The Philosophy of Integrating Technical Vocational Educational and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development - The case of Africa

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Abstract

This paper discusses the fundamental roles of integrating TVET in Industrial Engineering and Operational Management ecosystem towards inclusive, resilient and sustainable growth. It further navigates the dichotomy confronted by Africa Technical and Vocational Education and Training ecosystem created by the COVID 19 pandemic. Technical and Vocational Education and Training ecosystem is depended on pracademic. Migration to Technology Enabled Learning is a mammoth task as African countries are constrained by non-availability of resources. Compromisation of quality in Higher Education negatively affects industrial development as the two are intertwined. Rebuilding and Reconstructing Higher and Tertiary Education in a Transforming and Disruptive Environment creates a dichotomy which creates both paralysis and praxis. Bold curricula rethinking, redesigning and resetting through consultative processes and elimination of disconnection and dismemberment between learning institutions, industry, political ecosystem and the cultural discourse. Generally all engineering disciplines have their roots in TVET. Such development require appropriate and relevant demonstrable pracademic and transferable practical skills anchored and grounded in TVET. Creative industry is considered one of the most dynamic sectors of the world economy, offering innovative potential and growth opportunities for developing countries (UN¶s Creative Economy Reports, 2008, 2010, 2013). In 2020 Zimbabwe embarked on educational overhaul based on the fulcrum of Teaching, Research, Community Service, Innovation and Industrialization which was preceded by enactment of Manpower Planning and Development Amendment number 12 of 2020. The researcher will argue that development of a vibrant Technical and Vocational Education and Training ecosystem should anchor on sound cultural and traditional discourse that enable participants and practitioners to relive, reconstruct and redevelop Technical and Vocational Education and Training ecosystem embedded in Industrial Engineering and Operations Management. Industrial Engineering and Operations Management that is grounded in cultural and traditional Technical and Vocational Education and Training ecosystem, discourse, dichotomous and dissonance is likely to be robust resilient and sustainable. The researchers will employ and deploy both quantitative and qualitative research to unpack and unbundle the Philosophy of Integrating Technical and Vocational Education and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development. To mobilize people we need to understand and embrace their culture Ban Ki-Moon Former Secretary-General of the United Nations (2013).

Keywords

Dichotomy, Innovation and industrialisation, Technology Enabled Learning, Ecosystem, Technical and Vocational Education and Training (TVET), Industrial Engineering and Operational Management (IEOM), resilient and sustainable.

Motivated by the need to inform policy and policy makers on the invaluable pracademic nature of heritage based TVET and the ontological role of TVET to IEOM.

1. Introduction

1.1 Great Zimbabwe National Monument

Zimbabwe's many historical artefacts and standing monuments are a clear demonstration of the resilient and sustainable praxis in infrastructural construction that were built then. The architectural designs showed ingenuous and intelligent well formatted layout structures. Contemporary engineers remained baffled and mesmerised by these centuries' old infrastructures. Local resources formed the bedrock of all the ingredients for construction. The constructions were relevant, appropriate, resilient and sustainable. The Great Zimbabwe ruins, the capital of the Queen of Sheba, according to an age-old legend are a unique super-structure and testimony to the Bantu civilization of the Shona between the 11th and 15th centuries. The city, which covers an area of nearly 80 ha, was

an important trading centre and was renowned from the Middle Ages onwards. The structure were well blended with the environment, nature and climatic conditions as well as green technologies which are a buzz word today. Today's industrial Engineering and operations management stand challenged by such structures that have remained well blended with the environment.

Great Zimbabwe Ruins

Great Zimbabwe National Monument is approximately 30 km from Masvingo town and located in the lowveld at an altitude of some 1100 m in a sparsely populated region of the Bantu/Shona people. The property, built between 1100 and 1450 AD, extends over *almost* 80ha and is divided into three groups: the Hill Ruins, the Great Enclosure and the Valley Ruins.

The Great Enclosure-Resilient and Sustainable Infrastructure

This acropolis is generally considered a 'royal city'; the west enclosure is thought to have been the residence of successive chiefs and the east enclosure, where six steatite upright posts topped with birds were found, considered to serve a ritual purpose. It was built of cut granite blocks, laid in regular courses, and contains a series of daga-hut living quarters, a community area, and a narrow passage leading to a high conical tower. The bricks (daga) were made from a mixture of granitic sand and clay. Huts were built within the stone enclosure walls; inside each community area other walls mark off each family's area, generally comprising a kitchen, two living huts and a court. A true demonstration of the Philosophy of Integrating Technical Vocational Educational and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development. A well-blended environment ecosystem with the genesis of technical vocational education and training.

