes towards 4IR adoption to which in turn the current study reasons in determining its applicability for service quality improvement. Therefore, tertiary institutions ought to recognize value in terms of the usefulness of implementing 4IR which require less effort and enhance research capacities, teaching, and learning.

However, the tertiary institutions' capability to sense the need for 4IR was found to be insignificant for this study, meaning it does not have any evidence of impact towards service quality improvement.

6.2.2. 4IR Role in Service Quality Management

RQ2: To what extent is 4IR contributing to increased quality of teaching, learning and research processes?

This research question was answered based on three characteristics: 1) Quality planning, 2) Quality assurance, and 3) Quality control. Embedding quality in all areas of the institution including teaching and learning is required for customer satisfaction. Accordingly, the effective implementation of 4IR based quality planning, quality control and quality assurance activities becomes self-automated in the quality management process for delivering high service quality (Sony et al., 2020b). This study showed the importance of a 4IR based service quality management system within tertiary institutions

for better quality processes and governance. The findings indicated that among the three quality factors for this dataset, only quality planning influenced service quality improvement at a significant level of 0.005.

Various studies have explained the significance of quality planning in the quality management process. (S. H. Park et al., 2017) identifies that value creation relies on the planning dimension of quality management and highlighted the significance of a personalised service quality which demands for mass customisation. Their study coined the term “open quality” entailing diverse technologies for obtaining quality excellence which comes along the utilisation of Big Data, IoT, and Artificial Intelligence. (A. M. Carvalho et al., 2021) alluded that 4IR technologies can improve quality planning capacity, making it an important prerequisite for quality improvement. The key features of quality 4.0 planning include technology, people, and process. (Bahitham et al., 2021) opined that adequate quality 4.0 planning for teaching, learning and research is dependent on collaboration, culture, leadership, and competencies. Previous study by (Alzahrani et al., 2021) suggested that predictive analysis and social media become significant factors for quality planning and enhancing tertiary institutions performance. This is also in alignment with the investigation of which captured social media, big data, and predictive analysis as essential tools of quality planning (plan 4.0).

Although the respondents in this study believed quality planning could have a significant impact on service improvement, there was a negative significant relationship which could reflect that the institution is not active in terms of quality 4.0 planning. It should also be realised that compulsory use of quality 4.0. enabled technologies could prove to be effective if the relevant personnel understand the “know how” of it. Consequently, the IT staff indicated that the tertiary institution should facilitate enhancing capabilities required for: assessment of user needs, management of service levels, design, and delivery of service, monitoring of service, helpdesk service support, and creation of service-oriented culture. It can be alluded that with the necessary resources equipped, the traditional quality planning processes as such can be shifted to agile data driven processes. Additionally, it is implied that 4IR can make a visible difference to quality planning by utilising evidence-based decision making due to the possibility of real-time data availability. Therefore, it is suggested that a 4IR-based quality culture be promoted within the institution for better service delivery.

H4a: the 4IR quality planning has a significant influence on quality improvement.

The research of (Kennedy, 2021), explained that quality assurance needs to be transformed for resolving the current social, political, and economic challenges, while it argued that a lack of evidence in tertiary institutions responding to these challenges exists. An adaptive quality assurance environment demands instant availability of information, multiple device connectivity, increased processing capabilities, and innovative interactions. With a similar view, (Ali & Johl, 2022) and (Mtotywa, 2022) established a link between TQM practices and Quality 4.0. The quality 4.0 based quality assurance process has been abstracted by (Radziwill, 2018b) entailing inspection, design, empowerment, and discovery as core elements. This indicates that a total institutional involvement is promoted, that is, departments and faculties must be integrated as one unit internally and externally for enhancing end-to-end feedback through 4IR tools leading to a free flow of information for decision making.

Previous study by (Lodi et al., 2022) highlighted factors such as compliance, competencies, leadership, collaboration, connectivity, culture, web apps, integration, data, and analytics as significant for quality 4.0 assurance process for higher education institutions. The study of (Ülker, 2023) aligned with this study in that TQM for a university 4.0 environment require quality culture incorporated strategically and promote quality improvement via systematic feedback from stakeholders. While (Ramirez, 2018) signifies the findings of this study in viewing quality assurance through sustainability standards of obtaining quality education by adapting to a fast-changing environment. Therefore, Quality assurance teams are to systematically disseminate sustainability standards and align it to their teaching and learning vision and mission. It is suggested that tertiary institutions with their quality assurance teams rethink the role of 4IR technologies in accommodating Quality 4.0 assurance processes.

According to (Javaid et al., 2021), Quality 4.0 demands the digitisation of quality control processes through holistic approaches following an organised quality control strategy using technologies such as cyber physical systems, big data, and artificial intelligence. The study of (Rumagit et al., 2023) identified strategies for effective higher-education quality control in industry 4.0 using a swot analysis technique, which revealed the use of technology to monitoring and evaluating educational processes among academic and administration; encouraging a continuous quality improvement culture. (Hattinger &

Stylidis, 2023) explained that IoT and AI are equipping organisations to gather extensive data about services and its related processes. This could assist tertiary institutions in understanding quality issues within their teaching and learning processes and activities together with its monitoring and control in real time leading to an automatic alignment of quality standards. Based on previous research such as by (Apoorva et al., 2021), it can be realised that technologies like Big Data can contribute in gathering feedback from social media pages of tertiary institutions allowing to keep track of service opinions adding value to the service delivery process. Similarly, with IoT, student and academic performance can be monitored instantaneously to fulfil the specified quality standards outlined in the quality management process. While 24/7 availability of teaching and learning platforms can be guaranteed through cloud computing which further increases the quality of information. Yet, several challenges persist in the implementation of quality 4.0 in general including lack of processing capacities, lack of quality information feedback and system lack of human connectivity, and poor technology applications, which would act against a 4IR based quality management implementation (Godina & Matias, 2019).

For this study quality assurance and quality control dimensions resulted insignificant in regression analysis, hence, it is recommended that the scale be improved for future studies.

6.2.3. 4IR Challenges and Benefits

RQ3: How do the challenges and benefits of 4IR affect the quality of service in teaching and learning, and research?

This research question was answered by discovering various challenges of 4IR adoption from the perspectives of the respondents. (Lubinga et al., 2023b) explained that the adoption of 4IR technologies in higher education is not only influenced by perceptions of the users but also the obstacles it brings. Their study identified factors such as complexity, incompatibility, digital skills gap, and conflicting views as obstacles of 4IR adoption. Digital colonialism, digital divide and human driven change caused by 4IR creates unequal opportunities for students and academics increasing threat of foreign powers (Maringe & Chiramba, 2022).

In this study, the findings presented in chapter five showed that the students and academics felt a 4IR based service quality could be significantly affected by factors such

as inability to adapt, cost concerns, fear of change, technical difficulties, lack of infrastructure and devices, lack of skills and knowledge, lack of internet connectivity and privacy/security concerns. This creates an inverse effect on technology adoption and service quality improvement. The findings conform to the study of (Nwosu et al., 2023), which identified similar challenges of 4IR within the teaching and learning context in South Africa. It can be implied that the most significant impact will be caused by inability to adapt to 4IR (12.1%) and lack of trust in new technologies (13%). However, the research does not imply other challenges to be of least significant as it only referred to opinions of individual participants of this study. (Mhlanga et al., 2021) and (Mamphiswana & Bekele, 2020) concluded that 4IR innovations are associated with challenges such as lack of resources, infrastructure, and skills gap in the context of service delivery in Africa.

(Moila et al., 2020) established a lack of 4IR tools as a significant challenge for academics in adapting 4IR, while (Nkosi, 2021) identified lack of technology and teaching proportion, lack of stakeholder communication, poor SRC interference, and poor technology application as 4IR challenges in higher education. (Shonhe et al., 2023) identified non-compliance, inadequate facilities, inadequate lecturer interactions, resources, and support as some of the challenges faced by students which affects their ability to engage with 4IR technologies. Therefore, the adoption of 4IR depends on eliminating such challenges. Previous studies in general have identified multiple similar barriers in South African and global context, confirming the findings of this study (Alexander, 2022; Maphosa & Maphosa, 2023). Hence, it is suggested that tertiary institutions draft innovative policies for teaching and learning methodologies, 4IR curriculum development, and knowledge production to counter these challenges within the education ecosystem.

On the other hand, the research question also sought to explore the benefits tertiary institutions could receive in terms of service improvement through 4IR technologies. These benefits were investigated based on the opinions of students and academics within the context of teaching and learning. The following benefits were identified: personalized teaching and learning, improved research opportunities and facilities, improved access to educational resources, collaboration and career readiness, flexibility and enhanced engagement, experienced based teaching and learning support, efficient communication, improved student services and real time feedback. These benefits will ensure delivery of equal and quality education in developing countries and rural based tertiary institutions. Most of the respondents were of the opinion that experienced based learning (12.8%)

and personalized teaching experience (13%) could be highly beneficial. However, many emerging technologies in teaching and learning are more focused on technical capabilities than educational capabilities causing difficulties in engaging 4IR tools, posing more of a challenge than benefit (Nwosu et al., 2023). (Kruger & Steyn, 2024) explained that the realization of 4IR benefits is majorly dependent on the capabilities of countries and citizens for effective innovation. Similarly, the benefits of 4IR rely on the capabilities of tertiary institutions and its stakeholders for effective innovation in a university ecosystem. The finding concurs with (Shonhe et al., 2023), a recent study which looked at students 4IR experiences in online learning. Previous research by (Nkosi, 2021) also explained 4IR benefits such as improved academic performance, financial growth, new learning opportunities and social and economic development as some of the benefits of 4IR in higher education institutions.

It is implied that meeting individual's tailored service requirements can create a positive influence towards a better service quality experience. This also promotes the concept of engaged university. Amongst the technical advantages recognized by the IT staff were improved decision making, increased agility, improved communication, and improved productivity with improved user experiences shown to be the most significant. It should be noted that tertiary institutions are required to pay more attention towards improving user experiences with 4IR as this was shown to be a highly influential factor measuring service quality amongst the three segments of respondents.

6.2.4. Expectations, Perceptions and Awareness of 4IR

RQ4: Are the stakeholders of tertiary institutions aware of 4IR and how do they perceive the application of 4IR technologies?

Multiple studies have used the extended variations of the Servqual model to assess service quality and satisfaction of stakeholders (Kamakoty & Singh, 2023; Rahmat et al., 2022; Soares et al., 2017; Sohail & Hasan, 2021). In the 4IR subject, a recent extension known as P-Servqual 4.0 (Pandemic-Servqual 4.0) was conceptualized by (Tumsekcali et al., 2021b) for the public transportation service quality evaluation in Istanbul. (Entifar et al., 2022) applied the modified version of P-Servqual 4.0 model to evaluate customer satisfaction and loyalty in online food delivery services in Indonesia, while (Garside et al., 2023) applied to evaluate online transportation quality. Research by (Rahmat et al., 2022) discussed the performance of university 4.0 within the context of learning management

system improvement using the E-Servqual model and measured the gaps between expectations and perceptions of service quality, the findings of which indicated a significant relationship between service quality and performance improvement.

The primary principle for assessing service quality requires a comprehensive enforcement and meeting of student's expectations (Foropon et al., 2013). The expectation that using 4IR technologies improve service tangibility, reliability, responsiveness, assurance, and empathy are enablers of teaching and learning quality improvement. Therefore, the expectations of stakeholders in terms of 4IR were measured through five constructs: 1) tangibility, 2) reliability, 3) responsiveness, 4) assurance, and 5) empathy. However, two factors best represented the expectations variable based on the SEM assessment. The findings revealed that responsiveness and empathy positively influenced service quality improvement at a significant level of $p < 0.001$ and $P < 0.005$ respectively. The study aligns with that of (Nurani & Sari, 2023), which established a positive significant relationship between empathy and quality improvement, while (Setiawan & Ayuningtyas, 2022) found responsiveness to have a significant effect on satisfaction.

The outcome implies that the stakeholders are most likely to accept the application of 4IR technologies in their day-to-day tasks provided that their service quality expectations are met, as 72.2% of respondents have indicated to be aware of 4IR technologies. It is important for tertiary institutions to realize that a delay in providing 4IR based service delivery may create a negative impact on service quality. Therefore, this study recommends that it is critical to assess current trends and respond accordingly. This also means that the 4IR based service management should be implemented with simplicity and eliminating its complex nature since respondents have cited inability to adapt as a major challenge of adoption. Moreover, the results indicate that it is expected from the tertiary institutions to provide individual attentions to the needs of students and staff. This means that the institution is expected to understand the 4IR needs and interests of its stakeholders. For sustaining these expectations, it is required from the tertiary institutions to meet the demands of a smart campus environment. That is to introduce facilities for promoting education 4.0, research 4.0, University 4.0, and curriculum 4.0.

H5: expectations of 4IR have a significant influence on perceived service quality improvement of T&L through 4IR technologies.

- **H5a:** institutional responsiveness has a positive influence on service quality improvement.
- **H5b:** institutional empathy has a positive influence on service quality improvement.

The perceptions of stakeholders on 4IR were also measured through five constructs: 1) tangibility, 2) reliability, 3) responsiveness, 4) assurance, and 5) empathy. Upon the SEM assessments, these constructs were further reduced to two constructs, namely reliability and assurance. The findings revealed the relationship between assurance and service quality improvement was significant at $P < 0.001$, while reliability was shown to be insignificant. This proves that not all quality dimensions would positively influence quality improvement. The finding relates to the previous study of (Magasi et al., 2022b), which identified the assurance dimension to have a positive significant relationship with service quality satisfaction in higher education. It is implied that innovation in teaching and learning through 4IR is perceived to assure a less complicated personalised service delivery. It is established that the respondents are confident with the knowledge of academics and support staff in contributing to positive service delivery. However, it is assumed that due to issues such as loadshedding and connectivity problems, the users may not find online technologies to be reliable.

H6: perceptions of 4IR have a significant influence on perceived service quality improvement of T&L through 4IR technologies.

- **H6b:** institutional assurance has a significant influence on perceived service quality improvement of T&L through 4IR technologies.

The success, use and adoption of technology applications are popular topics in IS research. Therefore, awareness of innovative technologies for teaching and learning connects tertiary institutions in determining the procurement of suitable technologies for realizing their positions in initiating 4IR activities (Denhere & Moloji, 2021a). Previous research has recognized the essence of awareness in emerging technology preparedness and adoption (Al-Maskari et al., 2022; Bakama et al., 2022; Ugonma et al., 2022; Ujakapa et al., 2020). Hence, awareness becomes a critical factor in predicting the suitability of 4IR use within the context of teaching and learning. From the descriptive statistics, more than 50% of participants were aware of basic 4IR concepts, facilities,

accessibility, trainings and workshops, resources, risks, and their implications. However, only the IT personnel were aware of the 4IR policies and framework requirements. The findings from the SEM assessment revealed a significant correlation between awareness of 4IR technologies and quality improvement ($p < 0.001$). Although students and academics were shown to be aware of 4IR technologies, the knowledge in its practical application is yet to be introduced. The finding emphasizes that assessing the awareness levels of stakeholders is required for introducing 4IR technologies within tertiary institutions. This means they need to be aware of the various options of 4IR technologies to choose from to support teaching and learning.

It is alluded that the higher the level of 4IR awareness among stakeholders, the higher it will facilitate service quality improvement. It is suggested that tertiary institutions establish committees for tracking 4IR progress and impact on a continuous basis. Contribution can be made by recognizing the significance of awareness and service quality improvement by facilitating workshops, seminars, meetings, and orientations which will increase the stakeholder's confidence and understanding of 4IR. A holistic understanding of the role of 4IR awareness in service quality improvement can enable tertiary institutions to enhance quality.

H7: Awareness has a significant influence on perceived service quality improvement of T&L through 4IR technologies.

6.2.5. Measures for enhancing service quality via implementation of 4IR.

RQ5: What measures should be put in place to enhance the quality of services through the implementation of 4IR technologies in tertiary institutions?

Critical Success factors

To answer this research question, the researcher first investigated the critical success factors that can assist tertiary institutions in realising what is required for enabling 4IR technologies to bring a positive change in quality service provision. The findings depicted that most importantly, tertiary institutions are required to establish partnerships with industries such as government, research institutes and industry experts to build a powerful network/team of knowledge generation in the field to accelerate 4IR innovations. This must come with a seamless communication and development of trustful relationships. Additionally, tertiary institutions should avail infrastructure support by

upgrading the current ICT infrastructure to advanced infrastructure since the operation and sustenance of any technology requires adequate infrastructure, while a deficiency may negatively affect service quality.

The trends of 4IR are such that it requires continuous training for enabling a significant transformation in service quality. While the appropriate use of any 4IR technologies by students, academics and staff also depends on trainings, the results indicated a need for institutions to offer training programs which are critical to 4IR capabilities. Another CSF highlighted by participants was support from the leaders. Effective leadership is required for driving 4IR strategies through digital leaders responsible for enabling transformations in teaching and learning. It can be implied that new management practices in the form of leadership 4.0 are required for keeping up with the pace of the change in service quality standards. It is suggested that tertiary institutions provide continuous professional development for their leaders to learn more about 4IR-based service delivery.

The participants had also highlighted the need for skilled staff and experts as a significant CSF. A lack of qualified personnel may affect the productivity and preparedness of students in a smart learning environment causing a significant skills gap. Tertiary institutions must communicate with stakeholders on the skills required in remaining relevant to 4IR. Workforce programs can be developed for reskilling and upskilling academics and staff with the appropriate set of skills needed to adapt to change caused by 4IR technologies and leverage their application in teaching and learning. The findings therefore suggests that tertiary institutions need to ensure 4IR skills are integrated and aligned with curriculum 4.0 for ensuring highest service quality. Additionally, it is also important for tertiary institutions to allocate funding for implementing 4IR technologies within their financial sustainability plans. Failure to acquire necessary funding and resources to invest in 4IR technologies may cause tertiary institutions to remain behind.

The respondents have shown the desire to have facilities such as 4IR labs, smart classrooms, innovation hubs, virtual reality, and augmented reality simulations. Lastly, the views of IT personnel expressed that, for harnessing the benefits of 4IR developments, a policy framework must be formulated for providing a direction and sense of governance within the adoption of 4IR. These policies are required to be developed in alignment with the service quality policies to achieve service quality goals. Overall, it is suggested that these CSF must work together and receive equal effort in order to facilitate

a valuable 4IR adoption process. These findings coincide with various studies and reports highlighting CSFs of innovative technologies including 4IR in various contexts and sectors (Al-Maskari et al., 2024; Baijnath, 2021; Bongo et al., 2020; Daud, Wan Hanafi, & Mohamed Othman, 2021; Daud, Wan Hanafi, Rajadurai, et al., 2021; Govender, 2019; IEEE SA, 2021; L. Li, 2022; A. L. Marnewick & Marnewick, 2019, 2020; Miah et al., 2024; Muridzi, 2023; O. Olaitan & Mavuso, 2022; Osunsanmi et al., 2023; Pienaar, n.d.; Shilenge & Telukdarie, 2021; Suferi & Rahman, 2021; Tsiligiris & Bowyer, 2021; Uleanya, 2023).

Drivers

Establishing drivers of implementing 4IR technologies assisted in realising what could motivate the tertiary institutions to show interest towards 4IR. The findings revealed that keeping up with the demands of student's and stakeholder's needs can lead to an efficient service delivery. This could include introducing the concept of Education-as-a-Service, enabling students and academics to experience a holistic education system. This goes along with competitive advantage as a critical factor of 4IR adoption. 4IR technologies can be utilised to enhance competitive advantage as new opportunities will be explored for improving educational services. It is suggested that tertiary intuitions keep up with the trends of service 4.0 along with offering a blended service model which can increase the educational value chain.

Consequently, 4IR have a significant impact on industry workforce demand. The results highlighted that respondents believe their institution must introduce 4IR to prepare students with an industry ready workforce. For the tertiary institutions to promote growth, an increase in service quality is encouraged. The study also revealed that a potential driver of 4IR adoption is innovation. A lack of innovation capability may cause tertiary institutions to fail in restructuring their educational models. It can be implied that innovation can be driven with a change in curriculum to accommodate project based and experiential learning. Furthermore, globalization serves as a driver 4IR playing a significant role in enriching diversity by encouraging cross-cultural competencies. The concept of globalisation 4.0 must be capitalized to accommodate internationalization of research and curriculum and promote global networks amongst students and academics. This is because globalization 4.0 is altering knowledge creation and dissemination.