Scientific research has proved that Great Zimbabwe was founded in the 11th century on a site which had been sparsely inhabited in the prehistoric period, by a Bantu population of the Iron Age, the Shona. In the 14th century, it was the principal city of a major state extending over the gold-rich plateaux; its population exceeded 10,000 inhabitants.

Criterion (i): A unique artistic achievement, this great city has struck the imagination of African and European travellers since the Middle Ages, as evidenced by the persistent legends which attribute to it a Biblical origin.

Criterion (iii): The ruins of Great Zimbabwe bear a unique testimony to the lost civilisation of the Shona between the 11th and 15th centuries and the failure to harness the Philosophy of Integrating Technical Vocational Educational and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development.

Criterion (vi): The entire Zimbabwe nation has identified with this historically symbolic ensemble and has adopted as its emblem the steatite bird, which may have been a royal totem in 2020 heritage based education and training was initiated and adopted as means of harnessing local knowledge into the mainstream education system. An education system that is devoid, divorced alien to its environment cannot be resilient and sustainable.

The site has been legally protected since 1893 and is currently protected under the National Museum & Monuments Act Chapter 25:11 (1976) which provides for the legal protection of the resources within the property.

Mali

Equally Mali has so many unique architectural praxis which dates back centuries old infrastructures that blends well with nature and qualifies for green technologies designs. The Old Towns of Djenné, characterised by the extraordinary use of earth in their architecture, includes four archaeological sites with nearly 2,000 houses whose decorative facades have remained intact since the 3rd century BC. The buildings are among the most famous in Mali, a country that also boasts the ancient town of Timbuktu. Integrating such indigenous technical and vocational education and training with industrial engineering and operations management perspective would create a wealth of Knowledge Management Systems derived from investment in research in cultural Technical and Vocational Education and Training in would completely alter the rhetoric of resilient and sustainable development. Such interaction, intermixing and matrixing and integrating with Industrial Engineering and Operation Management would create an excellent environmental and industrial phenomenon that would alleviate the destruction of environment. This demonstrates the integration of cultural Technical and Vocational Education and Training with sustainable and resilient Industrial Engineering and Operations Management. Humanity could have been better placed if cultural Technical and Vocational Education and Training were not discarded and replaced with alien systems which are merely superimposed without due consideration for the consequences.

The matrix and integration included water we drink to the way we travel to work or school, infrastructure touches every aspect of human life. It has the power to shape the natural environment for good or for ill. The architectural engineers of today is grappling with climate change, persevering the environment yet if we invest in research of ancestral designs and constructional knowledge harvesting better and sustainable models can be generated.

1.2 Motivation/Problem Area

The study is motivated by the need to inform policy and policy makers on the invaluable nature of resilient and sustainable integration of technical vocation education and training with industrial engineering and operational management and the ontological role it plays to the socio-economic development for nation building.

Old Towns of Djenné

1.3 Research Objectives

This research study investigated the Philosophy of Integrating Technical Vocational Educational and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development on Traditional Knowledge Management practices for Africa and Zimbabwe in particular anchored on the following underlying research questions:

Objective 1: To provide an overview of the characteristics of resilient and sustainable Technical Vocational Education and Training Praxis in Zimbabwe**.**

Objective 2: To analyse the degree of Integrating Technical Vocational Educational and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development in Zimbabwe and Africa.

Objective 3: To understand the main drivers contributing to integration of resilient and sustainable TVET in Zimbabwe and Africa.

Objective 4: To provide recommendations to Zimbabwe and Africa on how to capitalise on Industrial Engineering and Operational Management to develop a heritage based resilient and sustainable educational engineering systems.

2.0 Literature Review

The world's population is alarmingly expanding, accelerating urbanisation and rapidly emerging middle classes in developing countries who demand more services in the form of infrastructure transport, education, health, and other related services. Engineers are challenged to come up with solutions that take cognisance of the environment, the changing weather and climatic patterns as well as mitigating against disasters and sickness. This has witnessed collapse or paralysis in infrastructure and services in most African cities and towns in terms of road networks, sewerages systems, educational systems, health systems, water supply and purification systems, and telecommunications networks. Indigenous TVET used to be at the forefront of addressing such issues but they have been displaced by foreign designs and services which tends to trample on and ignore the key ingredients for sustainable development. The pictorial view given below resemble un-resilient and sustainable urban system where services are almost zero.

Foreword planning, population projections and resources maintenance and mobilisation are never part of the game plan. The aspects of lack of resources, financial, human capital and material cannot be an excuse as Africa is bestowed with all these resources. However, within the context of climate change, it is becoming increasingly clear that the sustainability of humans on planet Earth is closely linked to resilient TVET social-ecological systems, which are influenced by social institutions, human agency, and human capabilities (Pelling, 2003; Bohle et al., 2009; Adger et al., 2011). The overflowing sewerage shown below is clear demonstration and testimony of poor integration of technical and vocational education and Training with Industrial Engineering and Operational Management planning for resilient and sustainable infrastructure development.

Undated: Uncollected garbage

Undated Overloaded and unmaintained sewerage system

Lack of precise knowledge about future climate change, demographic metamorphosis, making long-term planning increasingly difficult probably because the past was not fully researched in order to navigate the future. The New Climate Economy's Sustainable Infrastructure Imperative sees investing in sustainable infrastructure as "key to tackling the three central challenges facing the global community: reigniting growth, delivering on the Sustainable Development Goals, and reducing climate risk in line with the Paris Agreement." Indeed, the Paris Agreement, the 2030 Agenda for Sustainable Development. Among the SDGs, SDG 9 explicitly refers to building resilient infrastructure. However, all the goals are underpinned by infrastructure development. "Infrastructure is really at the centre of the delivery of the SDGs," says Virginia Marchal, senior policy analyst in the OECD's Environment Directorate. This demonstrates a high degree of intellectual lactation on the part of developing countries with Africa being at the core. A serious hybrid and integrative symbiotic relationship between TVET and industry is fundamental if nations are to get out of the quagmire disorientation and losing the environment and threaten the future of existence.

Resilient and sustainable infrastructure must primarily address climatic conditions, positive impact to the environment, water supply, power supply, equality, sustainability growth, opportunities and contributing to societal growth and economic benefits to all. Mining for example, in most cases leave a trail of destruction with communities being left worse off. This is generally lack of a clear discourse between cultural TVET and industrial engineering operational management. The competitive dichotomy between TVET and Industrial Engineering Operational Management must be reduced to complimentary adaption and adoption. Achieving SDG 10, reduced inequalities, means meeting a number of the other SDGs. For example, SDG 6, availability and sustainable management of water and sanitation for all, demands investments in infrastructure of at least US$114bn a year, according to the World Bank. When it comes to meeting SDG 7, access to affordable, reliable, sustainable and modern energy for all, investments needed include US$52bn per year to achieve universal electrification by 2030, only half of which is covered by planned investments. Women and girl empowerment, infrastructure contributes to meeting the objectives of SDG 5. But this all will be a pipe dream if the possibility of integrating Technical vocational education and Training and industrial Engineering and Operations Management remains a mirage.

The dichotomy evolving and enveloping African countries is the educational Knowledge Management Systems is situated and has remained stuck in foreign context. The educational ecosystem in developing countries are a mirror image of their colonial past which were meant to serve colonial system. African Technical and Vocational

education and Training was Sid lined due to colonial past. Educational curricula must be revamped and reconfigured to take cognisance of key indigenous Knowledge Management System to unlock and unpack potential and ensure integration of TVET with industrial engineering and operational management (IEOM) for the benefit of humanity.

Protecting the natural environment from the destructive nature of man is fundamental only if indigenous Technical and Vocational Education and Training is encapsulated in the curricula. The curricula should carry in it, green technologies, like solar technology, bio-fuels and environmentally friendly construction materials as dictated by country specific TVET domain needs. Developing countries suffer from ambivalent and diminishing returns as they now solely depend on foreign technologies, donor designs, donor funding, donor initiated and donor advised programs and projects and proliferation of foreign structures that are distant to local environment and defeat all sundries in terms of sustainability and resilent. Sustainable infrastructural assets can help to address climate and natural disasters, reduce greenhouse gas emissions and contamination, manage natural capital, and enhance resource efficiency. Strategies that are adopted to reduce climate change through greenhouse gas mitigation can affect biodiversity both negatively and positively (Edenhofer et al., 2011), which in turn influences the capacity to adapt to climate extremes. For example, some bioenergy plantations replace sites with high biodiversity, introduce alien species, and use damaging agrochemicals, which in turn may reduce ecosystem resilience and hence their capacity to respond to extreme events (Foley et al., 2005; Fargione et al., 2009). But this can only be achieved if the community are critical players in the whole process through appropriate Knowledge Management Systems. Test cases of Mali and Zimbabwe cited in the introduction reflect how the past can bridge us into the future. “It’s a threat but also a huge opportunity for countries to leapfrog to infrastructure that is fit for climate.” Professor Hall cites transportation as a tool in fossil-fuel reduction. The transport sector needs to be largely electrified or solarised. Resilient and sustainable infrastructure cuts across all facets of human activities.