Developing 4IR capacities for future education require financial support and investments from various agencies, industry partners and government programs/subsidies. It should be noted that specific grants from funding agencies and governments may only prioritise allotment to institutions initiating 4IR projects and require meeting the criteria for qualifying. It is alluded that accessibility to funding can enable tertiary institutions in covering the costs of upgrading technological infrastructure and creation of digital facilities for teaching and learning environment. Moreover, regulatory bodies may require tertiary institutions to integrate 4IR technologies into the curriculum for quality assurance and enhanced research outcomes. 4IR can also enable tertiary institutions to achieve sustainable development goals.

In line with the United Nations sustainable Development Goal no. 4, a sustainable education system requires taking education to students than bringing students to education for promoting the concept of immersive lifelong education. Quality education is a critical component requiring strategic priority for global sustainable development targets. Therefore, tertiary institutions ought to create significant improvement amongst the following sustainability indicators: Environmental sustainability (green technologies), social sustainability (community services), and economic sustainability (entrepreneurship). The drivers identified in this study also resonates with previous studies and reports which have identified the significance of a combination of these drivers in terms of 4IR adoption (Alexander, 2022; Ally & Wark, 2020; Chinyamunji et al., 2022; Cowin, 2021; KPMG, 2020; Lubinga et al., 2023; MITI, 2018; Mukherjee & Sarma, 2022; Nabi & Zohora, 2022; Oke et al., 2023; Oliver, 2022; Pezzuto, 2019; Pramjeeth et al., 2023; Ramirez, 2018; Sackey & Bester, 2016; Siekmann et al., 2023; Xing & Marwala, 2017; Yende, 2021).

Readiness Levels

The researcher also measured the 4IR readiness level of the institution to determine the current state of 4IR implementation within the teaching and learning context. Thereafter, a framework be proposed as a measure for improving quality of service. A total of nine indicators were used to measure the case institution's readiness level in terms of 4IR. Assessing the readiness will assist tertiary institutions to identify the conditions needed for the 4IR opportunities to be materialized.

In terms of management support, many respondents believed leaders at the institution were willing to welcome 4IR technologies. Tertiary institutions are required to assess the extent at which their vision and mission address the implementation of 4IR. This includes reassessing their strategic goals, resources, investments, and significance granted in enhancing teaching and learning, research, and development through 4IR. Welcoming 4IR technologies comes along with its own risks and challenges, therefore, tertiary institutions must prepare management in navigating these risks and challenges. Furthermore, tertiary institutions ought to assess management's mentoring capabilities to empower students and academics in the field of 4IR.

One of the readiness indicators was found to be developing strategies for 4IR initiatives. The current results showed that less than 50% respondents believed their institution has any strategies concerning 4IR indicating that the institution may have a limited 4IR plans. Strategies are also required concerning students and academics involvement in 4IR projects as direct receivers of service. Consequently, less than 40% of the respondents believed their institution has and processes for governing effective 4IR management. This requires processes concerning decision making and policy development for providing a value-based service delivery in teaching and learning. Processes that assist functionality of the tertiary institutions in an innovative educational environment must be drafted. This includes digitization of processes, integration processes, administrative processes, and agile change management processes to be reassessed. Benchmarking with other institutions could assist in developing simplified processes for governing 4IR technologies. Also, processes for policy making and decision making for establishing the use of 4IR in teaching and learning must be embedded into existing processes.

Effective programs are required for change management (internal and external) caused by 4IR implementation. Lack of clear change management process may create interoperability challenges and cause the 4IR initiatives to struggle. The participants believed their institution is prepared to introduce change management programs to facilitate the adoption of 4IR. The results further indicate that identifying the need for 4IR projects grants some level of preparedness in responding and scaling opportunities presented by 4IR trends. Projects including specialised qualifications in AI, cyber-security, 3D printing, robotics as well as providing its application and relevance in other

degrees may increase service quality. It is implied that 4IR can also aid in scaling entrepreneurship opportunities via service innovation benefiting stakeholders.

Accordingly, the findings revealed that tertiary institutions are required to assess the availability of skilled technicians and experts who will lead the 4IR initiatives (including academics and students). This means that the institution must introduce programs for developing the skills and knowledge of university's staff and employees which will allow the education system to produce human capital ready for smart working environment. While respondents were positive about their institution's preparedness in offering trainings and development for cooperating with 4IR implementation, it is significant for tertiary institutions to encourage participation of its stakeholders in conferences, workshops, research, and seminars related to 4IR for increasing their understanding on the practical aspects of 4IR. However, the study highlighted establishing 4IR partnerships with government, other tertiary institutions, and industries as a measure to assess 4IR readiness. The participants may have a believe that support from the government may push tertiary institutions to leverage opportunities presented by 4IR. The role of government may include establishing 4IR regulations and funding for 4IR teaching and learning practices, while industry partners may provide accessibility to 4IR technologies including infrastructure support.

Overall, a limited readiness of 4IR was found in the case institution. Previous studies have since shown the critical role of these 4IR readiness assessment measures for determining preparedness of organizations towards 4IR in various contexts (Al-Maskari et al., 2022; Awodiji & Naicker, 2023; Denhere & Moloji, 2021b; Fahim Faisal et al., 2023; Genesis Analytics & Pathways for Prosperity, n.d.; Harlan & karabo, 2019; Hizam-Hanafiah et al., 2021; Kalema & Mokgadi, 2017; Maisiri & van Dyk, 2019b; C. Marnewick & Marnewick, 2020; Ngemera Nfuka & Nfuka, 2023; O. O. Olaitan et al., 2021; Sami et al., 2022; Singaram et al., 2023; Smart Transformation, 2023; SME Corp, 2021; WEF, 2019).

6.3. Fourth Industrial Revolution Service Quality Improvement (4IRSQI) Framework within Tertiary Institutions.

The research developed a framework coined 4IRSQI Framework within Tertiary Institutions based on the findings and extensive literature review of 4IR and service quality constitutes significant elements for consideration prior 4IR implementation as

shown in Figure 6.1. The framework is divided into in three stages: input, throughput, and output as shown in Table 6.1. The framework acts as a practical tool for stakeholders in tertiary institutions and department of higher education responsible for quality educational service delivery. The findings have been supported by literature integration considering the factors that are relevant to the South African tertiary institution’s environment that influences service quality improvement in the 4IR. The components of the 4IR application Framework for quality improvement are explained in Table 6.1.

Table 6.1: components of the 4IRSQI Framework for Tertiary institutions

Phase	Element	Sub-Elements
Input	Analysis of readiness levels	<ul style="list-style-type: none"> -Change management programs -4IR initiatives strategies - identification of 4IR project needs - management’s interests in 4IR technologies -presence of effective 4IR management processes - leadership of skilled technicians and experts - preparation for trainings and developments - established partnerships
	Smart resources, Capabilities & Funding	<ul style="list-style-type: none"> -identification of new technologies, courses & research facilities -use of multiple technologies fuelling education 4.0 -creation of partnerships for targeted innovation hubs -advancing infrastructure support -expert engagements for creating 4IR learning experiences -establishing smart campus promoting university 4.0 -establishing helpdesk and training support for difficult 4IR experiences -prioritising investments in 4IR technologies, Knowledge & capacities -sourcing government funding for 4IR strategic Initiatives -investing in training programs for generating staff skills & competencies -facilitate economic benefits of 4IR programs via student entrepreneurship - initiate capacities for improving quality via management of 4IR curriculums, facilities, programs, and resources
	Stakeholder involvement	<ul style="list-style-type: none"> -Define governance and leadership of each stakeholder - Addressing changes in roles and competencies Guide change management priorities
	Assessment of Awareness Levels	<ul style="list-style-type: none"> -Determine stakeholder’s awareness regarding: 4IR facilities & its impact on learning, accessibility & use of 4IR equipment, 4IR skills, trainings & workshops, benefits, challenges & implications, library resources available, 4IR risks
Throughput	Establishment of 4IR key Activities and Components	<ul style="list-style-type: none"> -initiate at least one activity in the following 4IR technologies for supporting T&L: AI, IoT, ML,3D printing, VR, AR, Simulation, automation
	Determination of 4IR Role in Quality Management Integration	<ul style="list-style-type: none"> -Adress quality elements of 4IR in the overall management process. - include planning of: behaviour & performance analysis of students/ academics, LMS use in expansion of student service, sustainable technology use, monitoring visible changes in learning experiences. -address quality assurance via: alignment of mission & vision to 4IR services goals, equal quality standards of 4IR T&L in compliance with quality regulations, alignment of institutional vision & mission with new technologies.

	Enablers & Inhibitors Management	<ul style="list-style-type: none"> -eradicate 4IR challenges in terms of: Cost considerations, lack of training and support, lack of adaptation capabilities, resistance to change, technical difficulties, lack of infrastructure & devices, lack of trust, lack of skills, lack of internet connections, privacy, and security. - provisioning of the following 4IR T&L benefits in terms of: Customized T&L experiences, improved research facilities & opportunities, access to educational resources, career readiness through 4IR clubs, remote learning arrangement for promoting lifelong learning, establishing hands-on experience-based learning, improved collaboration and networking among students/academics, improved student services via real-time feedback. -ensure quality control via: evaluation & corrective actions on 4IR service feedback, assessment of students/academic online presence to meet service expectations, compiling sustainability reports, agile adaption performance improvement technologies on demand.
	Drivers and Critical Success Factors for institutional transformation	<ul style="list-style-type: none"> -progress with the pace of technology to accommodate: Changing stakeholder requirements, competitive advantage, industry demands, innovation, funding opportunities, sustainability. -promote the culture of continuous improvement with more focus on training and development, skilled experts, policy frameworks, funding, resource allocation, strong infrastructure, and industry partnerships
	Infrastructure management	
Output	Expectations	<p>Sustain stakeholder expectations regarding:</p> <ul style="list-style-type: none"> -4IR equipment -education 4.0 support - helpdesk support -changing 4IR demands -feedback mechanisms - expert availability for 4IR knowledge provision - safety measures -policy information -real-time data accessibility
	Perceptions	<ul style="list-style-type: none"> -Measure stakeholder's perceptions in terms of 4IR accuracy, dependability, relevancy, responsiveness, availability, competency, trustworthiness, value creation, quality, intention of use, commitment
	Revised Strategies for the dynamic environment	<ul style="list-style-type: none"> -Redesign standards, procedures, policies, strategies compliances -alignment of best practices
	Sustainable innovation	<ul style="list-style-type: none"> -reduce environmental impact -promote resource efficient practices - ensuring ethical use of 4IR technologies -foster inclusivity of stakeholders from all social groups in the use of 4IR -foster research in sustainable technology use -incorporate sustainable use in curriculum
	Growth evaluation (performance metrics and KPIs)	<ul style="list-style-type: none"> -provision of benchmarking and metrics for co-innovation -optimise return on investment by tracking performance
	Value creation (Impact assessment)	<ul style="list-style-type: none"> -Connect the tertiary institutions corporate value with the quality function -connect operational and managerial characteristics of the processes in the value chain for innovation via 4IR—based EQMS - Seamless and real-time communication between stakeholders

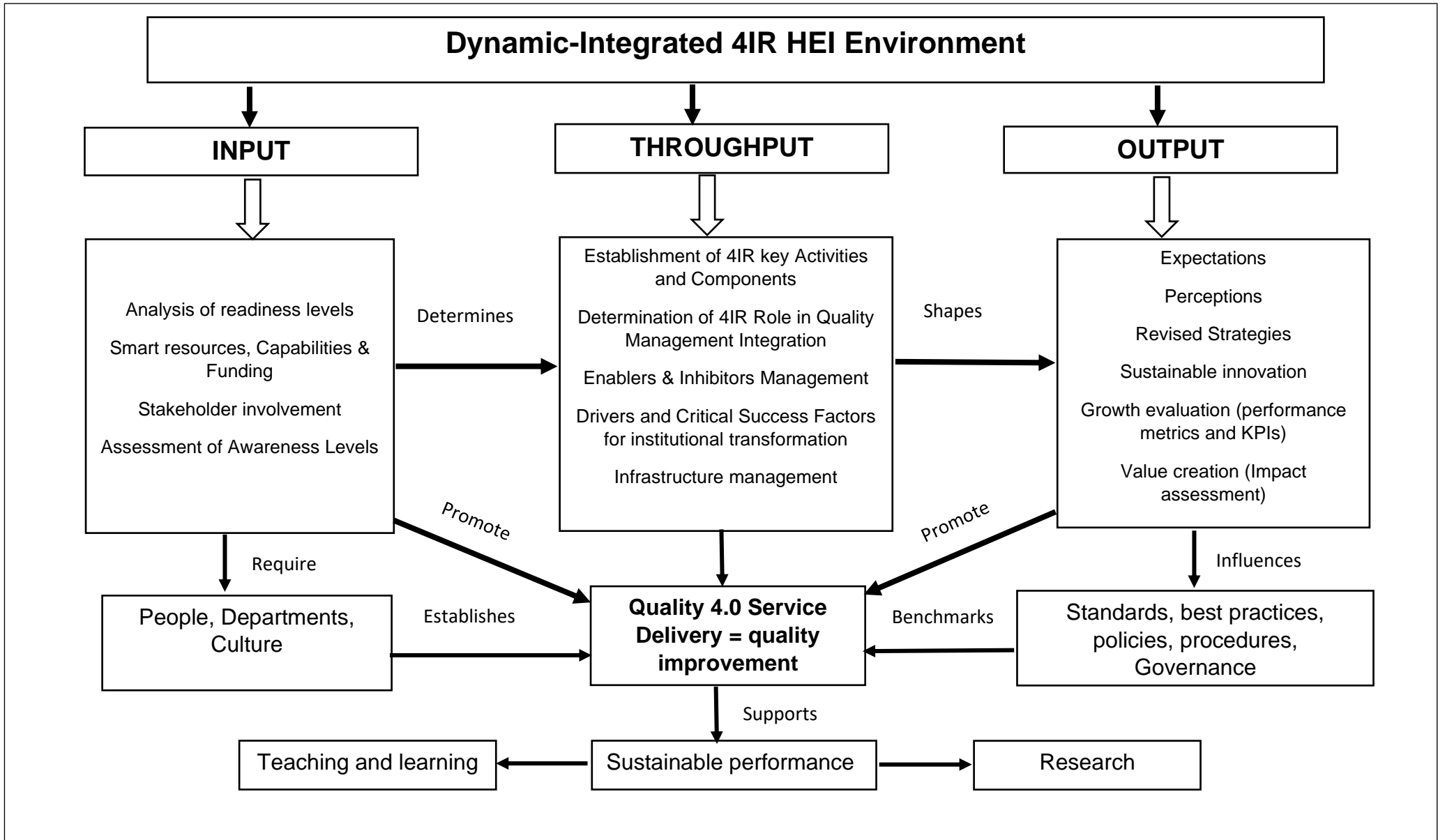


Figure 6.1: 4IRSQL Framework for Tertiary institutions.

6.5. Summary

The chapter discussed how the study responded to each of the research questions. In doing so, the findings from the qualitative and quantitative study were woven together to consolidate the findings of the two approaches used. Based on the integrated solution, a framework was arrived at, presented, and explained. The next chapter concludes, recommends, and shares limitations of the study based on findings discussed in this chapter.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1. Introduction

This chapter provided an overview of the research and highlighted the key findings of the study while providing concluding remarks on the 4IR-based service quality improvement framework (4IRSQI). The objectives of the study were reflected upon, and contribution to the body of knowledge were outlined. It also entailed recommendations for the tertiary institutions, management, students, academics, and IT staff based on the findings of the study. The chapter also highlights the study limitations and proposes recommendations. Lastly, the chapter reflects on future research suggestions.

7.2. Research Overview.

Many industries are transforming toward digitized quality management practices with the support of quality 4.0 technologies in the 4IR. While the benefits of 4IR are well informed in tertiary institution context, the progress of its application and implementation in various perspectives remain scarce despite its added value in teaching and learning services. In South Africa, although the government in alliance with the department of higher education and training have established commitments in support of 4IR, tertiary institutions have not yet obtained high adoption maturity. With a general perception that most of the 4IR technologies have been successfully implemented in developed nations, developing nations are still trapped with education 2.0 (Msila, 2023). Some studies have identified several factors contributing to unfulfilled 4IR expectations in developing countries such as unawareness, insufficient infrastructure, and financial constraints.

Previous studies have identified behavioural intention of using 4IR technologies in HEIs by investigating social influences, facilitating conditions, performance, and effort expectancies (Al-Riyami et al., 2023). There has been some documentation from studies that further analyzed the role of 4IR in curriculum development (Arek-Bawa & Reddy, 2022; Khoza & Bheki Mpungose, 2020), administrative improvements (Du Preez & Sinha, 2020), infrastructure development (Nkosi, 2021) and teaching and learning development (Nwosu et al., 2023; A. Oke & Fernandes, 2020).

To understand the significance of 4IR, studies have also identified the relationship between adoption of 4IR against various factors such as organizational culture (Al-Maskari et al., 2022; Singaram & Mayer, 2022), technological readiness (O. O. Olaitan et al., 2021) and environmental factors in terms of sustainable development (Ally & Wark, 2020b; Pramjeeth et al., 2023b; Ramos, 2020; Shenkoya & Kim, 2023). However, these were not emerged from a tertiary institutions service quality improvement setting. Only a few studies have focused on quality 4.0 and HEIs. Although studies have investigated the role of 4IR in service quality, much empirical investigation still has to be extended in various industries within which 4IR is implemented including tertiary institutions. This study was centered on realizing the factors regarded as influencing 4IR-based service quality improvement in the South African tertiary institutions context where previous industrial revolutions could not be fully understood due to resource constrained environments.

Whereas previous research constituted studies focusing on general technology adoption models such as DOI, TAM, UTAUT, and TPB, this study explored the role of 4IR in quality management by combining the TRAM and SERVQUAL models. The study infused the unique aspect of quality in bridging the technology gaps raised in an absence of an appropriate 4IR based quality of service improvement framework. This research proposed a framework for supporting a 4IR based quality improvement teaching and learning environment within tertiary institution. The overview of the research chapters is as follows:

Chapter one produced a background of 4IR by recognizing its significant influence in HEIs and quality of educational services. It after defined the research problem concerning a lack of recognition of quality perspectives in 4IR implementation especially with the presence of Covid-19 pandemic in tertiary institutions. It further outlined the research aims, objectives and research questions which guided study in developing the conceptual model. The justification of the research is shown in an effort to develop a model assisting tertiary institutions to improve quality of service through 4IR. The chapter then concludes with a general overview of the thesis structure.

Chapter two presented a holistic review of existing studies which contributed to the body of 4IR and quality of service knowledge which informed the research scope. It began by providing a brief history of previous industrial revolutions and introduced the

concept of 4IR and its relatedness in South African context. It also discovered the emergence of 4IR in education and level of preparedness with regards. It then discussed the general challenges of 4IR adoption in tertiary institutions. The chapter then explored the concept of Quality 4.0 and its implementation challenges. Lastly, it concluded by identifying the gaps in the implementation of the LNS Quality 4.0 framework, which showed that there was lack of single 4IR based service quality improvement framework specifically designed for tertiary institutions.

Chapter three discussed the various theories used in information systems research beginning with the service quality theories followed by the technology acceptance theories to understand 4IR based service quality improvement mechanisms. The significance of Technology Readiness and Acceptance model (TRAM), ServQual Model, and systems theory in guiding the conceptual framework was discussed as appropriate supporting theories for the application of 4IR service quality and understand the general challenges. The elements of the study guiding the conceptual model of the research were established to justify the influencing factors addressing 4IR service quality management in teaching and learning. The hypotheses were formulated based on the conceptual model, which were then revisited in chapter five. Seven constructs were initially identified as influencing service quality improvement. A revised conceptual model was presented in chapter six.

Chapter four presented the research methodology followed in completing this research. It outlined the research paradigm and provided a justification of the suitable research design for establishing the relevance of 4IR based service quality in tertiary institution context. Furthermore, the relevant research approaches being explanatory-sequential mixed methods were discussed for achieving the research objectives. It then addressed the data collection techniques through surveys and documents analysis to validate the conceptual model.