Integrating and including green infrastructure such as trees, plantings and forests into the integration of TVET and Industrial Engineering and Operations management portfolio of assets can improve air quality and contribute to reducing carbon dioxide from the atmosphere or, in the case of mangroves, increasing flood protection and preventing soil erosion. Green roofs act as giant camouflage and absorbent, saturating storm water before it contaminate rivers and lakes, assist with flood control and, collectively, can amortise temperatures in cities during summer seasons.

2.1 The Critical Role of TVET in Resilient and Sustainable Infrastructural Development

Resilient and sustainable infrastructure must ensure continuity of critical services such as power, water, road connectivity and usability during a crisis, it should offer greater stability to communities and reduce disruption to their livelihoods. The infrastructure should have community ownership not as individualised assets, such as a power plant, a hospital, or a water network, but as part of a system with a portfolio of assets that deliver essential services. The convenience of infrastructure, including economic benefits, protecting the natural environment, underpinning social development, and constructing resilience and sustainable integral systems were Technical and Vocational education and training and Industrial Engineering and Operations management seamlessly merge by adopting and adapting to the best of each. This entails employing and deploying traditional TVET Knowledge Management Systems coupled with international best practices to construct resilient and sustainable infrastructure ecosystem.

The communities have vast knowledge of traditional TVET and resources dating back generations and such knowledge may include water harvesting, traditional agro-chemicals and community governance systems; and solutions and best practices, including harnessing innovative finance, filling the project, blending green and grey, making infrastructure smart, managing infrastructure, and improving transparency. The focus of resilient and sustainable infrastructure should be designed in such a way that include fail-safe avenues.

Industrial Engineering and Operations Management services must ensure, equitable access to critical services through TVET, an aspiration enshrined in many of the SDGs, which call for basic services such as health, education, shelter, water and sanitation to be available to all built on resilient and sustainable designs and models with full participation of the community for the community. Gender equality is critical if infrastructure is to play a pivotal role in protecting women and accelerating their advancement. Sanitation infrastructure is also crucial in ensuring equal participation in economic and education opportunities. However, if toilets or private hygiene facilities in schools or workplaces are unavailable, during menstruation women and girls are often compelled to abscond or absent themselves from school or their jobs altogether. The World Bank estimates that at least 500m women and girls globally lack adequate facilities for menstrual hygiene management.

2.1.1 Future-proofing infrastructure

Recognising the importance of the Philosophy of Integrating Technical Vocational Educational and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development in infrastructure and adopting an integrative systems approach is what will underpin the resilience not only of infrastructure itself but also of society and the planet. “One side of the sustainable development agenda is linked to one planet-living and finite resources,” says Ms da Silva. The other side is about resilience. But over the past decade, we’ve become more aware of how complex and interconnected the world is, how much uncertainty is out there, whether its climate change or economic downturns like 2018, or the sudden turn of life due to COVID 19 pandemic. The pandemic demonstrated that our systems especially hospitals were not resilient as they were overwhelmed and in some cases collapsed as a result of system overload and lack of integrated operational systems.

The future cannot be predicted or foretold, but the ability for critical infrastructure to continue to be operational and provide essential services under whatever circumstances is fundamental. Infrastructure assets should be in place for generations “future-proof” assets are critical for the sustainability of societies. This can be achieved through harnessing and harvesting traditional Knowledge System and merge them with international best practices. London’s Thames Estuary 2100 strategy, to manage tidal flood risk in the Thames estuary over the next 100 years is one example of infrastructure design that uses an adaptive capacity approach to not only current risks but also future climate adaptation. Milestones and reviews are scheduled at defined points, along with a plan for how to enhance capacity of not only a specific flood barrier but also of the wider system over the next century. Infrastructures like the Great Zimbabwe Monument and the Egyptian Pyramids among others typically signify and represent original TVET and symbolic of resilient and sustainable infrastructure. They have stood the test of time for centuries.

Investment in The Philosophy of Integrating Technical Vocational Educational and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development is key to achieving sustainable development goals. There is need to integrate indigenous Knowledge Management Systems to better support investment decisions related to resilient infrastructure. Basically the designs and models must be relevant, appropriate and fit for purpose. Sustainable adaptation is classified as a process that addresses the underlying causes of vulnerability and poverty, including ecological fragility; it is considered a way of generating socio-economic transformation, or changes in the fundamental attributes of communities that contribute to vulnerability (Eriksen and O’Brien, 2007; Eriksen and Brown, 2011). The social, economic, and environmental dimensions of investment decisions within local communities to enable best serve them and address their concerns. The tri-matrix of climate change adaptation, environment preservation, socioeconomic factors and poverty reduction should be integrated to harness robust investments that take cognisance of multiple future dimensions.

2.1.2 Build for Durability and Sustainability

Resilient and sustainability infrastructure cannot serve its purpose if communities or societies are not involved and consulted. Generally in developing countries there has been a central tendency were communities are pushed to the periphery to make way for multinationals in the name of economic development. The displaced communities are left with nothing while the harvested resources are shipped to foreign lands to build true resilient and sustainable infrastructures where communities in developing countries have no access to. Government or political leadership in developing countries are at the fore-front of packing and unpacking local resources for the benefit of foreign companies or nations and a few individuals locally. Yet harnessing The Philosophy of Integrating Technical Vocational Educational and Training Ecosystem into the Dynamics of Industrial Engineering and Operational Management for Resilient and Sustainable Economic Development will solve most challenges. Development must primarily benefit local communities in terms of roads, power systems, bridges and telecommunications systems. Fundamentally partners must consider benefits to the local communities, climate change and integrate climate-resilient features as appropriate into the planning, design and implementation of infrastructure projects to help ensure the investments will endure.

Across Africa depleted mining ventures are left with scares of environmental degradation, impoverished communities, and diseases thereby defeating the whole aspects of resilient and sustainable development. The benefits of investing in climate resiliency and community sustainability are more in the design thinking and construction which must take cognisance of the indigenous TVET combined with what the community need, want and for what purpose should the structure be put in place. In most cases communities are just told that a particular construction or infrastructure has been put in place for their benefit without them being involved and many a times such structures generally go to waste.

The Millennium Challenge Corporation (MCC) recently partnered with the Philippines to upgrade more than 133 miles of a coastal roadway on the island of Samar. This road serves as the main artery for travel and commerce. During the environmental assessment of the project, climate evaluation revealed climate change-related risks and concluded that over the next 20 years, the road would be subjected to increasingly frequent storms, intense rainfall and a potential rise in sea level. Any of these factors could significantly threaten the long-term viability of the road and, more importantly, negatively impact families and the local economy. This then entailed reconfigured and restructured design and modelling thinking to integrate climate adaptation measures, including raising bridges, upgrading drainage systems, installing protective sea walls and strengthening road embankments. These climate-resilient modifications were made for a modest investment of 10 percent of the total project costs.

Such integration of climate change considerations in programmes and projects which indigenously grounded are vital, given the increase in the frequency and intensity of climate related disasters. The world has witnessed how above average rainfall brought severe damage to infrastructure in the islands of St Lucia, St Vincent and the Grenadines and Dominica in December, 2013 and the manner in which Tropical Storm Erika wreaked havoc on roads and bridges in Dominica in August 2015. The 2022 Madagascar torrential rains and the Zimbabwe march 2012 destructive Cyclone Idai. The incorporation and integration of TVET and IEOM in design, construction and implementation of infrastructure are critical in ensuring the durability of the investments as well as in preserving lives and meeting local community needs.

2.1.3 Summary

The section look at historical infrastructures that have demonstrated resiliency and sustainability. Great Zimbabwe Monument, Pyramids of Egypt and the Old Towns of Djenné in Mali. The current state of infrastructural development now include 3D printing and Artificial Intelligence (AI) which generally are products of developed countries but do not respond to resiliency and sustainability in terms of weather conditions, climate change and cultural and indigenous knowledge infusion.. However, in developing countries multinationals, political and government policies generally negate these requirements thereby put nations at risk on getting into vicious circle of unsustainable infrastructural development. Solid community, climatic and environmental policy matrix should be put in place to create robust resilient and sustainable development projects.