Chapter five presented the quantitative data as gathered from the empirical findings. The data was collected from students, academics, and IT staff at the University of Venda to discover the influence of the independent variables on quality improvement of teaching and learning in tertiary institution context. The chapter began by outlining the challenges and presented a trial of data preparation for inferential analysis. It reported on the participant's demographics and presented the descriptive statistics.

The reliability of data constructs was reported using Cronbach's alpha test, possessing a score above 0.7. The exploratory factor analysis was then implemented to validate the factors via a Principal Component Analysis test after which regression analysis and correlation analysis were performed. The initial 7 constructs were subdivided into 12 factors of which 9 factors significantly influenced service quality improvement. The Structural Equation Modelling assessed the model fit which confirmed the significance of the initial 9 factors positively influencing service quality improvement. However, the demographic factors had no significant influence on quality improvement.

Chapter six presented a detailed discussion on the factors that influenced the application of 4IR in service quality improvement. The chapter entailed a literature synthesis with previous studies for adequately interpreting the current results and a framework was proposed as medium for encouraging tertiary institutions in implementing 4IR technologies for offering better service quality. It highlighted the importance of recognizing 4IR capabilities, assessing the readiness levels, identifying the role of 4IR in quality management, acknowledging the benefits and challenges of 4IR, and meeting the expectations of stakeholders, and evaluating their perceptions together with raising its awareness in the teaching and learning environment.

Chapter seven presented an overview of the research reflecting on key findings. It reflected on the research aim and objectives achieved through literature analysis and empirical findings. The unique contributions of the study, recommendations and implications were recognized. It then provided concluding remarks as the last stage of the study.

7.3. Meeting the Research Aim, Research Objectives and Research Questions

The research aimed at developing a 4IR Service quality improvement framework for tertiary institutions to promote the implementation of 4IR technologies in teaching and learning environment. The study was guided by five objectives in accomplishing this aim. Each of the objectives were achieved at various stages of the study. The following section outlines how these objectives were met.

Research objective one: To determine 4IR readiness levels of and capabilities required by tertiary institutions in improving the quality of services.

After a thorough review of literature and theoretical underpinnings, the possible 4IR capabilities required by tertiary institutions in quality improvement were identified. Chapter five presented the empirical data on several specific capabilities deemed necessary by the stakeholders in the case institution which informed the proposed framework (see section (5.6.3 and 5.6.4).

Reach objective two: To understand the role of 4IR in contributing to the improved quality of services at a selected tertiary institution in South Africa.

From reviewing the literature, several 4IR technologies were identified in contributing towards quality improvement. Exploring the concept of Quality 4.0 guided this study in analysing the role of 4IR in service quality (see section 5.6.6). Chapter 3 provided a further analysis of the service quality models which assisted in identifying three quality factors namely quality planning, quality control and quality assurance, which may impact service quality in the teaching and learning context. Chapter five and six confirmed the role of 4IR-based quality planning for service improvement.

Research objective three: To analyse how the challenges and benefits of 4IR in South African tertiary institutions affected the quality of service in teaching, learning, and research.

Empirical data collected quantitatively in chapter five confirmed various challenges faced by students and staff in the use of 4IR which chapter 6 presented its negative effect in the quality of teaching and learning. Implementation challenges of Quality 4.0 were also found through the literature. Addressing 4IR challenges therefore became an important component of the 4IRQI framework. The research further explored the factors which promotes the use of 4IR in tertiary institutions by identifying the 4IR benefits, critical success factors and drivers in teaching, learning and research based on the case institution. Literature synthesis enabled supported similar factors contributing to the success and failure of 4IR application in education.

Research objective four: To evaluate the level of awareness, expectations, and perceptions of stakeholders towards the application of 4IR in tertiary institutions.

Chapter five and six recorded the expectations, perceptions and awareness levels of the students, academics, and IT staff which contributes towards service quality

assessments. Chapter three outlined the features of service quality which enables to evaluate the perceived 4IR-based service quality management process. Whereas chapter four found the suitability of the quantitative method for collecting and analysing this data. Based on the empirical findings for this data set, meeting stakeholder's expectations and evaluating their perceptions significantly influences service quality improvements. Awareness levels of 4IR technologies were obtained through survey data as presented in chapter five which supported its inclusion in the 4IRQI framework.

Research objective five: To develop a suitable 4IR driven quality management framework for improving the service quality of teaching, learning and research in tertiary institutions.

Through the analysis of literature and empirical findings, the study proposed the 4IRQI framework to improve teaching and learning service quality in tertiary institutions in a 4IR environment. The components of the framework are arranged into a dynamic 4IR environment by adopting systems theory. The validation of the framework enabled to refine the research adoption model and confirmed the effectiveness of the framework.

7.4. Key Findings of the Study

Through this study it was found that new technology plays an important role in achieving service quality improvement in tertiary institutions. 4IR technologies create a valuable platform for education systems, therefore tertiary institutions must take advantage of the benefits it produces while maintaining consciousness of its challenges. The following gives an outline of the key findings:

- It was found that most of the respondents have heard of the fourth industrial revolution, although many of them were not aware of any 4IR projects in the institution.
- In terms of the specific 4IR technologies, respondents were mostly familiar with augmented reality and blockchain technologies.
- With regards to the readiness extent of tertiary institutions, the findings showed the institution to have programs for adapting change management, while lacking effective processes for 4IR service management.
- The results showed that stakeholders need 4IR support clubs as the most required resource for the effective use of 4IR.

- The findings also showed that, in initiating 4IR activities, respondents believed their institution had the capability to monitor the effectiveness of 4IR in service quality.
- The study indicated that respondents were aware of the challenges in using 4IR technologies and indicated a lack of trust in 4IR which may significantly affect the tertiary institutions' efforts in initiating 4IR projects.
- The results found that some of the benefits of 4IR were acknowledged by respondents such as personalized teaching and learning.
- Sustainability obligation was perceived as a major driver of 4IR use in teaching and learning, while establishing partnerships was identified as the most critical success factor in 4IR adoption.
- The role of 4IR-based quality planning was found to be significant in the quality 4.0 management process.
- Respondents showed to have major expectations regarding the availability of modern technology equipment and facilities governing university 4.0 platforms. The findings portrayed that institutional responsiveness and institutional empathy best measures service quality improvement expectations.
- The results revealed that respondents perceived 4IR to be accurate in improving standards of service operations. Institutional assurance was found to be having an important influence in quality improvement of teaching and learning.
- It was also found that some awareness was present concerning the impacts of 4IR facilities on teaching and learning.
- The findings obtained significantly influenced the development of the 4IRQI framework.

7.5. Contributions of the Study

The following subsections highlights the contributions of the current study in terms of theory, methodology and practice:

7.5.1. Contribution to Theory

Although the topic of 4IR in higher education has been investigated under various contexts, the current study was motivated by the sudden increased popularity of digital technologies in tertiary institutions due to the covid19 pandemic. Chapter two and three acknowledged the scarcity of frameworks addressing 4IR from the perspectives

of service quality specifically in higher education and proposed the conceptual model filling this gap. The research explored the quality perspectives of 4IR under the teaching and learning paradigm within tertiary institutions in South Africa. A thorough review of various technological and service quality models assisted developing the 4IR service quality conceptual model in tertiary institutions. The unique combination of the TRAM, Servqual and systems theory enabled establishing the components of the 4IRSQI framework contributing to the body of knowledge. The use of these models through this research presents a justifiable theoretical framework for studying 4IR service quality. Literature synthesis further established the significance of the identified factors in enhancing the quality of teaching and learning and research quality. The effect of 4IR readiness, capabilities required and 4IR awareness in tertiary institutions on quality improvement were analyzed empirically from a South African context further contributing to the theory. The research also contributed by identifying three factors namely quality planning, institutional responsiveness and institutional assurance of services which influence quality improvement.

7.5.2. Contributions to Methodology

This research conducted a thorough analysis of the various research methods and approaches in IS research prior to the adoption of quantitative approach. This study showcased the suitability of quantitative research design by analyzing its benefits under the current study setting. Based on the nature of the research phenomenon, the quantitative research techniques enabled answering the research questions and obtaining the research aim. This provides an impression that other research of similar nature could implement these methodologies in conducting their studies. The study ruled out the adoption of qualitative and mixed-methods, however it provided a clear outline and review of mixed-method approaches. The use of different sampling methods was demonstrated by employing and providing an overview of simple random and purposive sampling techniques. Data analysis techniques implemented in this study were laid-out clearly as it could provide guidance to future researchers in their own studies.

7.5.3. Contributions to Practice

The empirical findings of this study led to the development of the 4IRSQI framework which is necessary in promoting the use of 4IR by students and academics. Through

the implementation of the 4IRQI framework, tertiary institutions could enhance their service performances. The decision makers and policy makers can make use of the proposed framework to establish strategies and policies for creating an advanced and successful 4IR teaching and learning environment. The study provided clarity on the key factors influencing service quality improvement, which could assist the Department of Higher Education and Training in understanding and eliminating 4IR challenges faced by multiple institutions across South Africa. The framework can be used for the prediction and management of the students' and staffs' expectations of 4IR-based service delivery. The framework highlighted the role of 4IR in quality management that various stakeholders must understand in contributing to a smart campus development. The framework highlighted the key inputs required by tertiary institutions in terms of capabilities in meeting the 4IR expectations of students and staff members sustainably. This research bridged the gap of Quality 4.0 towards the adoption of 4IR in the higher education context. The findings perceived that 4IR was positively perceived by the subjects to improve quality of service in teaching and learning. These findings add significant value in terms of 4IR contributions to the body of knowledge as it provides immense information and understanding of 4IR-based quality implementation. It therefore provides a basis for future investigations regarding the study phenomena.

7.6. Limitations of the Study

The study encountered limitations regarding a few elements as discussed in this section. Although South Africa comprises of 26 public universities, only one tertiary institution was selected, which allowed the researcher to build a thorough case. Other tertiary institutions were excluded due to time and resource constraints. However, including other universities would have a positive impact on the validity of data and knowledge creation. Moreover, qualitative data would have provided more in-depth knowledge through interviews. Secondly, the sample size was limited to 402 participants since the voluntary participating nature of this study could only seek data from random available participants. Due to data accessibility challenges, the finding and analysis were presented based on available data. Regarding the data collected, some bias could be present in individual responses due to reasons such as lack of understanding, sensitive questions, uncomfortable questions, unsuitable response options, and favored responses. Lastly, the framework proposed is not practically

tested but only validated for context applicability as evaluated by the supervisors. Nonetheless, the results obtained can be useful in justifying the respondents' opinions towards the applicability of 4IR technologies in assisting service quality improvement stretching the concept of quality 4.0.

7.7. Recommendations

The findings from this study proposes the following recommendations:

For tertiary institutions:

- Each faculty and department within tertiary institutions should use 4IR technologies and tools as a measure to initiate innovative quality-based learning environment.
- A careful choice ought to be made in selecting the various 4IR tools which could be acquired by different vendors.
- It is recommended that tertiary institutions implement 4IR technologies using a phased approach to avoid any change resistance and conflicts with stakeholders.
- In implementing 4IR, collaborations must be made with members from different departments with the IT department and quality management team to receive significant input in drafting policies and establishing strategies.
- It is recommended that requirements of certain 4IR technologies be specified and analyzed thoroughly to ensure those technologies meet the current needs and demands with proper resource allocation and avoid investments disappointments.

For students and academics:

- Students and academics must work as a team to identify the technologies they need to encourage a smart campus environment.
- Training should be taken advantage of in staying informed of the emerging technologies, and acquire the right skills needed to embrace life-long learning and function effectively in the 4IR environment.
- Students and academics are required to actively participate in any 4IR projects to get firsthand experience with 4IR technologies.

- Academics are encouraged to promote research that leverages 4IR technologies with industry partners and students as well as incorporate 4IR themes in their curriculum. Student support must be provided by means of case studies to transfer theoretical knowledge in real world practices.
- It is advised that students and academics share their perspectives on the implementation of 4IR in order to meet their expectations of quality service delivery.

For management:

- Sustainability principles are required to be incorporated in initiating 4IR strategies to comply with UN's SDG4 of quality education.
- The management is recommended to remain transparent in communicating their purpose of 4IR initiatives within the education environment to receive appropriate trust and support from stakeholders.
- Establish 4IR projects targeted towards entrepreneurial initiatives providing students with practical learning opportunities.
- Strategic objectives must be aligned with 4IR initiatives using flexible governance approaches and agility. Create 4IR strategies in alignment with the vision and mission of the institution.
- Create an environment that promotes the culture of adapting 4IR technologies by fostering innovation hubs, organization seminars and workshops.
- Institutional policies must be drafted to support application of 4IR in tertiary institutions. These policies must be aligned with the teaching and learning policies, quality assurance policies and IT policies.
- It is advised that management seek sufficient funding and allocate resources for investing in 4IR technologies to increase the possibility of service quality improvement.

For IT staff:

- The IT department must provide accessibility to infrastructure to support the implementation of 4IR technologies.

- The IT staff must facilitate ongoing training upon the requests of stakeholders to educate them on 4IR technology use and provide support to troubleshoot any challenges.
- Create an environment for prototyping and testing 4IR technologies with the presence of students and staff for analyzing 4IR performance in teaching an learning context.

7.8. Further research suggestions

The current research increased knowledge in the applicability of 4IR in service quality improvement, based on a selected tertiary institution. Despite obtaining the aim and objectives of the research, the limitations of this study restricted the scope in covering several other areas. Therefore, it is required to expand the knowledge in understating 4IR from the context of service quality, especially in the presence of limited similar studies in literature. The following areas can be investigated in line with this study:

The restricted geographical attributions limited this study to depend on a single case institution, therefore it suggested that similar research be conducted in other Southern African tertiary institutions for obtaining valuable comparative data and establishing conclusive results. Other comparative studies in similar context can also be conducted among urban and rural based institutions, along with public and private institutions. The geographical lens can also be expanded towards international universities.

This study was focused on a positivist paradigm limited to a quantitative research approach. This study can provide a background for future studies by examining 4IR quality perspectives using qualitative or mixed methodologies through interviews and focus groups or observations and complement the findings of this research. The findings could be relevant for comparing contributions of each method in knowledge creation. Factors influencing 4IR-based service quality improvement which could have been left out in this study may therefore be revealed.

The nature of the current research was cross-sectional, therefore the factors influencing the service quality improvement through 4IR may change with time. Hence it is recommended that a longitudinal study be conducted in measuring and revalidating the significance of factors such 4IR readiness assessments, capability

generation, awareness, quality management roles and additional factors in quality improvement.

A study could be furthered in determining the actual adoption of 4IR technologies and its effect on quality of service within the same institution or other institutions who have adopted 4IR technologies. This will provide an overview of the performance of service quality post implementation. With this, a study can also be initiated to compare quality between adopting and non-adopting institutions.

The research model of this study only focused on the Servqual, TRAM and Systems theory. It is suggested that other studies be conducted with other theories such as UTAUT, DOI, TPB, where other variables influencing the relationship between quality and 4IR can be debated. In this study, moderators such as age, level of education and gender were found to be insignificant for this dataset. However, these moderators could be retested for its influence on quality with other datasets from various institutions.

This research did not focus on a specific 4IR technology, therefore further studies could emerge focusing on the use of a specific 4IR technology or technologies such as application of Robotics and Generative Artificial Intelligence to enhance service quality in teaching, learning and research.

A further study could emerge focusing on testing, implementing, and monitoring the proposed 4IRQI framework within tertiary institutions across South Africa. This could assist in determining the suitability of the framework in a lived environment.

7.9. Conclusion

As the study focused on addressing quality improvement through 4IR in the teaching and learning environment of tertiary institutions, the empirical findings and thorough literature review was sufficient in answering the research questions. It was revealed students and staff were familiar with the concept of 4IR in general. However, 4IR use in practice was not found to be extensive. In assessing the readiness of the case institution, indicators such as change management programs, strategy development, availability of skills assisted in revealing a limited readiness of 4IR adoption. The review of literature together with the empirical findings related to the presence of 4IR challenges creates complications in initiating 4IR activities and projects. The study

also identified the drivers and critical success factors which can encourage the progression of 4IR in the education field. It is encouraged that tertiary institutions' capability to adapt 4IR technologies be improved through revised models together with sustainable investments and well established 4IR technology usefulness plan. The successful improvement service quality requires tertiary institutions to acquire smart resources and possess capabilities of 4IR implementation. It is also realized that increasing awareness levels among the stakeholders of tertiary institutions could promote the advanced use of 4IR technologies. It was also shown that most of the respondents had positive expectations concerning the implementation of 4IR by their institutions. Discussions emerging from the perceptions of students and staff indicated that the role of quality planning in the management of quality through 4IR is shown to influence quality improvement. The students and staff also perceived institutional responsiveness, empathy, and assurance to positively contribute towards an improved 4IR environment.

7.10. Chapter summary

This chapter concluded the research study on the application of 4IR service quality improvement of tertiary institutions' teaching and learning environment. It reflected on the aim and objectives achieved and summarized the key findings. The contributions towards the body of knowledge were highlighted and recommendations were provided. Lastly, the chapter produced the limitations and suggestions for future research.

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ANNEXURE A: Ethical Clearance

ETHICS APPROVAL CERTIFICATE

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Mrs N Patala

STUDENT NO:
11634215

PROJECT TITLE: **A Framework for the Application of Fourth Industrial Revolution in Improving the Service Quality of Tertiary Institutions in South Africa.**

ETHICAL CLEARANCE NO: **FMCL/22/BIS/14/2909**

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Prof. A Kadyamalimba	UNIVEN, Business Information Systems	Supervisor
Dr. W Munyoka	UNIVEN, Business Information Systems	Co-supervisor
Mrs N Patala	UNIVEN, Business Information Systems	Investigator – Student

Type: **Doctoral Research**

Risk: **Straightforward research without ethical problems (Category 1)**

Approval Period: **September 2022 – September 2025**

The Research Ethics Social Sciences Committee (RESSC) hereby approves your project as indicated above.

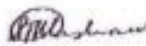
General Conditions

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- The project leader (principal investigator) must report in the prescribed format to the REC:
 - Annually (or as otherwise requested) on the progress of the project, and upon completion of the project.
 - Within 48hrs in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
 - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the REC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date; a new application must be made to the REC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the REC retains the right to:
 - Request access to any information or data at any time during the course or after completion of the project.
 - To ask further questions; Seek additional information; Requires further modification or monitor the conduct of your research or the informed consent process.
 - withdraw or postpone approval if:
 - Any unethical principles or practices of the project are revealed or suspected.
 - It becomes apparent that any relevant information was withheld from the REC or that information has been false or misrepresented.
 - The required annual report and reporting of adverse events was not done timely and accurately.
 - New institutional rules, national legislation or international conventions A it necessary

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE
Date Considered: August 2022

Name of the RESSC Chairperson of the Committee: **Prof TS Mashau**

Signature 



ANNEXURE B: Research Approval Letter

UNIVERSITY OF VENDA

OFFICE OF THE DVC: RESEARCH AND POSTGRADUATE STUDIES

TO : MR/MS N. PATALA
FACULTY OF MANAGEMENT, COMMERCE AND LAW

FROM: PROF. N.N FEZA
DVC: RESEARCH AND POSTGRADUATE STUDIES

DATE : 22 NOVEMBER 2022

DECISIONS TAKEN BY UHDC OF 22nd NOVEMBER 2022

Application for approval of Thesis Proposal Report in the Faculty of Management, Commerce and Law: N. Patala (15018006)

Topic: "A Framework for the application of Fourth Industrial Revolution in improving the Service Quality of Tertiary Institutions in South Africa."

Supervisor	UNIVEN	Prof. A. Kadyamatimba
Co-supervisor	UNIVEN	Dr. W. Munyoka

UHDC approved of Thesis Proposal



PROF. N.N FEZA
DVC: RESEARCH AND POSTGRADUATE STUDIES

ANNEXURE C: Informed Consent Letter

Research and Innovation
Office of the Director

RESEARCH ETHICS COMMITTEE

UNIVEN Informed Consent

Appendix B

LETTER OF INFORMATION

Title of the Research Study: A FRAMEWORK FOR THE APPLICATION OF FOURTH INDUSTRIAL REVOLUTION IN IMPROVING SERVICE QUALITY OF TERTIARY INSTITUTIONS IN SOUTH AFRICA.

Principal Investigator/s researcher : Mrs. Patale Najiyabanu

Co-Investigator/s/supervisor/s : Prof. Armstrong Kadyamatimba and Dr. Willard Munyoka

Brief Introduction and Purpose of the Study: the fourth industrial revolution (4IR) have altered the standard of living of people around the world in terms of their work and social interactions leading to a profound socio-economic impact. The purpose of the current research is to investigate how selected 4IR-based technologies can be applied within the context of tertiary institutions for improving the quality of service and develop a framework for implementing 4IR in teaching, learning, and research [context](#)

Outline of the Procedures : The researcher will distribute questionnaires to the student participants and conduct interviews with the staff participants [ipaper](#) to collect data.

Risks or Discomforts to the Participant: There will be no risks to the participants when taking part in the study.

Benefits : The benefits of the study include publications.

Reason/s why the Participant May Be Withdrawn from the Study: the participant(s) may be withdrawn due to reasons such as illness or health conditions and anxiety caused which may hamper their participation. There will be no negative consequences for the participants if they choose to withdraw.

Remuneration : No remuneration will be awarded to the participants.

Costs of the Study : No costs are required from the participants.

Confidentiality : Permission will be obtained from the participants before collecting data. Also, data collected will be kept anonymous and confidential.

Research-related injury : There will be no research related injury to be expected.

Persons to Contact in the Event of Any Problems or Queries:

Please contact the researcher (0712308881), my supervisor (Prof. Armstrong Kadyamatimba, Email: armstrong.kadyamatimba@univen.ac.za, 082 803 8015), my co-supervisor (Dr. Willard Munyoka, Email: Willard.Munyoka@unive.ac.za, 0718378043) or the University Research Ethics Committee Secretariat on 016 882 8088. Complaints can be reported to the Director: Research and Innovation, Prof GE Ekosse on 016 882 8313 or Georges.Ivo.Ekosse@univen.ac.za

UNIVEN Informed Consent Page 1 of 3


Research and Innovation
Office of the Director

General:
Potential participants must be assured that participation is voluntary and the approximate number of participants to be included should be disclosed. A copy of the information letter should be issued to participants. The information letter and consent form must be translated and provided in the primary spoken language of the research population.

CONSENT


Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher (Mrs. Patale Najiyabanu), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: _____
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerized system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.


Full Name of Participant	Date	Time	Signature
<u>I, Patale Najiyabanu</u>	<u>08-08-2022</u>	<u>12:30pm</u>	

(Name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Full Name of Researcher

Patale Najiyabanu Date 08-08-2022 Signature 

Full Name of Witness (If applicable)

Rushil Vadher Date 06-08-2022 Signature 

UNIVEN Informed Consent Page 2 of 3

Research and Innovation
Office of the Director

Full Name of Legal Guardian (If applicable)

..... Date..... Signature.....

Please note the following:

Research details must be provided in a clear, simple and culturally appropriate manner and prospective participants should be helped to arrive at an informed decision by use of appropriate language (grade 10 level-use Flesch Reading Ease Scores on Microsoft Word), selecting of a non-threatening environment for interaction and the availability of peer counseling (Department of Health, 2004)

If the potential participant is unable to read/literate, then a right thumb print is required and an impartial witness, who is literate and knows the participant e.g. parent, sibling, friend, pastor, etc. should verify in writing, duly signed that informed verbal consent was obtained (Department of Health, 2004).

If anyone makes a mistake completing this document e.g. a wrong date or spelling mistake, a new document has to be completed. The incomplete original document has to be kept in the participant's file and not thrown away, and copies thereof must be issued to the participant.

References:

Department of Health: 2004. Ethics in Health Research: Principles, Structures and Processes <http://www.doh.gov.za/docs/factsheets/guidelines/ethics/>

Department of Health: 2008. South African Good Clinical Practice Guidelines: 2nd Ed. Available at: http://www.nhrec.org.za/?page_id=14

UNIVEN Informed Consent Page 3 of 3

ANNEXURE D: Questionnaires

STUDENT QUESTIONNAIRE

A FRAMEWORK FOR THE APPLICATION OF FOURTH INDUSTRIAL REVOLUTION IN IMPROVING THE SERVICE QUALITY OF SELECTED TERTIARY INSTITUTIONS IN SOUTH AFRICA

SECTION A: BACKGROUND INFORMATION

For each item below, please indicate your answer by putting a clear cross (X) in the relevant block (choose only one response in each question).

1. What is your gender? <input type="radio"/> Male <input type="radio"/> Female	2. What is your age group? <input type="radio"/> 15-25 <input type="radio"/> 26-35 <input type="radio"/> 36-45 <input type="radio"/> 46 and above
3. What is your race? <input type="radio"/> African/Black <input type="radio"/> Coloured <input type="radio"/> Asian/Indian <input type="radio"/> White <input type="radio"/> Other....., please specify	4. What is your current level of study? <input type="radio"/> 1 st Year <input type="radio"/> 2 nd Year <input type="radio"/> 3 rd Year <input type="radio"/> 4 th Year <input type="radio"/> Honours <input type="radio"/> Masters <input type="radio"/> PhD
	5. Have you heard of the Fourth Industrial Revolution? <input type="radio"/> Yes <input type="radio"/> No

SECTION B: 4IR COMPONENTS and KEY ACTIVITIES

6. Are you aware of any projects that your institution is engaged with in the field of 4IR?

<input type="radio"/> Yes	<input type="radio"/> No
---------------------------	--------------------------

7. Which of the following 4IR technologies have you heard of? Select all that apply:

<input type="checkbox"/> Artificial intelligence	<input type="checkbox"/> Cloud computing	<input type="checkbox"/> Augmented reality	<input type="checkbox"/> Simulation
<input type="checkbox"/> Big data	<input type="checkbox"/> Virtual reality	<input type="checkbox"/> 3D/4D printing	<input type="checkbox"/> Automation
<input type="checkbox"/> Block chain	<input type="checkbox"/> Internet of things	<input type="checkbox"/> Robotics	<input type="checkbox"/> None

8. Please rate the following statements that best represents your opinion regarding the extent to which your institution is ready for 4IR by putting a Cross (X) on it.

NE=No Extent, SE=Somewhat Extent, N=Neutral, ME=Moderate Extent, GE=Great Extent	NE	SE	N	ME	GE
To what extent do you think your institution: and its management is welcoming 4IR technologies in teaching and learning by offering 4IR courses and programs					
is partnered with the government, industry and other tertiary institutions in preparing and promoting 4IR initiatives and research					
has strategies in place to embrace 4IR-initiatives					
Has identified current and future 4IR needs to implement 4IR projects					
is prepared to offer training and development programs to students for successfully implementing 4IR projects					
has skilled technicians and experts to lead and manage 4IR projects and practices					
is involving students in leading 4IR projects					
has programs to quickly adapt to the culture of change required by the 4IR					
processes for managing effective 4IR based teaching and learning					

SECTION C: 4IR KEY RESOURCES, CAPABILITIES, AND FUNDING

9. Please specify the necessary resources that your institution should provide you with to support your effective use of 4IR. Select all the apply.

<input type="checkbox"/> High speed internet	<input type="checkbox"/> Smart Computers	<input type="checkbox"/> 4IR Training programs	<input type="checkbox"/> Mentors
<input type="checkbox"/> ICT support	<input type="checkbox"/> 4IR learning material	<input type="checkbox"/> 4IR student clubs	<input type="checkbox"/> 4IR labs
<input type="checkbox"/> None	<input type="checkbox"/> Any other, specify		

10. Please rate the following statements that best represents your opinion regarding your institutions capabilities (abilities) in initiating 4IR activities for improving service quality by putting a Cross (X) on it.

SA=strongly, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree.	SA	A	N	D	SD
I believe my institution can:					
identify new technologies, create new courses and build new research facilities to keep up with the demands of 4IR					
use many technologies to support teaching and learning					
identify partnerships to make my university an innovation hub					
allocate infrastructure to support implementing new technologies for teaching, learning and research facilities					
work with experts & engage with students to develop a 4IR based learning experience					
manage various 4IR technologies & programs to provide a smart learning environment					
provide support service to students experiencing difficulties in using 4IR technologies					
I believe my institution should:					
prioritise investing in 4IR technologies, knowledge & capacities to remain competitive					
secure funding from governments, donation & internal revenues to support strategic 4IR initiatives					
invest in training programs to equip staff with 4IR competencies and skills					
support student entrepreneurship in the 4IR to facilitate for their economic benefits					
I believe my institution's ability to					
identify the need for new technology-based curriculum, research facilities and innovative labs will improve quality of teaching and learning					
allocate resources towards 4IR programs will improve service quality					
manage 4IR facilitates will improve service quality					

SECTION D: 4IR CHALLENGES, BENEFITS AND CRITICAL SUCCESS FACTORS

11. What according to you are or could be the benefits of using 4IR technologies? (Select all that applies)

With 4ir technologies I can get:		
<input type="checkbox"/> Personalized/customized learning experience	<input type="checkbox"/> Improved research opportunity	<input type="checkbox"/> Improved access to education and resources
<input type="checkbox"/> Career ready for future jobs	<input type="checkbox"/> Flexible & remote learning availability	<input type="checkbox"/> Hands-on experience-based learning
<input type="checkbox"/> Better communication with lecturers and university	<input type="checkbox"/> Improvised student services	<input type="checkbox"/> Repetitive learning experience for improved student performance
<input type="checkbox"/> None	<input type="checkbox"/> Any other, specify	

12. What according to you are or could be the challenges of using 4IR technologies? (Select all that applies)

For me to use 4ir technologies I feel:		
<input type="checkbox"/> It can be costly	<input type="checkbox"/> I don't have appropriate training and support	<input type="checkbox"/> I don't have the ability to adapt to new technology
<input type="checkbox"/> I am afraid of any changes to my current learning	<input type="checkbox"/> I don't have the necessary infrastructure and devices	<input type="checkbox"/> I don't trust technology
<input type="checkbox"/> I don't have the skills and knowledge to use new technology	<input type="checkbox"/> I don't have proper internet connectivity	<input type="checkbox"/> I am worried about the privacy and security of my information
<input type="checkbox"/> None	<input type="checkbox"/> Any other, specify	

13. What factors do you think can motivate your institution to support the use of 4IR in teaching and learning? (Select all that applies)

I think my institution will support the use of 4ir to:		
<input type="checkbox"/> Meet changing student's needs	<input type="checkbox"/> Gain competitive advantage from other universities	<input type="checkbox"/> Meet demands from the industry where students will find work
<input type="checkbox"/> Drive innovation	<input type="checkbox"/> Keep up with globalization	<input type="checkbox"/> Sustain for the future
<input type="checkbox"/> None	<input type="checkbox"/> Any other, specify	

14. What do you think your institution requires to successfully implement 4IR technologies to improve teaching and learning quality? (Select all that applies)

I think my institution will be able to implement 4ir if they have:		
<input type="checkbox"/> Funding and resources	<input type="checkbox"/> Skilled staff and experts	<input type="checkbox"/> Support from the leaders in the field
<input type="checkbox"/> Training and support	<input type="checkbox"/> Strong infrastructure	<input type="checkbox"/> Partnerships with the industry
<input type="checkbox"/> None	<input type="checkbox"/> Any other, specify	

SECTION E: 4IR ROLE IN QUALITY MANAGEMENT

15. Are you familiar with the term "Quality 4.0"?

<input type="radio"/> Yes	<input type="radio"/> No
---------------------------	--------------------------

16. Rate the following statements according to the response most suitable to your beliefs regarding the role of 4IR technologies in quality management.

SA=strongly, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree.	SA	A	N	D	SD
My institution's:					
is giving importance to offering personalized teaching and learning services to learn more about student behaviour and performance					
mission and values are aligned with offering personalized academic services					
is evaluating services offered via online feedback and corrective actions are taken					
is using online learning systems to expand and attract new students					
is ensuring the standards of online learning experiences are as valuable as physical learning and comply with quality regulations					
is continuously evaluating the student's online presence to make sure students expectations are met					
commitment to promote sustainable technology use is creating a positive learning environment					
is complying with the global sustainability goals					
is sharing their sustainability reports to students on their website					
has visible changes in the quality of teaching and learning over time using new technologies for improving learning experience					
Vision and mission support the use of new technologies mission and vision					
is quick in adapting fast changing technologies on student demand to improve their academic performance					

SECTION F: 4IR PERCEPTIONS, EXPECTATIONS AND AWARENESS

17. Rate the following statements according to the response most suitable to your beliefs regarding your expectations 4IR technologies.

SA=strongly, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree.	SA	A	N	D	SD
I expect my institution to:					
have modern technology equipment that will support 4IR such as laboratories, modern libraries, 3D printers, VR headsets, robotic kits, IoT devices					
have modern technology facilities that will support education 4.0, such as face recognition to enter the gate, digital student cards, digital classrooms, robotic labs, robot assistants at the library, chatbots, 3D printing labs, VR labs.					
implement the right, user-friendly, error-free and 24/7 available 4IR technologies for students to use in a smart campus					
have approachable and sincerely helpful staff in solving student's problems in using 4IR technologies					
be flexible in keeping up with the changing needs and demands of the 4IR with student's interest in mind					
provide guidance and timely feedback to student's enquires regarding the use of 4IR technologies in various labs and learning management systems					

employ qualified staff and lecturers who have skills and knowledge in using 4IR technologies to assist with teaching and learning					
have appropriate measures and policies in providing safety for students while using 4IR technologies, equipment's and facilities					
Have staff to acknowledge that every student may have different 4IR needs and therefore should provide individual attention to each student					
value student's feedback in terms of which 4IR technologies, equipment and facilities they would want to use for their teaching and learning/ research					

18. Rate the following statements according to the response most suitable to your beliefs regarding your perceptions about 4IR technologies.

	SA	A	N	D	SD
I believe the use of 4IR technologies in education:					
Is accurate for improving the standards of teaching and learning					
are more dependable in terms of accessing educational contents					
Are more relevant for personalized education than physical classes					
Best captures feedback and interest of students needs automatically					
Can be more responsive in timely assisting students with their learning					
Is always available to answer individual student queries					
Is more competent than only relying on lecturers' knowledge and skills					
Is more trustworthy and safer in receiving teaching and learning services					
Gives students access to tools and platforms that adds more value to learning					
Will improve the quality of teaching and learning at my institution					
Student's 4IR technology service quality satisfaction:					
Given that I have access to 4IR technologies, I intend to use them					
I will encourage other students to use 4IR technologies for their learning					
I will be committed to staying up to date with latest technology for learning					

19. Rate the following statements according to the response most suitable to your beliefs regarding your level of awareness about the 4IR technologies.

	SA	A	N	D	SD
Awareness: I am aware					
of the 4IR facilities available at my institution and its impact on my learning					
of how to access and use 4IR technologies and equipment to improve my academic performance					
of the skills and knowledge and understanding of basic concepts of 4IR required to use 4IR technologies in my course					
of the trainings, support, and workshops available to assist me in learning how to use 4IR technologies at my institution					
of the benefits and challenges and implications of using 4IR technologies in teaching and learning					
of the resources available at the library to learn about 4IR technologies					
of the risks and negative consequences of 4IR technologies					

THANK YOU FOR YOUR PARTICIPATION

ANNEXURE E: BUDGET

ITEM	QUANTITY	RAND/UNIT	AMOUNT (RANDS)	MOTIVATION
RESEARCH ASSISTANCE				
Stipend for two research assistants for:				
- data collection @165 x 30 days	30	160	4 950	Researcher requires assistance with data collection, transcription and analysis as there are approximately 400 participants.
- transcription and data capturing @ 165 x 30 days	30	160	4 950	
- data analysis @ 165 x 30 days	30	160	4 950	
Subtotal for research assistance			R 14 850	
STATIONARY AND CONSUMABLES				
Stapler	1	100	100	The researcher will require these consumables to smoothly conduct the study. It will be easier to make notes on the go whilst interacting with research participants and will allow to store research digitally and printed. Data and airtime will be required to communicate with participants, assistants, and companies considered for the research
Staple pins	1 box	100	100	
Writing pens	10	10	100	
Highlighter pens	5	20	100	
Events diary	1	70	70	
Files for storage	4	100	400	
Writing pads (manuscripts)	5	14	70	
Puncher	1	100	100	
Memory sticks	2	200	400	
Vodacom data bundles airtime	Will be purchased as required	10gb data @ R 699 for 6 months+	4194	
Vodacom airtime	Will be purchased as required.	airtime @ R 275 for 6 months +	1650	
Stationary subtotal			7284	
SUBSISTENCE AND TRAVELLING				
Data collection trips: To Thohoyandou from Louis Trichardt (researcher and 1 assistants). (25 trips).	(70km x 2) = 140km x 25 trips = 3500	3.61	12635	These are the calculated costs for the travelling, and subsistence while conducting research activities such as visiting sites, and participants for
Meals: 25 trips: researcher	25 days	435 x 25 days	10875	
Meals: 5 trips: 1 research assistant	25 days	134x 25 days	3350	

				data collection for the different phases of the study.
Subtotal for subsistence and travelling			26860	
BINDING				
Spiral binding	5	100	500	The research has to be bind for easy handling and safe storage.
Hard copy binding	6 books	600	3 600	
Binding subtotal			4 100	
PRINTING AND PROOF READING				
Proof reading of proposal	85 pages	30	2550	Proposal has to be printed and submitted to the relevant people. The questionnaires are to be printed and to be distributed to the research participants and the complete research is required to be submitted as a hard copy. Proof reading is important for identifying language and grammar errors.
Proof reading of final research	250 pages	30	7500	
Printing of questionnaires (4 pages of 2 sets)	200 copies	3	2 400	
Printing of research for spiral binding (250 pages)	6 books	3	4500	
Printing of final research for hard copy binding (250 pages each)	6 copies	3	4500	
Printing and proof reading subtotal			21450	
GRANDTOTAL FOR WHOLE RESEARCH			74544	

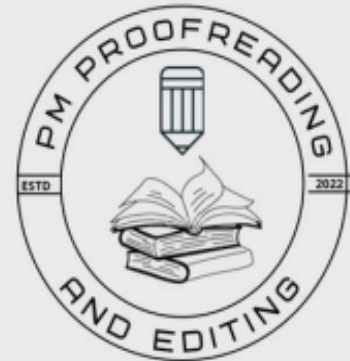
ANNEXURE F: ACTIVITY DIAGRAM

Activity	Duration	J	F	M	A	M	J	J	A	S	O	N	D
2021													
Identification of research Gap, topic development, write up of research concept paper, formulating research objectives and research questions	June 2021-December 2021												
2022													
Proposal write up,	January 2022-March 2022												
presentations of proposal to the department and faculty	April 2022-May 2022												
Submission of proposal to Univen school higher degrees committee for approval	August 2022												
Register research proposal with the research and innovation directorate	September 2022												
Submission of application for ethical clearance to the university ethics committee	November 2022												
Research chapter one write-up and submission	December 2022												
Corrections of research chapter one	December 2022												
2023													
Write up and submission of literature review	January 2023-February 2023												
Corrections of literature review chapter	March 2023												
Article writeup on systematic literature review	April 2023 – May 2023												
2023													
Write up of research methodology chapter and submission	June 2023 – July 2023												
Corrections of research methodology	July 2023												
Article write up on research methodology	August												
Begin data collection	August 2023 – September 2023												
Data transcription and coding	September 2023												
Complete Data analysis	October 2023												
Interpretation of results	October 2023												
Submission of data analysis chapter	October 2023												
Correction of data analysis	November 2023												
Article write up on results obtained	November 2023												
Conclusions and recommendations	December 2023												
2024													
Submission of first draft of the research thesis to the business information systems department	January 2024												
Submission of research thesis for examination	February 2024												
Corrections	March 2024												
Oral defence of the thesis PhD thesis	April 2024												
Submit citation of thesis for approval by higher university degrees committee	May 2024												
Final submission to the faculty	June 2024												
Submit articles for publication in DHET-accredited peer-reviewed journals	June 2024												
Participate in graduation upon completion	September 2024												

ANNEXURE H: Proof Reading Letter



**CERTIFICATE
OF
PROOFREADING**



CONTACT

061 552 2079/076 254 6919

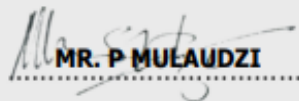
phindani.mulaudzi@gmail.com

phindani@jicho.co.za

DEAR SIR/MADAM/DR./PROF

This serves to certify that the Thesis for Doctor of Philosophy: BUSINESS INFORMATION SYSTEMS titled "A Framework for the Application of Fourth Industrial Revolution in Improving the Service Quality of Tertiary Institutions in South Africa" by **Patala Najlyabanu Noormohmed**. (Of student number **11634215**) has been edited and proofread for grammar, spelling, punctuation, overall style, and logical flow. The edits were carried out using the "Track changes" feature in MS Word as well as the knowledge of the language, giving the author final control over whether to accept or reject effected changes prior to submission, provided the changes I recommended are effected to the text, the language is of acceptable standard.