3. Research Methodology

The previous section contextualises the identification of factors contributing to the successful implementation of resilient and sustainable infrastructure and services through integration of in Technical and Vocational Education and Training and Industrial Engineering and Operations Management. The researchers hereby provide the research design process encapsulating the measurement, the phases followed by the data collection and the methods employed for data analysis. For the purpose of gathering comprehensive data set, the research study was approached as an analysis of implementation of resilient and sustainable infrastructure in Zimbabwe and Africa.

3.1 Research Approach

This research pursued a quantitative-qualitative approach planted in the ontology of constructivist and interpretivism philosophy in which reality within this perspective is subjective and influenced by the context of the situation, namely the individual's experience and perceptions, the social settings and the interaction between the individual and the researchers (Schwandt, 1994 in Ponterotto, 2005). Manen (2002) argued that the approach represents an attitude or disposition of sensitivity and openness. It is a matter of openness to everyday experienced meanings as opposed to theoretical ones.

Sampling and Target Population

Purposive Sampling

Purposive sampling method was used to select the participants. The purposive sampling technique also called judgment sampling is the deliberate choice of an informant due to the qualities the informant possesses. It is a non-random or non-probability technique that does not need underlying theories or a set number of informants.

3.1.2 Data Collection in Quantitative Approach

Both quantitative and qualitative data collection methods were employed. Structured online survey questionnaires were used for data collection from all selected categories in the sampled institutions. The strength of the mixed methods of data collection adopted in this study anchored in the fact that the quantitative and the qualitative survey questionnaires are contrasting measuring instruments, they tend to complement each other's weaknesses.

3.1.3 Design and development of data collection instruments

The design and development of the data collection instruments were done after a thorough and comprehensive literature review. The literature review led to the identification of the elements (research constructs, sub constructs

and items) that constitute research variables. The data instruments were designed and developed to provide adequate information on the research questions and the overall research objectives of the study. The interviews were conducted because the researcher realised the added advantage of gaining an in-depth comprehension of the underlying issues inherent in **resilient and sustainable infrastructure** efforts in the research entities.

3.1.4 Data Analysis

Quantitative data analysis

Data collected using the structured questionnaires were analysed using descriptive statistics methods. Inferential statistics in the form of the Chi-square test and frequency diagrams were conducted on the research data. Babbie *et al.* (2006) referred to descriptive statistics as a method of presenting data in a manageable form. Quantitative data analysis involves aspects such as the frequencies of variables, differences between variables, a statistical test designed to estimate the significance of the results and the probability that they did not occur by chance.

3.1.5 Qualitative data analysis

Data collected through the interviews were analysed using the qualitative methods of data analysis. The process of organising and thinking about data was fundamental to understanding what the data does and does not contain. The data analysis commenced with the organisation of the gathered data, which involved creating an inventory of the researcher's findings and establishing how the data was completed.

4. Research Results and Interpretation

This section presents the analysis and interpretation of the research data for the TVET institutions in Africa with particular reference to Zimbabwe. The analysis follows the triangulation approach where data collected through the survey questionnaires is supported through the use of interviews and literature review.

4.1 Demographic Characteristics of the Quantitative Respondents

4.1.2 Demographic Characteristics of The Quantitative Respondents

Emanating from the quantitative research data (demographical characteristics of the respondents), the researcher provides a demographical characteristic's of the respondents in terms of age, gender, religion, academic qualifications, marital status, experience and grade as presented below

Table 4.1 Gender distribution of respondents

Distribution		Gender	Valid%
	Male	13	59%
	Female	9	41%
	Total	22	100%

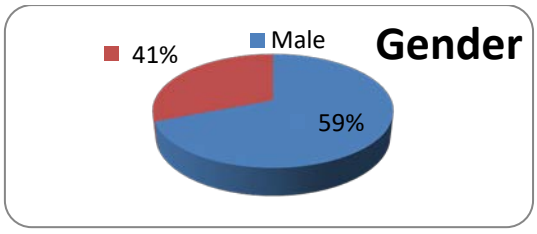


Figure 4.1 Gender

As highlighted in the Table 4.1 and Figure 4.1 above respectively, it is observed that both gender categories are represented with a 41% of 22 of the quantitative respondents being females and 59% of 22 being males respectively. This makes the research data representative as both views of the gender are considered as part of the research study.