With best regards,


MR. P MULAUDZI

BA MS (UNIVEN); BA HONS [BAHELT] (UNIVEN)

Annexure I: Normality Assessments

Normality test: Academics data (Skewness and Kurtosis)

Scale Items	Skewness			Kurtosis			Scale Items	Skewness			Kurtosis			Scale Items	Skewness			Kurtosis		
	statistic	Std error	Z Score	statistic	Std error	Z score		statistic	Std error	Z score	statistic	Std error	Z score		statistic	Std error	Z Score	statistic	Std error	Z Score
O1	-.090	.333	-.270	-1.048	.656	-1.598	PU3	.588	.333	1.766	-.086	.656	-0.131	EEM2	.652	.333	1.958	-.671	.656	-1.023
O2	.321	.333	.964	-.800	.656	-1.220	QP1	.287	.333	0.862	-.247	.656	-0.377	PRL1	.331	.333	0.994	-.788	.656	-1.201
O3	.304	.333	.913	-.608	.656	-0.927	QA1	.200	.333	0.601	-.695	.656	-1.059	PRL2	.456	.333	1.369	.193	.656	0.294
INN1	.247	.333	.742	-.604	.656	-0.921	QC1	.849	.333	2.550	.978	.656	1.491	PEM1	.694	.333	2.084	1.142	.656	1.741
INN2	.365	.333	1.096	-.749	.656	-1.142	QP2	.663	.333	1.991	.416	.656	0.634	PEM2	.878	.333	2.637	1.143	.656	1.742
INS1	.182	.333	.547	-.798	.656	-1.216	QA2	.225	.333	0.676	-.647	.656	-0.986	PRS1	.297	.333	0.892	-.606	.656	-0.924
INS2	.029	.333	.087	-.712	.656	-1.085	QC2	.905	.333	2.718	.673	.656	1.026	PRS2	.652	.333	1.958	-.499	.656	-0.761
D1	.290	.333	.871	-.578	.656	-0.881	QP3	-.227	.333	-0.682	-.508	.656	-0.774	PAS1	.331	.333	0.994	1.380	.656	2.104
D2	.475	.333	1.426	-.338	.656	-0.515	QA3	.060	.333	0.180	-.180	.656	-.274	PAS2	.456	.333	1.369	1.231	.656	1.877
SS1	.659	.333	1.979	-.036	.656	-0.055	QC3	-.234	.333	-0.703	-.563	.656	-.858	PT1	.694	.333	2.084	-.345	.656	-0.526
SS2	.904	.333	2.715	.764	.656	1.165	QP4	.164	.333	0.492	-.643	.656	-0.980	PQ1	.878	.333	2.637	-.236	.656	-0.360
SS3	.608	.333	1.826	.015	.656	0.023	QA4	.409	.333	1.228	-.221	.656	-0.337	PQI2	.297	.333	0.892	-.212	.656	-0.323
SZ1	.778	.333	2.336	.420	.656	0.640	QC4	.379	.333	1.138	.079	.656	0.120	PQI3	.652	.333	1.958	-.374	.656	-0.570
SZ2	.851	.333	2.556	-.578	.656	-0.881	ET1	2.178	.333	6.541	-.598	.656	-0.912	PQI4	.465	.333	1.396	-.656	.656	-1.000
TS1	.408	.333	1.225	-.338	.656	-0.515	ET2	1.595	.333	4.790	2.934	.656	4.473	A1	.412	.333	1.237	-.124	.656	-0.189
TS2	.723	.333	2.171	-.036	.656	-0.055	ERL1	.738	.333	2.216	-.424	.656	-0.646	A2	.081	.333	0.243	-.031	.656	-0.047
I1	.981	.333	2.946	.764	.656	1.165	ERL2	.889	.333	2.670	.305	.656	0.465	A3	-.081	.333	-0.243	-.031	.656	-0.047
I2	.839	.333	2.520	.015	.656	0.023	ERS1	1.031	.333	3.096	.803	.656	1.224	A4	.090	.333	0.270	-.475	.656	-0.724
I3	.990	.333	2.973	.420	.656	0.640	ERS2	1.179	.333	3.541	1.021	.656	1.556	A5	.274	.333	0.823	-.438	.656	-0.668
I4	.920	.333	2.763	.687	.656	1.047	EAS1	1.512	.333	4.541	.024	.656	0.037	A6	.090	.333	0.270	.073	.656	0.111
PU1	.670	.333	2.012	-.010	.656	-0.015	EAS2	1.065	.333	3.198	.398	.656	0.607	A7	.292	.333	0.877	.078	.656	0.119
PU2	.643	.333	1.931	.114	.656	-0.174	EEM1	1.317	.333	3.955	1.834	.656	2.796							

Normality test: IT staff data (Skewness and Kurtosis)

Scale Items	Skewness			Kurtosis			Scale Items	Skewness			Kurtosis			Scale Items	Skewness			Kurtosis		
	statistic	Std error	Z Score	statistic	Std error	Z score		statistic	Std error	Z score	statistic	Std error	Z score		statistic	Std error	Z Score	statistic	Std error	Z Score
O1	-.630	.550	-1.145	.094	1.063	0.088	PU1	.522	.550	0.949	-.443	1.063	-0.417	EAS2	.496	.550	0.902	-1.357	1.063	-1.277
O2	-1.114	.550	-2.025	1.721	1.063	1.619	PU2	.634	.550	1.153	.189	1.063	0.178	EEM1	.117	.550	0.213	-1.516	1.063	-1.426
O3	-.654	.550	-1.189	.229	1.063	0.215	PU3	.456	.550	0.829	.284	1.063	0.267	EEM2	.496	.550	0.902	-1.357	1.063	-1.277
INN1	-1.309	.550	-2.380	2.171	1.063	2.042	QP1	.000	.550	0.000	-1.714	1.063	-1.612	PRL1	1.035	.550	1.882	-.087	1.063	-0.082
INN2	-.798	.550	-1.451	-.210	1.063	-0.198	QA1	.161	.550	0.293	-.674	1.063	-0.634	PRL2	1.156	.550	2.102	2.111	1.063	1.986
INS1	-1.320	.550	-2.400	2.243	1.063	2.110	QC1	.099	.550	0.180	-1.047	1.063	-0.985	PEM1	.310	.550	0.564	-.479	1.063	-0.451
INS2	-1.180	.550	-2.145	1.753	1.063	1.649	QP2	.869	.550	1.580	1.096	1.063	1.031	PEM2	.592	.550	1.076	-.975	1.063	-0.917
D1	-.091	.550	-0.165	-.903	1.063	-0.849	QA2	.000	.550	0.000	-1.326	1.063	-1.247	PRS1	.826	.550	1.502	-.404	1.063	-0.380
D2	-.273	.550	-0.496	-.813	1.063	-0.765	QC2	.161	.550	0.293	-.674	1.063	-0.634	PRS2	.435	.550	0.791	-.986	1.063	-0.928
SS1	-1.372	.550	-2.495	-.149	1.063	-0.140	QP3	.290	.550	0.527	-.890	1.063	-0.837	PAS1	.380	.550	0.691	-1.669	1.063	-1.570
SS2	.291	.550	0.529	-.505	1.063	-0.475	QA3	.117	.550	0.213	-1.516	1.063	-1.426	PAS2	.291	.550	0.529	-.505	1.063	-0.475
SS3	.109	.550	0.198	-.325	1.063	-0.306	QC3	-.353	.550	-0.642	-1.342	1.063	-1.262	PT1	.750	.550	1.364	-.223	1.063	-0.210
SS4	-.677	.550	-1.231	-1.766	1.063	-1.661	QP4	.219	.550	0.398	-1.241	1.063	-1.167	PQI1	.750	.550	1.364	-.223	1.063	-0.210
SZ1	-.083	.550	-0.151	.053	1.063	0.050	QA4	.057	.550	0.104	-.314	1.063	-0.295	PQI2	.537	.564	0.952	-.643	1.091	-0.589
SZ2	.109	.550	0.198	-.325	1.063	-0.306	QC4	.919	.550	1.671	2.041	1.063	1.920	PQI3	.109	.550	0.198	-.325	1.063	-0.306
SZ3	.695	.550	1.264	-.730	1.063	-0.687	QC5	-.117	.550	-0.213	-1.516	1.063	-1.426	PQI4	.997	.550	1.813	.201	1.063	0.189
TS1	-.083	.550	-0.151	.053	1.063	0.050	ET1	.826	.550	1.502	-.404	1.063	-0.380	A1	-.117	.550	-0.213	-1.516	1.063	-1.426
TS2	-.994	.550	-1.807	-1.166	1.063	-1.097	ET2	.994	.550	1.807	-1.166	1.063	-1.097	A2	.353	.550	0.642	-1.342	1.063	-1.262
TS3	.291	.550	0.529	-.505	1.063	-0.475	ERL1	.634	.550	1.153	-.576	1.063	-0.542	A3	.057	.550	0.104	-.314	1.063	-0.295
TS4	.997	.550	1.813	.201	1.063	0.189	ERL2	.592	.550	1.076	-.975	1.063	-0.917	A4	.099	.550	0.180	-1.047	1.063	-0.985
I1	1.266	.550	2.302	.398	1.063	0.374	ERS1	.750	.550	1.364	-.223	1.063	-0.210	A5	.099	.550	0.180	-1.047	1.063	-0.985
I2	1.596	.550	2.902	1.899	1.063	1.786	ERS2	.592	.550	1.076	-.975	1.063	-0.917	A6	.000	.550	0.000	.229	1.063	0.215
I3	.634	.550	1.153	-.576	1.063	-0.542	EAS1	1.035	.550	1.882	-.087	1.063	-0.082	A7	.635	.550	1.155	.546	1.063	0.514
I4	.826	.550	1.502	-.404	1.063	-0.380								A8	-.161	.550	-0.293	-.674	1.063	-0.634

Univariate Normality Tests: Student data (Kolmogorov-Smirnov and Shapiro-Wilk)..

Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk			Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk			Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	statistic	df	sig	statistic	df	sig		statistic	df	sig	statistic	df	sig		statistic	df	sig	statistic	df	sig
Opt	.077	334	<.001	.967	334	<.001	PUC	.185	334	<.001	.903	334	<.001	EE	.195	334	<.001	.880	334	<.001
Inn	.086	334	<.001	.953	334	<.001	QPR	.087	334	<.001	.977	334	<.001	PRL	.210	334	<.001	.856	334	<.001

Ins	,110	334	<,001	,942	334	<,001	QAR	,085	334	<,001	,979	334	<,001	PE	,163	334	<,001	,908	334	<,001
Dis	,106	334	<,001	,937	334	<,001	QCR	,097	334	<,001	,976	334	<,001	PRS	,178	334	<,001	,905	334	<,001
SS	,149	334	<,001	,914	334	<,001	ET	,197	334	<,001	,835	334	<,001	PAS	,175	334	<,001	,866	334	<,001
SZ	,186	334	<,001	,902	334	<,001	ERL	,172	334	<,001	,880	334	<,001	PT	,232	334	<,001	,848	334	<,001
TS	,190	334	<,001	,909	334	<,001	ERS	,186	334	<,001	,880	334	<,001	AWS	,082	334	<,001	,969	334	<,001
I	,197	334	<,001	,845	334	<,001	EAS	,175	334	<,001	,866	334	<,001	QI	,135	334	<,001	,904	334	<,001

Univariate Normality Tests: Academics data (Kolmogorov-Smirnov and Shapiro-Wilk).

Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk			Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk			Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	statistic	df	sig.	statistic	df	sig.		statistic	df	sig.	statistic	df	sig.		statistic	df	sig.	statistic	df	sig.
O1	.190	51	<,001	.890	51	<,001	PU3	.202	51	<,001	.866	51	<,001	EEM2	.308	51	<,001	.758	51	<,001
O2	.222	51	<,001	.903	51	<,001	QP1	.278	51	<,001	.859	51	<,001	PRL1	.263	51	<,001	.788	51	<,001
O3	.239	51	<,001	.894	51	<,001	QA1	.255	51	<,001	.870	51	<,001	PRL2	.280	51	<,001	.817	51	<,001
INN1	.203	51	<,001	.911	51	<,001	QC1	.317	51	<,001	.839	51	<,001	PEM1	.292	51	<,001	.773	51	<,001
INN2	.215	51	<,001	.903	51	<,001	QP2	.304	51	<,001	.825	51	<,001	PEM2	.323	51	<,001	.787	51	<,001
INS1	.220	51	<,001	.903	51	<,001	QA2	.236	51	<,001	.875	51	<,001	PRS1	.295	51	<,001	.771	51	<,001
INS2	.216	51	<,001	.898	51	<,001	QC2	.315	51	<,001	.841	51	<,001	PRS2	.315	51	<,001	.767	51	<,001
D1	.190	51	<,001	.896	51	<,001	QP3	.267	51	<,001	.859	51	<,001	PAS1	.319	51	<,001	.780	51	<,001
D2	.222	51	<,001	.900	51	<,001	QA3	.240	51	<,001	.889	51	<,001	PAS2	.344	51	<,001	.781	51	<,001
SS1	.239	51	<,001	.835	51	<,001	QC3	.247	51	<,001	.873	51	<,001	PT1	.342	51	<,001	.747	51	<,001
SS2	.203	51	<,001	.832	51	<,001	QP4	.238	51	<,001	.877	51	<,001	PQ1	.352	51	<,001	.741	51	<,001
SS3	.215	51	<,001	.841	51	<,001	QA4	.293	51	<,001	.853	51	<,001	PQ2	.354	51	<,001	.717	51	<,001
SZ1	.220	51	<,001	.860	51	<,001	QC4	.201	51	<,001	.896	51	<,001	PQ3	.361	51	<,001	.700	51	<,001
SZ2	.216	51	<,001	.858	51	<,001	ET1	.305	51	<,001	.740	51	<,001	PQ4	.278	51	<,001	.767	51	<,001
TS1	.205	51	<,001	.851	51	<,001	ET2	.241	51	<,001	.779	51	<,001	A1	.206	51	<,001	.895	51	<,001
TS2	.231	51	<,001	.858	51	<,001	ERL1	.289	51	<,001	.792	51	<,001	A2	.229	51	<,001	.903	51	<,001
I1	.221	51	<,001	.831	51	<,001	ERL2	.287	51	<,001	.782	51	<,001	A3	.229	51	<,001	.903	51	<,001
I2	.220	51	<,001	.832	51	<,001	ERS1	.268	51	<,001	.781	51	<,001	A4	.198	51	<,001	.909	51	<,001
I3	.248	51	<,001	.831	51	<,001	ERS2	.274	51	<,001	.764	51	<,001	A5	.195	51	<,001	.907	51	<,001
I4	.253	51	<,001	.842	51	<,001	EAS1	.253	51	<,001	.804	51	<,001	A6	.257	51	<,001	.892	51	<,001
PU1	.223	51	<,001	.844	51	<,001	EAS2	.289	51	<,001	.774	51	<,001	A7	.269	51	<,001	.885	51	<,001
PU2	.199	51	<,001	.855	51	<,001	EEM1	.255	51	<,001	.783	51	<,001							

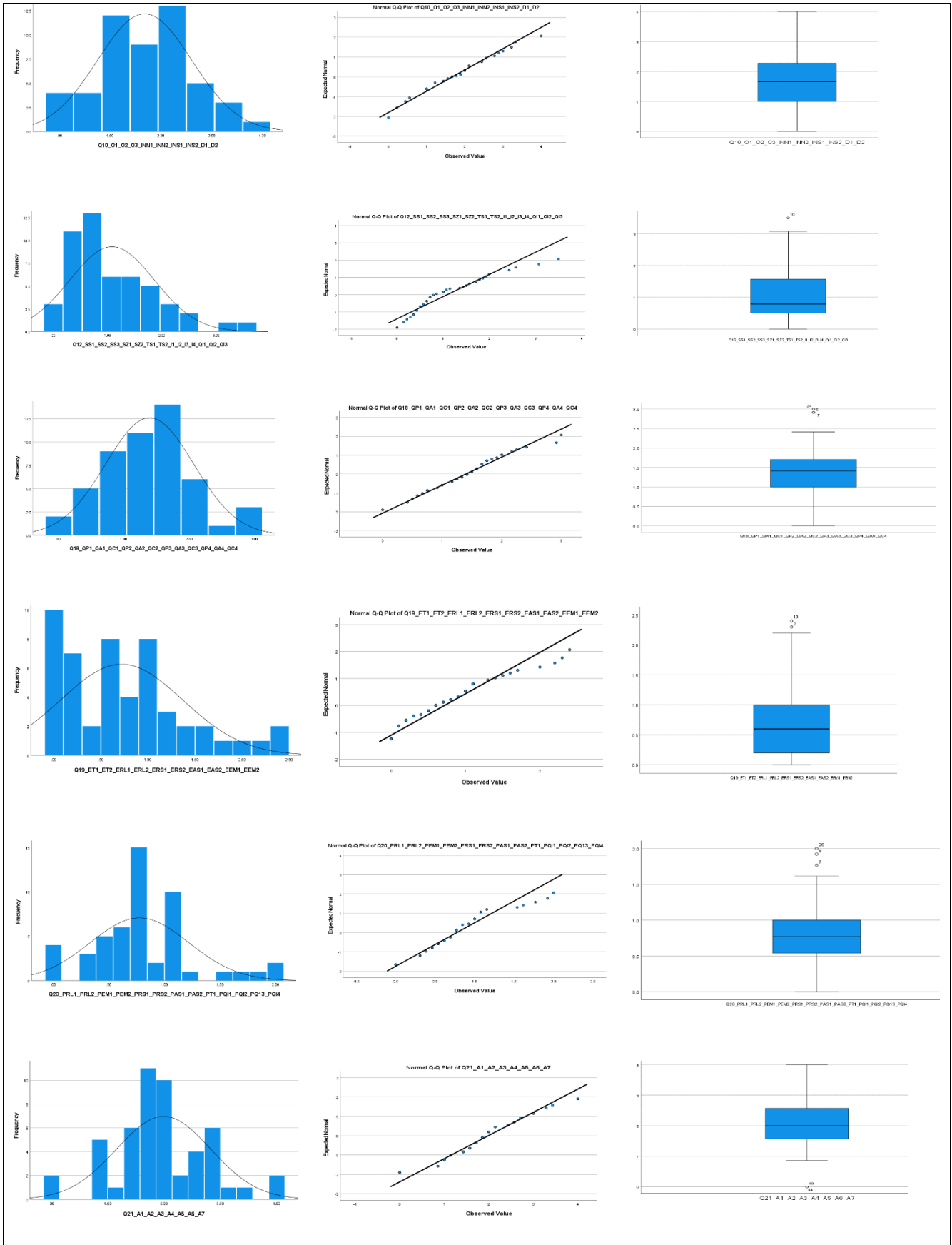
Univariate Normality Tests: IT Staff data (Kolmogorov-Smirnov and Shapiro-Wilk).

Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk			Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk			Scale Items	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	statistic	df	sig.	statistic	df	sig.		statistic	df	sig.	statistic	df	sig.		statistic	df	sig.	statistic	df	sig.
O1	.293	16	<,001	.862	16	.020	PU1	.314	16	<,001	.750	16	<,001	EAS2	.309	16	<,001	.757	16	<,001
O2	.289	16	<,001	.860	16	.019	PU2	.273	16	.002	.788	16	.002	EEM1	.239	16	.015	.796	16	.002
O3	.250	16	.009	.859	16	.019	PU3	.273	16	.002	.788	16	.002	EEM2	.272	16	.002	.787	16	.002
INN1	.375	16	<,001	.725	16	<,001	QP1	.243	16	.012	.776	16	.001	PRL1	.343	16	<,001	.738	16	<,001
INN2	.246	16	.011	.845	16	.011	QA1	.257	16	.006	.814	16	.004	PRL2	.286	16	.001	.787	16	.002
INS1	.363	16	<,001	.768	16	.001	QC1	.250	16	.009	.820	16	.005	PEM1	.323	16	<,001	.759	16	<,001
INS2	.302	16	<,001	.851	16	.014	QP2	.283	16	.001	.832	16	.008	PEM2	.271	16	.003	.793	16	.002
D1	.186	16	.143	.892	16	.060	QA2	.220	16	.038	.819	16	.005	PRS1	.343	16	<,001	.738	16	<,001
D2	.227	16	.027	.886	16	.049	QC2	.287	16	.001	.807	16	.003	PRS2	.271	16	.003	.793	16	.002
SS1	.492	16	<,001	.484	16	<,001	QP3	.236	16	.018	.809	16	.004	PAS1	.309	16	<,001	.757	16	<,001
SS2	.268	16	.003	.796	16	.002	QA3	.202	16	.080	.812	16	.004	PAS2	.268	16	.003	.796	16	.002
SS3	.323	16	<,001	.759	16	<,001	QC3	.272	16	.002	.787	16	.002	PT1	.348	16	<,001	.729	16	<,001
SS4	.398	16	<,001	.621	16	<,001	QP4	.220	16	.038	.819	16	.005	PQ1	.348	16	<,001	.729	16	<,001
SZ1	.355	16	<,001	.746	16	<,001	QA4	.287	16	.001	.807	16	.003	PQ2	.273	16	.002	.788	16	.002
SZ2	.323	16	<,001	.759	16	<,001	QC4	.345	16	<,001	.803	16	.003	PQ3	.323	16	<,001	.759	16	<,001
SZ3	.264	16	.004	.828	16	.006	QC5	.239	16	.015	.796	16	.002	PQ4	.382	16	<,001	.695	16	<,001
TS1	.355	16	<,001	.746	16	<,001	ET1	.308	16	<,001	.768	16	.001	A1	.239	16	.015	.796	16	.002
TS2	.431	16	<,001	.591	16	<,001	ET2	.431	16	<,001	.591	16	<,001	A2	.272	16	.002	.787	16	.002
TS3	.268	16	.003	.796	16	.002	ERL1	.308	16	<,001	.768	16	.001	A3	.330	16	<,001	.778	16	.001
TS4	.348	16	<,001	.729	16	<,001	ERL2	.271	16	.003	.793	16	.002	A4	.220	16	.038	.819	16	.005
I1	.378	16	<,001	.697	16	<,001	ERS1	.314	16	<,001	.750	16	<,001	A5	.220	16	.038	.819	16	.005
I2	.415	16	<,001	.648	16	<,001	ERS2	.271	16	.003	.793	16	.002	A6	.356	16	<,001	.748	16	<,001
I3	.308	16	<,001	.768	16	.001	EAS1	.343	16	<,001	.738	16	<,001	A7	.312	16	<,001	.846	16	.012
I4	.308	16	<,001	.768	16	.001							A8	.257	16	.006	.814	16	.004	

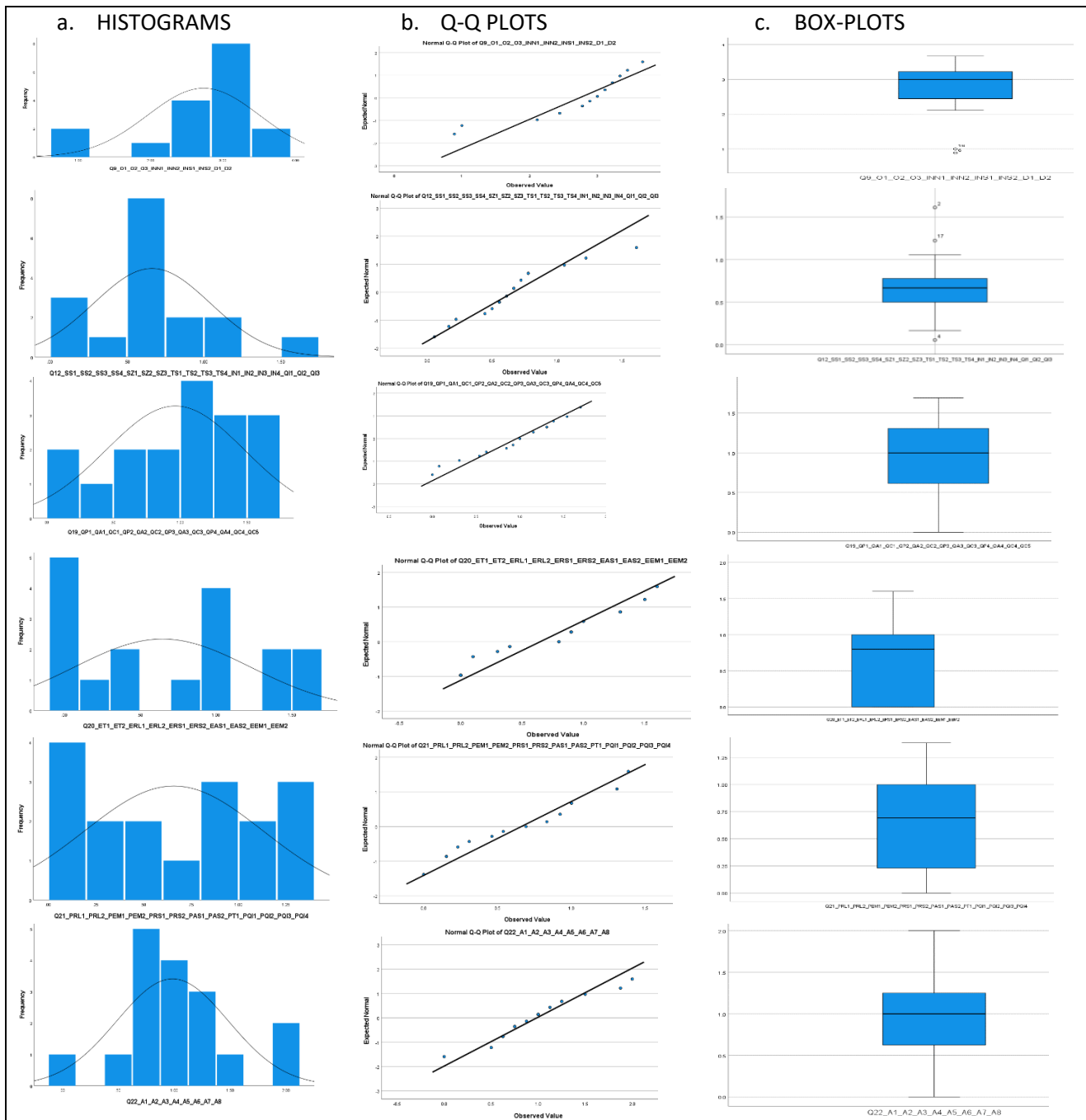
a. HISTOGRAMS

b. Q-Q PLOTS

c. BOX-PLOTS

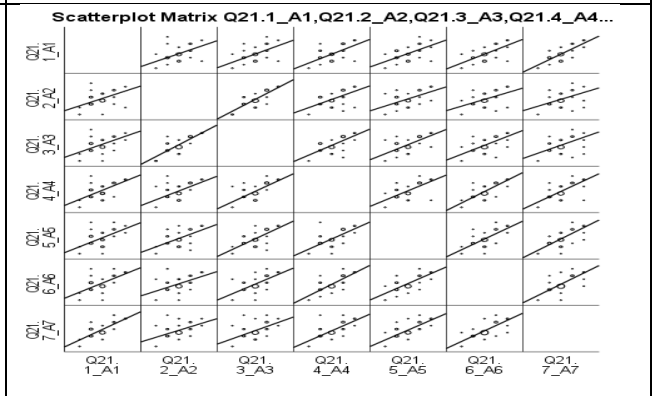
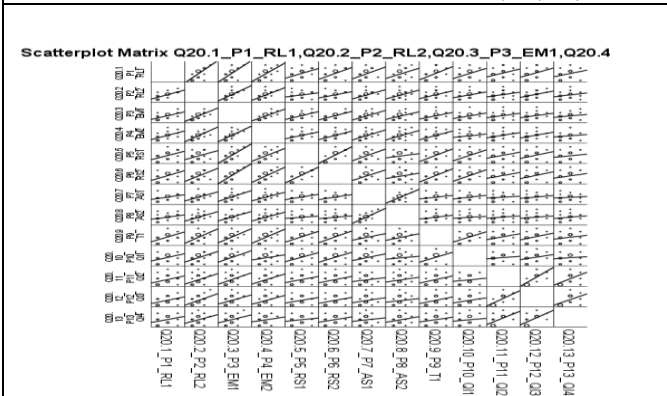
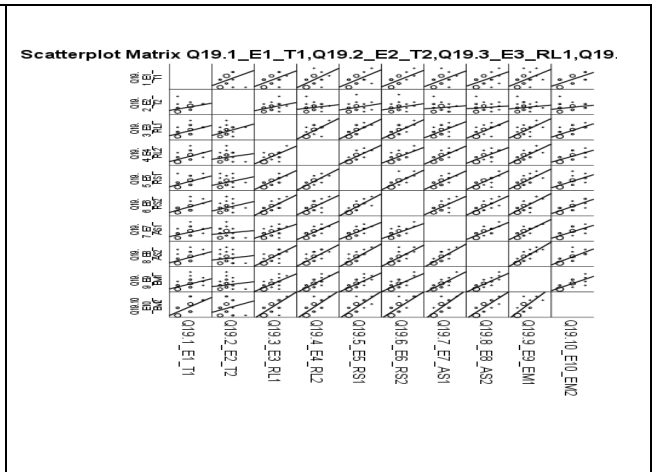
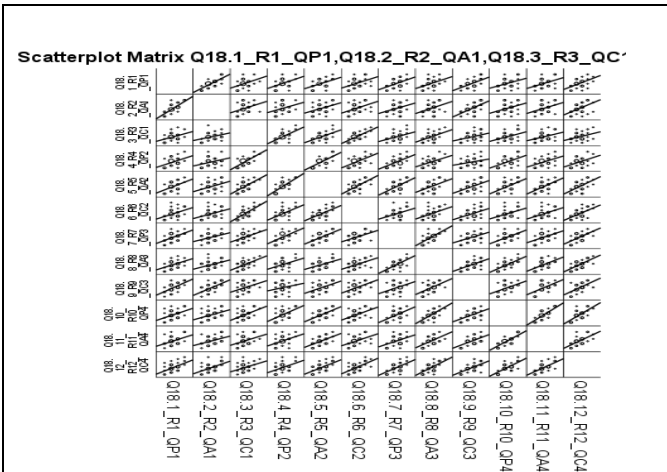


Visual representation of normality tests of variables in the Academic sample (Histogram, QQ Plots, Box Plots).

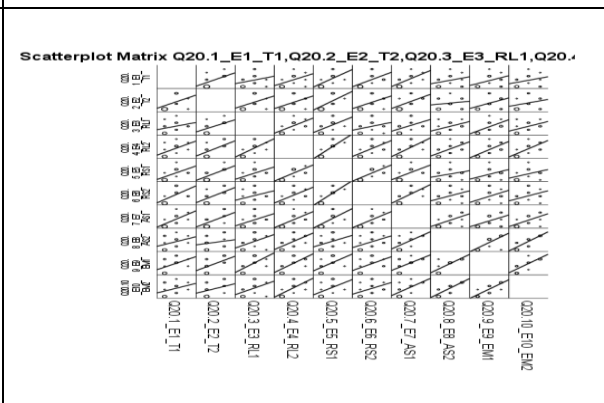
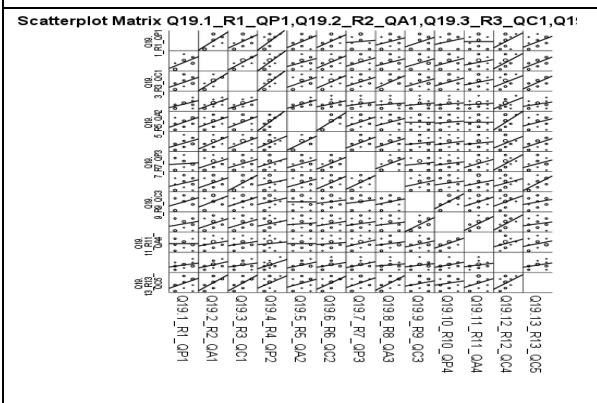
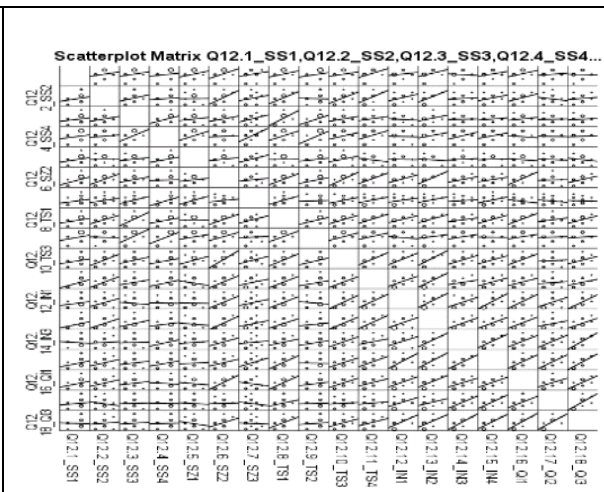
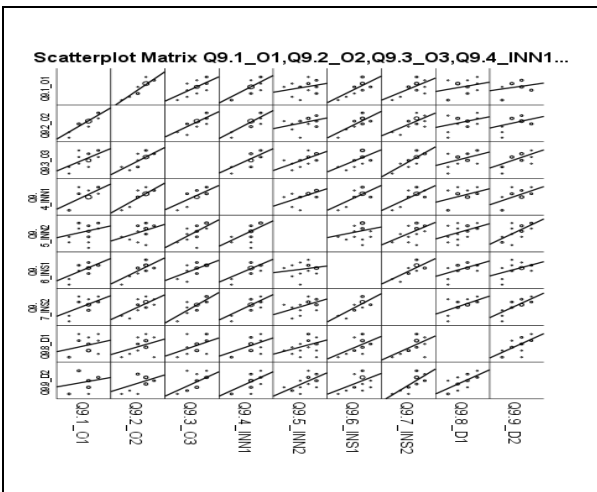


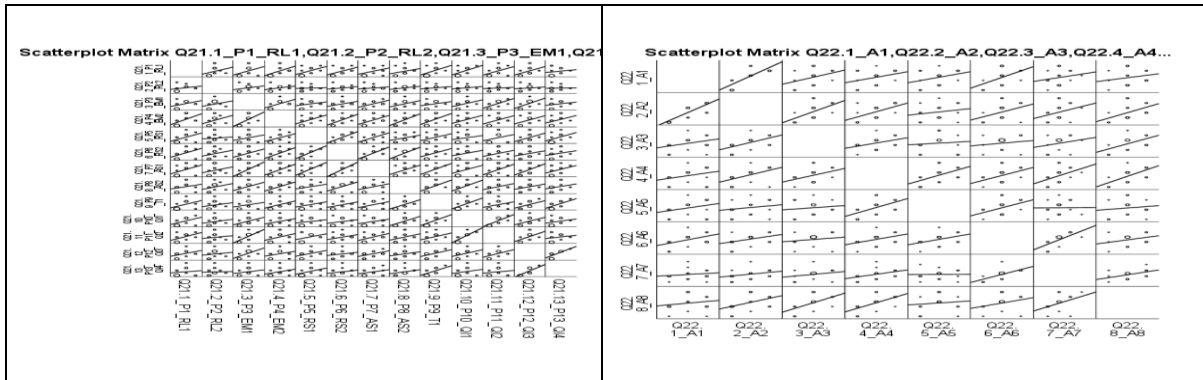
Visual representation of normality tests of variables in the IT staff sample (Histogram, QQ Plots, Box Plots).

ANNEXURE J: Linearity Assumptions



Matrix Scatter plots of the Study variables and linearity results. (academic data)



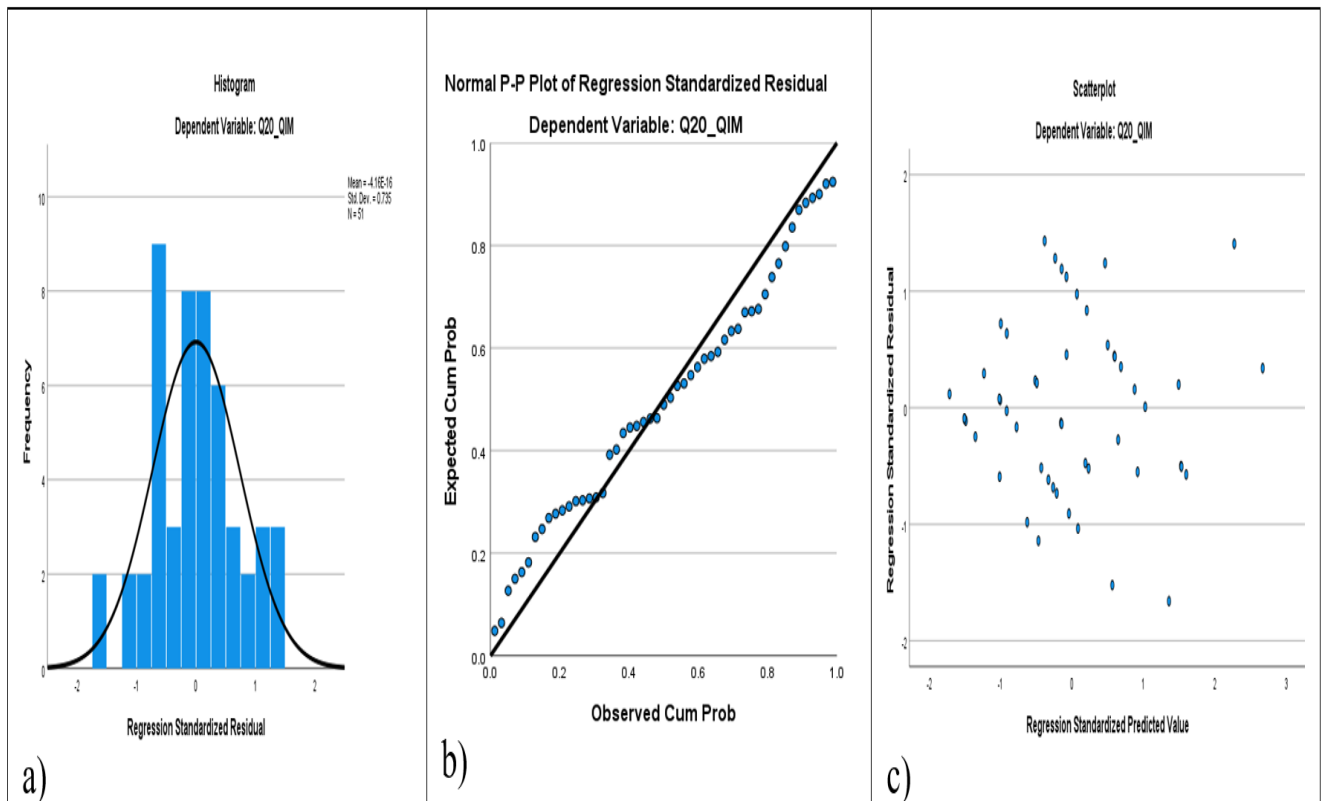


Matrix Scatter plots of the Study variables and linearity results. (IT staff)

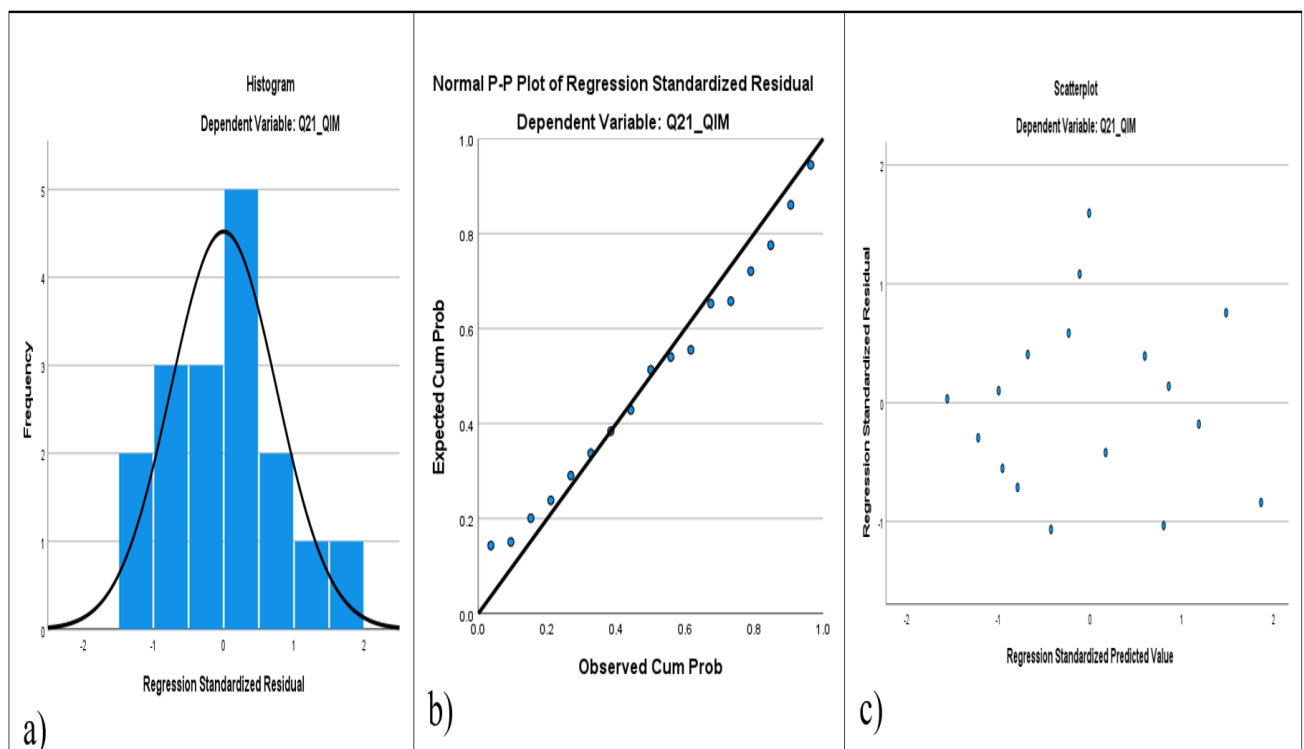
Pearson Correlations of variables (student data)

		Correlations											
Items		1	2	3	4	5	6	7	8	9			
Q8.1_O1, N=334	Pearson Correlation	1											
Q8.2_O2, Sig. (2-tailed: <,001)	Pearson Correlation	.577**											
	N	334	334										
Q8.3_O3, Sig. (2-tailed: <,001)	Pearson Correlation	.526**	.552**	1									
	N	331	331	331									
Q8.4_INN1, Sig. (2-tailed: <,001)	Pearson Correlation	.491**	.431**	.566**	1								
	N	333	333	330	333								
Q8.5_INN2, Sig. (2-tailed: <,001)	Pearson Correlation	.411**	.455**	.478**	.538**	1							
	N	334	334	331	333	334							
Q8.6_INS1, Sig. (2-tailed: <,001)	Pearson Correlation	.396**	.426**	.516**	.494**	.598**	1						
	N	332	332	329	331	332	332						
Q8.7_INS2, Sig. (2-tailed: <,001)	Pearson Correlation	.497**	.570**	.467**	.484**	.608**	.651**	1					
	N	332	332	329	331	332	330	332					
Q8.8_D1, Sig. (2-tailed: <,001)	Pearson Correlation	.393**	.367**	.417**	.503**	.432**	.520**	.595**	1				
	N	334	334	331	333	334	332	332	334				
Q8.9_D2, Sig. (2-tailed: <,001)	Pearson Correlation	.415**	.468**	.411**	.417**	.503**	.529**	.580**	.681**	1			
	N	334	334	331	333	334	332	332	334	334			
**. Correlation is significant at the 0.01 level (2-tailed).													
		1	2	3	4	5	6	7	8	9	10	11	12
Q10.1_SS1, N=334	Pearson Correlation	1											
Q10.2_SS2, Sig. (2-tailed: <,001)	Pearson Correlation	.618**	1										
	N	334	334										
Q10.3_SS3; Sig. (2-tailed: <,001)	Pearson Correlation	.440**	.644**	1									
	N	334	334	334									
Q10.4_SZ1, Sig. (2-tailed: <,001)	Pearson Correlation	.412**	.516**	.471**	1								
	N	334	334	334	334								
Q10.5_SZ2, Sig. (2-tailed: <,001)	Pearson Correlation	.329**	.407**	.420**	.562**	1							
	N	334	334	334	334	334							
Q10.6_TS1, Sig. (2-tailed: <,001)	Pearson Correlation	.391**	.396**	.436**	.547**	.669**	1						
	N	334	334	334	334	334	334						
Q10.7_TS2, Sig. (2-tailed: <,001)	Pearson Correlation	.367**	.396**	.325**	.497**	.648**	.672**	1					
	N	333	333	333	333	333	333	333					
Q10.8_I1	Pearson Correlation	.167**	.113*	.179**	.244**	.287**	.267**	.265**	1				
	Sig. (2-tailed)	.002	.040	.001	<,001	<,001	<,001	<,001	<,001				
	N	334	334	334	334	334	334	333	334				
Q10.9_I2	Pearson Correlation	.104	.143**	.197**	.238**	.265**	.226**	.195**	.649**	1			
	Sig. (2-tailed)	.057	.009	<,001	<,001	<,001	<,001	<,001	<,001	<,001			
	N	334	334	334	334	334	334	333	334	334			
Q10.10_I3	Pearson Correlation	.114*	.173**	.249**	.190**	.233**	.129*	.116*	.544**	.693**	1		
	Sig. (2-tailed)	.038	.002	<,001	<,001	<,001	.019	.034	<,001	<,001	<,001		
	N	334	334	334	334	334	334	333	334	334	334		
Q10.11_I4	Pearson Correlation	.088	.151**	.239**	.268**	.273**	.204**	.207**	.514**	.688**	.741**	1	
	Sig. (2-tailed)	.109	.006	<,001	<,001	<,001	<,001	<,001	<,001	<,001	<,001	<,001	
	N	334	334	334	334	334	334	333	334	334	334	334	
**. Correlation is significant at the 0.01 level (2-tailed).													
*. Correlation is significant at the 0.05 level (2-tailed).													
		1	2	3	4	5	6	7	8	9	10	11	12
Q16.1_R1_QP1, N=334													
Q16.2_R2_QA1, Sig. (2-tailed: <,001)	Pearson Correlation	.618**	1										
	N	334	334										
Q16.3_R3_QC1, Sig. (2-tailed: <,001)	Pearson Correlation	.567**	.610**	1									

ANNEXURE K: Assumptions of Multivariate analyses



Normality, Linearity and Homoscedasticity Assumptions tested for multivariate analysis of the 4IRQIM model (Academic data)



Normality, Linearity and Homoscedasticity Assumptions tested for multivariate analysis of the 4IRQIM model (IT Staff data)

ANNEXURE L- Multiple response

4IR technologies heard of and Resources Required: Comparison

4IR technologies heard of	students			Academics			IT Staff			TOTAL		
	N	%	% of Cases	N	%	% of Cases	N	%	% of Cases	N	%	% of Cases
Artificial intelligence	189	6,0%	56,6%	19	4,3%	37,3%	2	1,5%	11,8%	210	5.6%	52.2%
Cloud Computing	255	8,0%	76,3%	24	5,4%	47,1%	2	1,5%	11,8%	281	7.5%	69.9%
Augmented reality	323	10,2%	96,7%	47	10,7%	92,2%	16	12,1%	94,1%	386	10.3%	96.0%
Simulation	296	9,3%	88,6%	42	9,5%	82,4%	15	11,4%	88,2%	353	9.4%	87.8%
Big data	311	9,8%	93,1%	41	9,3%	80,4%	9	6,8%	52,9%	361	9.6%	89.8%
Virtual reality	274	8,6%	82,0%	35	7,9%	68,6%	14	10,6%	82,4%	323	9.3%	80.3%
3D and 4D printing	245	7,7%	73,4%	34	7,7%	66,7%	11	8,3%	64,7%	290	7.7%	72.1%
Automation	293	9,2%	87,7%	36	8,2%	70,6%	10	7,6%	58,8%	339	9.0%	84.3%
Block chain	312	9,8%	93,4%	47	10,7%	92,2%	16	12,1%	94,1%	375	10.0%	93.3%
Internet of things	228	7,2%	68,3%	38	8,6%	74,5%	4	3,0%	23,5%	270	7.2%	67.2%
Robotics	195	6,1%	58,4%	30	6,8%	58,8%	16	12,1%	94,1%	241	6.4%	59.9%
None	255	8,0%	76,3%	48	10,9%	94,1%	17	12,9%	100%	320	8.5%	79.6%
TOTAL	3176	100%	950,9%	441	100%	864,7%	132	100%	776,5%	3749	100%	932.4%
4IR Resources Required												
High speed internet	108	6.7%	32.8%	24	8.8%	47.1%	1	2.2%	5.9%	133	6.9%	33.5%
Smart computers	129	8.0%	39.2%	23	8.4%	45.1%	3	6.7%	17.6%	155	8.0%	39.0%
Training programs	143	8.9%	43.5%	25	9.2%	49.0%	4	8.9%	23.5%	172	8.9%	43.3%
Mentors	169	10.5%	51.4%	31	11.4%	60.8%	--	--	--	200	10.4%	52.6%
ICT support	137	8.5%	41.6%	31	11.4%	60.8%	--	--	--	168	8.7%	44.2%
4IR learning environment	162	10.1%	49.2%	25	9.2%	49.0%	5	11.1%	29.4%	192	9.9%	48.3%
4IR student clubs	245	15.3%	74.5%	29	10.6%	56.9%	--	--	--	274	14.2%	72.1%
4IR labs	188	11.7%	57.1%	34	12.5%	66.7%	3	6.7%	17.6%	225	11.7%	56.6%
No support needed	322	20.1%	97.9%	51	18.7%	100.0%	17	37.8%	100.0%	390	20.3%	98.2%
Data centers and servers	--	--	--	--	--	--	3	6.7%	17.6%	3	0,15%	17.6%
Skilled workforce	--	--	--	--	--	--	6	13.3%	35.3%	6	0.31%	35.2%
Advanced infrastructure	--	--	--	--	--	--	3	6.7%	17.6%	3	0.15%	17.6%
TOTAL	1603	100%	487.2%	273	100%	535.3%	45	100%	264.7%	1921	100%	558,2%

Service Quality Capabilities: IT staff

Service Quality Capabilities requiring improvement	IT STAFF		
	N	%	% of Cases
User needs assessments as a service quality capability requiring improvement	6	12.0%	35.3%
Service design and delivery as a service quality capability requiring improvement	4	8.0%	23.5%
Service level management as a service quality capability requiring improvement	4	8.0%	23.5%
Service desk and support as a service quality capability requiring improvement	5	10.0%	29.4%
Service Monitoring as a service quality capability requiring improvement	6	12.0%	35.3%
creation of service-oriented culture as a service quality capability requiring improvement	8	16.0%	47.1%
None	17	34.0%	100.0%
TOTAL	356	100.0%	698.0%

4IR benefits and challenges: Comparison

4IR Benefits (students)	N	%	% of Cases	4IR Challenges (students)	N	%	% of Cases
Personalized learning experience	166	9.9%	50.3%	It can be costly	127	5.8%	38.0%
Improved research opportunity	93	5.5%	28.2%	No training and support	151	6.8%	45.2%
Improved access to education and resources	90	5.3%	27.3%	No ability to adapt new technology	269	12.2%	80.5%
Become career ready for future jobs	112	6.6%	33.9%	Fear of change towards current learning	270	12.2%	80.8%
Flexible and remote learning	157	9.3%	47.6%	No infrastructure and devices	184	8.3%	55.1%
Hands on experience-based learning	216	12.8%	65.5%	Lack of trust in technology	297	13.5%	88.9%
Better communication with lecturers	150	8.9%	45.5%	No skills and knowledge to use new technology	227	10.3%	68.0%
Improvised student services	180	10.7%	54.5%	No internet connectivity	145	6.6%	43.4%
Repetitive learning-based for improved performance	195	11.6%	59.1%	Data Privacy and security concerns	219	9.9%	65.6%
None	326	19.3%	98.8%	None	319	14.4%	95.5%
TOTAL	1685	100%	510.6%	TOTAL	2208	100.0%	661.1%
4IR Benefits (academics)				4IR Challenges (academics)			
Personalized teaching experience	34	13.0%	66.7%	It can be costly	38	10.7%	74.5%
Improved research facilities	22	8.4%	43.1%	No training and support	26	7.3%	51.0%
Improved access to educational resources	28	10.7%	54.9%	No ability to adapt to new technology	41	11.5%	80.4%
Easy to collaborate & network	28	10.7%	54.9%	technical difficulties	31	8.7%	60.8%
Enhanced student engagement	25	9.6%	49.0%	No infrastructure and devices	27	7.6%	52.9%
Remote learning availability	22	8.4%	43.1%	Lack of trust in technology	36	10.1%	70.6%
Improved teaching efficiency	19	7.3%	37.3%	No skills and knowledge in new technology	36	10.1%	70.6%
Real-time feedback	33	12.6%	64.7%	No internet connectivity	36	10.1%	70.6%
None	50	19.2%	98.0%	Data privacy and security	36	10.1%	70.6%
				None	49	13.8%	96.1%
TOTAL	261	100.0%	511.8%	TOTAL	356	100%	698%
4IR benefits IT staff				4IR Challenges (IT Staff)			
Improve decision making	1	3.3%	5.9%	expensive to maintain	4	7.8%	23.5%
Increase agility	3	10.0%	17.6%	technical complexities	8	15.7%	47.1%
Improve user experiences	4	13.3%	23.5%	data privacy/security risks	10	19.6%	58.8%
Improve security management	2	6.7%	11.8%	difficult to integrate	6	11.8%	35.3%
Improve communication	2	6.7%	11.8%	Need highly skilled staff	2	3.9%	11.8%
Improve productivity	1	3.3%	5.9%	resistance to change	4	7.8%	23.5%
None	17	56.7%	100.0%	None	17	33.3%	100.0%
TOTAL	30	100.0%	176.5%	TOTAL	51	100%	300%

4IR Drivers: Comparison

4IR Drivers (students & academics)	students			Academics			4IR Drivers (IT staff)	IT staff		
	N	%	% of Cases	N	%	% of Cases		N	%	% of Cases
Meet changing student's needs	128	10.7%	38.3%	22	11.5%	43.1%	Meet stakeholder Expectations	2	5.7%	11.8%

Gain competitive advantage from other universities	134	11.2%	40.1%	20	10.4%	39.2%	Gain competitive advantage	3	8.6%	17.6%
Meet industry demands where students will work	116	9.7%	34.7%	20	10.4%	39.2%	Improve service quality	1	2.9%	5.9%
Drive innovation	174	14.6%	52.1%	19	9.9%	37.3%	Promote innovation	1	2.9%	5.9%
Attract funding opportunities	--	--	--	26	13.5%	51.0%	Comply with regulations	6	17.1%	35.3%
Keep up with globalization	149	12.5%	44.6%	--	--	--	Support sustainability goals	5	14.3%	29.4%
Sustain for the future	167	14.0%	50.0%	34	17.7%	66.7%				
None	324	27.2%	97.0%	51	26.6%	100.0%	None	17	48.6%	100.0%
TOTAL	1192	100%	356.9%	192	100%	376.5%	TOTAL	35	100	205.9%

4IR critical success factors: Comparison

Critical Success Factors	students			Academics			IT staff			TOTAL		
	N	%	% of Cases	N	%	% of Cases	N	%	% of Cases	N	%	% of Cases
Funding and resources	84	7.8%	25.1%	26	12.7%	51.0%	2	5.4%	11.8%	112	8.5%	27.7%
Skilled staff and experts	102	9.4%	30.5%	25	12.3%	49.0%	2	5.4%	11.8%	129	9.8%	32.1%
Support from the leaders in the field	165	15.3%	49.4%	--	--	--	5	13.5%	29.4%	170	12.9%	42.3%
Policy framework	--	--	--	29	14.2%	56.9%	--	--	--	29	2.2%	7.2%
Training and support	124	11.5%	37.1%	23	11.3%	45.1%	3	8.1%	17.6%	150	11.3%	37.3%
Strong infrastructure	136	12.6%	40.7%	18	8.8%	35.3%	2	5.4%	11.8%	156	11.8%	38.8%
Partnerships with the industry	142	13.1%	42.5%	33	16.2%	64.7%	6	16.2%	35.3%	181	13.7%	45.0%
None	328	30.3%	98.2%	50	24.5%	98.0%	17	45.9%	100.0%	395	29.9%	98.3%
TOTAL	1081	100%	323.7%	204	100%	400%	37	100%	217%	1322	100	328.9%

ANNEXURE M -Likert Scale

4IR Readiness: Comparison

4IR readiness	Students										Academics										IT staff										TOTAL									
	GE		ME		N		SE		NE		GE		ME		N		SE		NE		GE		ME		N		SE		NE		GE		ME		N		SE		NE	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
O1	71	21.3	82	24.6	88	26.3	53	15.9	40	12.0	1	2.0	15	29.4	13	25.5	15	29.4	7	13.7	3	17.6	9	52.9	3	17.6	2	11.8	-	-	75	18.7	106	26.4	104	25,9	70	17.4	47	11,7
O2	54	16.2	84	25.1	98	29.3	58	17.4	40	12.0	5	9.8	10	19.6	12	23.5	18	35.3	6	11.8	2	11.8	9	52.9	4	23.5	1	5.9	1	5.9	61	15,2	103	25,6	114	28,4	77	19,1	47	11,7
O3	72	21.8	81	24.5	81	24.5	58	17.5	39	11.8	2	3.9	11	21.6	14	27.5	20	39.2	4	7.8	5	29.4	8	47.1	3	17.6	1	5.9	-	-	79	19,7	100	24,9	98	24,4	79	19,6	43	10,7
Inn1	71	21.3	83	24.9	80	24.0	59	17.7	40	12.0	3	5.9	10	19.6	15	29.4	17	33.3	6	11.8	4	23.5	11	64.7	2	11.8	-	-	-	78	19,4	104	25,9	97	24,1	76	18,9	46	11,4	
Inn2	53	15.9	68	20.4	86	25.7	70	21.0	57	17.1	4	7.8	9	17.6	12	23.5	17	33.3	9	17.6	6	35.3	5	29.4	3	17.6	2	11.8	1	5.9	63	15,7	82	20,4	101	25,1	89	22,1	67	16,7
Ins1	62	18.7	82	24.7	91	27.4	51	15.4	46	13.9	2	3.9	12	23.5	13	25.5	18	35.3	6	11.8	2	11.8	10	58.8	3	17.6	1	5.9	1	5.9	66	16,4	104	25,9	107	26,6	70	17,4	53	13,2
Ins2	74	22.3	72	21.7	73	22.0	58	17.5	55	16.6	1	2.0	8	15.7	19	37.3	13	25.5	10	19.6	3	17.6	9	52.9	3	17.6	1	5.9	1	5.9	78	19,4	89	22,1	95	23,6	72	17,9	66	16,4
D1	82	24.6	76	22.8	78	23.4	57	17.1	41	12.3	1	2.0	9	17.6	14	27.5	20	39.2	7	13.7	3	17.6	6	35.3	5	29.4	3	17.6	-	-	86	21,4	91	22,6	97	24,1	80	19,9	48	11,9
D2	64	19.2	64	19.2	76	22.8	60	18	70	21.0	3	5.9	7	13.7	14	27.5	19	37.3	8	15.7	3	17.6	7	41.2	4	23.5	3	17.6	-	-	70	17,4	78	19,4	94	23,4	82	20,3	78	19,4

4IR Institutional capabilities in 4IR initiation: Comparison

Institutional capabilities in 4IR initiation	Students										Academics										IT staff										TOTAL										
	SA		A		N		D		SD		SA		A		N		D		SD		SA		A		N		D		SD		SA		A		N		D		SD		
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	
SS1	111	33.2	117	35.0	71	21.3	20	6.0	15	4.5	12	23.5	26	51.0	8	15.7	5	9.8	-	-	4	23.5	13	76.5	-	-	-	-	-	-	127	31,6	156	38,8	79	19,7	25	6,2	15	3,7	
SS2	102	30.5	137	41.0	64	19.2	18	5.4	13	3.9	9	17.6	28	54.9	8	15.7	5	9.8	1	2.0	6	35.3	9	52.9	2	11.8	-	-	-	-	117	29,1	174	43,3	74	18,4	23	5,7	14	3,5	
SS3	75	22.5	135	40.4	89	26.6	21	6.3	14	4.2	12	23.5	26	51.0	9	17.6	4	7.8	-	-	6	35.3	10	58.8	1	5.9	-	-	-	-	93	23,1	171	42,5	99	24,6	25	6,2	14	3,5	
SS4																						6	35.3	11	64.7	-	-	-	-	-	6	35,3	11	64,7	0	0,0	0	0,0	0	0,0	
SZ1	110	32.9	116	34.7	79	23.7	16	4.8	13	3.9	13	25.5	23	45.1	10	19.6	4	7.8	1	2.0	5	29.4	11	64.7	1	5.9	-	-	-	-	128	31,8	150	37,3	90	22,4	20	5,0	14	3,5	
SZ2	97	29.0	129	38.6	75	22.5	19	5.7	14	4.2	15	29.4	20	39.2	10	19.6	4	7.8	2	3.9	6	35.3	10	58.8	1	5.9					118	29,4	159	39,6	86	21,4	23	5,7	16	4,0	
SZ3																						8	47.1	4	23.5	4	23.5	1	5.9	-	-	8	47,1	4	23,5	4	23,5	1	5,9	0	0,0
TS1	92	27.5	118	35.3	89	26.3	21	6.3	14	4.2	17	33.3	18	35.3	13	25.5	3	5.9	-	-	5	29.4	11	64.7	1	5.9	-	-	-	-	114	28,4	147	36,6	103	25,6	24	6,0	14	3,5	
TS2	97	29.1	123	36.9	71	21.3	25	7.5	17	5.1	17	33.3	18	35.3	10	19.6	5	9.8	1	2.0	5	29.4	12	70.6	-	-	-	-	-	-	119	29,6	153	38,1	81	20,1	30	7,5	18	4,5	
TS3																						6	35.3	9	52.9	2	11.8	-	-	-	-	6	35,3	9	52,9	2	11,8	0	0,0	0	0,0
TS4																						10	58.8	6	35.3	1	5.9	-	-	-	-	10	58,8	6	35,3	1	5,9	0	0,0	0	0,0
I1	143	42.8	115	34.4	47	14.1	18	5.4	11	3.3	18	35.3	18	35.3	12	23.5	1	2.0	2	3.0	11	64.7	4	23.5	2	11.8	-	-	-	-	172	42,8	137	34,1	61	15,2	19	4,7	13	3,2	
I2	158	47.3	113	33.8	41	12.3	9	2.7	13	3.9	19	37.3	18	35.3	12	23.5	1	2.0	1	2.0	12	70.6	4	23.5	1	5.9	-	-	-	-	189	47,0	135	33,6	54	13,4	10	2,5	14	3,5	

I3	135	40.4	123	37.1	50	15.0	12	3.6	13	3.9	18	35.3	21	41.2	9	17.6	2	3.9	1	2.0	8	47.1	7	41.2	2	11.8	-	-	-	-	161	40,0	151	37,6	61	15,2	14	3,5	14	3,5
I4	150	44.9	110	32.9	46	13.8	14	4.2	14	4.2	17	33.3	21	4.2	9	17.6	3	5.9	1	2.0	9	52.9	6	35.3	2	11.8	-	-	-	-	176	43,8	137	34,1	57	14,2	17	4,2	15	3,7
PU1	122	36.5	120	35.9	64	19.2	19	5.7	9	2.7	19	37.3	15	29.4	14	27.5	2	3.9	1	2.0	8	47.1	8	47.1	1	5.9	-	-	-	-	149	37,1	143	35,6	79	19,7	21	5,2	10	2,5
PU2	98	29.3	128	38.3	74	22.2	23	6.9	11	3.3	17	33.3	17	33.3	14	27.5	2	3.9	1	2.0	8	47.1	7	41.2	2	11.8	-	-	-	-	123	30,6	152	37,8	90	22,4	25	6,2	12	3,0
PU3	116	34.7	117	35.0	66	19.8	21	6.3	14	4.2	16	31.4	17	33.3	14	27.5	3	5.9	1	2.0	7	41.2	8	47.1	2	11.8	-	-	-	-	139	34,6	142	35,3	82	20,4	24	6,0	15	3,7

4IR Role in Quality Management: Comparison

4IR Role in Quality Management	Students										Academics					IT staff					TOTAL																			
	SA		A		N		D		SD		SA		A		N		D		SD		SA		A		N		D		SD											
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P								
QP1	70	21.0	120	35.9	102	30.5	28	8.4	14	4.2	7	13.7	25	49.0	15	29.4	4	7.8	-	-	6	35.3	5	29.4	6	35.3	-	-	-	-	83	20,6	150	37,3	123	30,6	32	8,0	14	3,5
QP2	85	25.4	121	36.2	79	23.7	41	12.3	8	2.4	12	23.5	28	54.9	8	15.7	3	5.9	-	-	5	29.4	9	52.9	2	11.8	1	5.9	-	-	102	25,4	158	39,3	89	22,1	45	11,2	8	2,0
QP3	74	22.2	106	31.7	105	31.4	36	10.8	13	3.9	7	13.7	17	33.3	23	45.1	4	7.8	-	-	6	35.3	8	47.1	3	17.6	-	-	-	-	87	21,6	131	32,6	131	32,6	40	10,0	13	3,2
QP4	58	17.4	118	35.3	96	28.7	49	14.7	13	3.9	8	15.7	21	41.2	16	31.4	6	11.8	-	-	6	35.3	7	41.2	4	23.5	-	-	-	-	72	17,9	146	36,3	116	28,9	55	13,7	13	3,2
QA1	57	17.1	139	41.6	103	30.8	26	7.8	9	2.7	6	11.8	22	43.1	15	29.4	8	15.7	-	-	5	29.4	9	52.9	3	17.6	-	-	-	-	68	16,9	170	42,3	121	30,1	34	8,5	9	2,2
QA2	68	20.4	122	36.5	95	28.4	43	12.9	6	1.8	10	19.6	21	41.2	15	29.4	5	9.8	-	-	5	29.4	7	41.2	5	29.4	-	-	-	-	83	20,6	150	37,3	115	28,6	48	11,9	6	1,5
QA3	50	15.0	117	35.0	116	34.7	39	11.7	12	3.6	8	15.7	15	29.4	22	43.1	5	9.8	1	2.0	6	35.3	6	35.3	5	29.4	-	-	-	-	64	15,9	138	34,3	143	35,6	44	10,9	13	3,2
QA4	75	22.5	107	32	97	29	42	12.6	13	3.9	7	13.7	26	51.0	13	25.5	5	9.8	-	-	4	23.5	10	58.8	3	17.6	-	-	-	-	86	21,4	143	35,6	113	28,1	47	11,7	13	3,2
QC1	63	18.9	129	38.9	101	30.4	27	8.1	12	3.6	7	13.7	28	54.9	11	21.6	4	7.8	1	2.0	5	29.4	8	47.1	4	23.5	-	-	-	-	75	18,7	165	41,0	116	28,9	31	7,7	13	3,2
QC2	65	19.5	99	29.6	110	32.9	46	13.8	14	4.2	7	13.7	27	52.9	10	19.6	5	9.8	2	3.9	5	29.4	9	52.9	3	17.6	-	-	-	-	77	19,2	135	33,6	123	30,6	51	12,7	16	4,0
QC3	56	16.8	131	39.2	86	25.7	47	14.1	14	4.2	5	9.8	15	29.4	22	43.1	9	17.6	-	-	4	23.5	6	35.3	7	41.2	-	-	-	-	65	16,2	152	37,8	115	28,6	56	13,9	14	3,5
QC4	62	18.6	110	32.9	83	24.9	54	16.2	25	7.5	7	13.7	18	35.3	19	37.3	5	9.8	2	3.9	3	17.6	11	64.7	2	11.8	1	5.9	-	-	72	17,9	139	34,6	104	25,9	60	14,9	27	6,7
QC5																					5	29.4	6	35.3	6	35.3	-	-	-	-	5	1,2	6	1,5	6	1,5	0	0,0	0	0,0

Expectations from 4IR technologies: Comparison

4IR Technologies expectations	Students										Academics					IT staff					TOTAL																			
	SA		A		N		D		SD		SA		A		N		D		SD		SA		A		N		D		SD											
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P										
ET1	170	50.9	105	31.4	42	12.6	11	3.3	6	1.8	24	47.1	24	47.1	3	5.9	-	-	-	-	9	52.9	6	35.3	2	11.8	-	-	-	-	203	50,5	135	33,6	47	11,7	11	2,7	6	1,5
ET2	128	38.3	131	39.2	55	16.5	15	4.5	5	1.5	21	41.2	22	43.1	7	13.7	-	-	1	2.0	12	70.6	5	29.4	-	-	-	-	-	-	161	40,0	158	39,3	62	15,4	15	3,7	6	1,5
RL1	130	38.9	132	39.5	53	15.9	16	4.8	3	0.9	24	47.1	17	33.3	9	17.6	1	2.0	-	-	8	47.1	7	41.2	2	11.8	-	-	-	-	162	40,3	156	38,8	64	15,9	17	4,2	3	0,7
RL2	138	41.3	121	36.2	60	18.0	10	3.0	5	1.5	24	47.1	20	39.2	6	11.8	1	2.0	-	-	8	47.1	6	35.3	3	17.6	-	-	-	-	170	42,3	147	36,6	69	17,2	11	2,7	5	1,2
RS1	121	36.2	135	40.4	59	17.7	16	4.8	3	0.9	23	45.1	21	41.2	5	9.8	2	3.9	-	-	9	52.9	7	41.2	1	5.9	-	-	-	-	153	38,1	163	40,5	65	16,2	18	4,5	3	0,7
RS2	139	41.6	122	36.5	53	15.9	16	4.8	4	1.2	24	47.1	20	39.2	4	7.8	3	5.9	-	-	8	47.1	6	35.3	3	17.6	-	-	-	-	171	42,5	148	36,8	60	14,9	19	4,7	4	1,0

AS1	172	51.5	96	28.7	53	15.9	10	3.0	3	0.9	21	41.2	22	43.1	17	13.7	1	2.0	-	-	10	58.8	5	29.4	2	11.8	-	-	-	-	203	50,5	123	30,6	62	15,4	11	2,7	3	0,7
AS2	126	37.7	128	38.3	60	18.0	15	4.5	5	1.5	25	49.0	17	33.3	6	11.8	3	5.9	-	-	8	47.1	5	29.4	4	23.5	-	-	-	-	159	39,6	150	37,3	70	17,4	18	4,5	5	1,2
EEM1	128	38.3	117	35.0	65	19.5	18	5.4	6	1.8	23	45.1	19	37.3	6	11.8	2	3.9	1	2.0	6	35.3	6	35.3	5	29.4	-	-	-	-	157	39,1	142	35,3	76	18,9	20	5,0	7	1,7
EEM2	127	38.0	118	35.3	58	17.4	23	6.9	8	2.4	25	49.0	20	39.2	6	11.8	-	-	-	-	8	47.1	5	29.4	4	23.5	-	-	-	-	160	39,8	143	35,6	68	16,9	23	5,7	8	2,0

Perceptions of 4IR technologies =: Comparison

4IR Technologies Perceptions	Students										Academics										IT staff										TOTAL									
	SA		A		N		D		SD		SA		A		N		D		SD		SA		A		N		D		SD		SA		A		N		D		SD	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
PRL1	168	50.3	123	36.8	29	8.7	10	3.0	4	1.2	19	37.3	25	49.0	7	13.7	-	-	-	-	10	58.8	5	29.4	2	11.8	-	-	-	-	197	49,0	153	38,1	38	9,5	10	2,5	4	1,0
PRL2	112	33.6	146	43.8	57	17.1	15	4.5	3	0.9	14	27.5	28	54.9	8	15.7	1	2.0	-	-	6	35.3	9	52.9	1	5.9	1	5.9	-	-	132	32,8	183	45,5	66	16,4	17	4,2	3	0,7
PEM1	109	32.6	129	38.6	77	23.1	13	3.9	6	1.8	17	33.3	29	56.9	4	7.8	1	2.0	-	-	7	41.2	9	52.9	1	5.9	-	-	-	133	33,1	167	41,5	82	20,4	14	3,5	6	1,5	
PEM2	117	35.2	137	41.3	67	20.2	8	2.4	3	0.9	13	25.5	30	58.8	5	9.8	3	5.9	-	-	8	47.1	6	35.3	3	17.6	-	-	-	138	34,3	173	43,0	75	18,7	11	2,7	3	0,7	
PRS1	113	33.8	127	38.0	75	22.5	11	3.3	8	2.4	19	37.3	27	52.9	5	9.8	-	-	-	-	9	52.9	6	35.3	2	11.8	-	-	-	141	35,1	160	39,8	82	20,4	11	2,7	8	2,0	
PRS2	107	32.0	126	37.7	81	24.3	15	4.5	5	1.5	17	33.3	29	56.9	5	9.8	-	-	-	-	7	41.2	7	41.2	3	17.6	-	-	-	131	32,6	162	40,3	89	22,1	15	3,7	5	1,2	
PAS1	110	32.9	117	35.0	84	25.1	19	5.7	4	1.2	13	25.5	31	60.8	5	9.8	2	3.9	-	-	8	47.1	4	23.5	5	29.4	-	-	-	131	32,6	152	37,8	94	23,4	21	5,2	4	1,0	
PAS2	116	34.7	112	33.5	78	23.4	19	5.7	9	2.7	10	19.6	32	62.7	6	11.8	3	5.9	-	-	6	35.3	9	52.9	2	11.8	-	-	-	132	32,8	153	38,1	86	21,4	22	5,5	9	2,2	
PT1	115	34.4	126	37.7	66	19.8	24	7.2	3	0.9	16	31.4	31	60.8	4	7.8	-	-	-	-	9	52.9	7	41.2	1	5.9	-	-	-	140	34,8	164	40,8	71	17,7	24	6,0	3	0,7	
PQI1	137	41.0	106	31.7	67	20.1	21	6.3	3	0.9	15	29.4	32	62.7	4	7.8	-	-	-	-	9	52.9	7	41.2	1	5.9	-	-	-	161	40,0	145	36,1	72	17,9	21	5,2	3	0,7	
PQI2	145	43.5	111	33.3	58	17.4	16	4.8	3	0.9	29	56.9	18	35.3	4	7.8	-	-	-	-	7	43.8	7	43.8	2	12.5	-	-	-	181	45,0	136	33,8	64	15,9	16	4,0	3	0,7	
PQI3	137	41.0	121	36.2	61	18.3	11	3.3	4	1.2	29	56.9	20	39.2	2	3.9	-	-	-	-	6	35.3	10	58.8	1	5.9	-	-	-	172	42,8	151	37,6	64	15,9	11	2,7	4	1,0	
PQI4	147	44.0	108	32.3	60	18.0	15	4.5	4	1.2	22	43.1	24	47.1	5	9.8	-	-	-	-	10	58.8	6	35.3	1	5.9	-	-	-	179	44,5	138	34,3	66	16,4	15	3,7	4	1,0	

Awareness of 4IR Technologies: Comparison

4IR Awareness	Students										Academics										IT staff										TOTAL										
	SA		A		N		D		SD		SA		A		N		D		SD		SA		A		N		D		SD		SA		A		N		D		SD		
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	
A1	96	28.7	107	32.0	77	23.1	41	13.3	13	3.9	3	5.9	18	35.3	19	37.3	8	15.7	3	5.9	5	29.4	6	35.3	6	35.3	-	-	-	-	104	25,9	131	32,6	102	25,5	49	12,2	16	4,0	
A2	87	26.0	121	36.2	74	22.2	44	13.2	8	2.4	3	5.9	12	23.5	23	45.1	10	19.6	3	5.9	7	41.2	6	35.3	4	23.5	-	-	-	-	97	24,1	139	34,6	101	25,1	54	13,4	11	2,7	
A3	76	22.8	126	37.7	94	28.1	32	9.6	6	1.8	3	5.9	10	19.6	23	45.1	12	23.5	3	5.9	4	23.5	10	58.8	3	17.6	-	-	-	-	83	20,6	146	36,3	120	29,9	44	10,9	9	2,2	
A4	78	23.4	118	35.3	85	25.4	42	12.6	11	3.3	2	3.9	13	25.5	19	25.5	13	25.5	4	7.8	5	29.4	8	47.1	4	23.5	-	-	-	-	85	21,1	139	34,6	108	26,9	55	13,7	15	3,7	
A5	81	24.3	133	39.8	80	24.0	34	10.2	6	1.8	3	5.9	16	31.4	18	35.3	10	19.6	4	7.8	5	29.4	8	47.1	4	23.5	-	-	-	-	89	22,1	157	39,1	102	25,4	44	10,9	10	2,5	
A6	84	25.1	98	29.3	93	27.8	47	14.1	12	3.6	3	5.9	9	17.6	25	49.0	9	17.6	5	9.8	3	17.6	11	64.7	3	17.6	-	-	-	-	90	22,4	118	29,4	121	30,1	56	13,9	17	4,2	
A7	77	23.1	104	31.1	88	26.3	53	15.9	12	3.6	2	3.9	11	21.6	25	49.0	8	15.7	5	9.8	4	23.5	9	52.9	3	17.6	1	5.9	-	-	-	83	20,6	124	30,8	116	28,9	62	15,4	17	4,2
A8																																									

ANNEXURE N: Total Variance explained.

Total Variance Explained for institutional capabilities for quality improvement

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	of Variance	Cumulative	Total	% of Variance	Cumulative	Total	% of Variance	Cumulative
1	3,810	54,432	54,432	3,810	54,432	54,432	2,664	38,061	38,061
2	1,055	15,072	69,504	1,055	15,072	69,504	2,201	31,443	69,504

Extraction Method: Principal Component Analysis.

Total Variance Explained for investment capabilities and perceived usefulness

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	of Variance	Cumulative	Total	of Variance	Cumulative	Total	of Variance	Cumulative
1	4,161	59,443	59,443	4,161	59,443	59,443	2,765	39,501	39,501
2	1,101	15,732	75,175	1,101	15,732	75,175	2,497	35,674	75,175

Extraction Method: Principal Component Analysis.

Total Variance Explained for 4IR Role in Quality Management

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	of Variance	Cumulative	Total	of Variance	Cumulative	Total	of Variance	Cumulative
1	4,426	49,174	49,174	4,426	49,174	49,174	3,356	37,288	37,288
2	1,117	12,416	61,590	1,117	12,416	61,590	2,187	24,302	61,590

Extraction Method: Principal Component Analysis.

Total Variance Explained For 4IR Expectations.

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	of Variance	Cumulative	Total	of Variance	Cumulative	Total	of Variance	Cumulative
1	5,122	51,221	51,221	5,122	51,221	51,221	3,335	33,353	33,353
2	1,520	15,199	66,419	1,520	15,199	66,419	3,307	33,067	66,419

Extraction Method: Principal Component Analysis.

Total Variance Explained for 4IR Perceptions

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	of Variance	Cumulative	Total	of Variance	Cumulative	Total	of Variance	Cumulative
1	4,357	48,411	48,411	4,357	48,411	48,411	2,909	32,318	32,318
2	1,290	14,330	62,741	1,290	14,330	62,741	2,738	30,424	62,741

Extraction Method: Principal Component Analysis.