Table 4.2 Marital status of the respondents

Marital Status		Respondents	Valid Percent
	Married	16	73%
	Single	6	27%
	Sub Total	22	100%

From the Table 4.2 above demonstrates that respondents covered all the categories and this authenticates the representativeness of the research data with the married category constituting the majority (73%) of 22 of the quantitative respondents and single constituting 27%.

Table 4.3 Religious status of the respondents

Religious Status		Respondents	Valid Percent
	African Traditional	0	0
	Christianity	22	100%
	Islam	0	0%
	Grand Total	22	100%

From Table 4.3, 100% of the respondents constitute christian religion. This may point to the fact that zimbabwe is mainly a christain commuinity.

Table 4.4 Educational qualifications of the respondents

Educational Background		Respondents	Valid Percent
	PhD	1	4%
	National Diploma	2	10%
	Higher National Diploma	3	13%
	Bachelor's Degree	5	23%
	Master's Degree	11	50%
	Total	22	100%

From Table 4.4 above it is noted that educational qualifications of respondents range from national certificate to PhD. it is further noted that 50% of 22 of the quantitative respondents Master degrees. 23% of 22 of the quantitative respondents hold Bachelor's and 13% of 22 having Higher National diploma. PhD constitutes 4% and National Diploma 10% respectively. This validates the cross sectional representativeness of the respondents' in as far as resilient and sustainable development is concerned.

Table 4.5 Employment status of the respondents

Employment Status		Respondents	Valid Percent
	Employed (f/t)	21	95.4%
	Students	1	4.3%
	Total	22	100%

The employment status in Table 4.5.shows 95.4% of 22 of the quantitative respondents are full time employees which gives a wide spectrum of their understanding of the global development and make information gathered more representative. From Table 4.6.it is noted that the range of status covered all spectrum structures in the system. Views obtained from the research respondents will be evenly spread thereby being representative of resilient and sustainable infrastructural development.

Table 4.6 Status of the respondents

Status	Respondents	Valid Percent
Supervisory(mgmt.)	12	55%
Civil engineering lecturers	2	9%
Engineering Projects coordinators	4	18%
Principal/Director	4	18%
Total	22	100%

Table 4.7 Work experience of the respondents

Work Experience		Respondents	Valid Percent
	2yrs	3	14%
	4yrs	2	9%
	5yrs	2	9%
	6yrs	2	9%
	7yrs	2	9%
	8yrs	2	9%
	9yrs	2	9%
	10yrs+	7	32%
	Total	22	100%

As highlighted in the Table 4.7.above, years of experience range from less than 2 years to more 10 years working experiences in Zimbabwe polytechnics. The representativeness demonstrates that there are enough years of experience among the knowledge workers to competently cover all the views related to resilient and sustainable infrastructural Knowledge Management implementation.

Table 4.8 Resilient and Sustainable Infrastructural Systems are the processes of harnessing Community Knowledge to enhance construction of resilient infrastructures.

		Respondents	**Valid Percent**
	Yes	22	100%
	No	0	0%
	Total	22	100%

It is apparent from Table 4.8.above that 100% of the respondents portray a positive image of the Resilient and Sustainable Infrastructural Knowledge Management Systems in Zimbabwean an Africa. This provides a solid footing for harnessing Resilient and Sustainable Infrastructural Systems Development in Zimbabwe and Africa.

Table 4.9 Zimbabwe and Africa Resilient and Sustainable Infrastructural Enabled systems are useful to the development of commerce and industry?

Development of commerce and industry		**Respondents**	**Valid Percent**
	Yes	20	91%
	No	2	9%
	Total	22	100%

Table 4.9, indicates 96% of 22 of the quantitative respondents demonstrate a positive belief in Zimbabwean and Africa Resilient and Sustainable Infrastructural Systems. Only 9% of 22 of the respondents gave negative answers. Generally Zimbabwe and Africa's Resilient and Sustainable Infrastructural Systems are perceived to be positive and considered of high quality locally, regionally and internationally.

Table 4.10 Zimbabwe and Africa Resilient and Sustainable Infrastructural Systems are highly developed and operational and covers all African regions.

		Respondents	**Valid Percent**
	Yes	2	9%
	No	20	91%
	Total	22	100%

Table 4.10 shows that 91% of 22 of the quantitative respondents concur that resilient and sustainable infrastructures do not cover all African regions. This pose challenges when it comes to the implementation of the resilient and sustainable infrastructure development as some communities are lagging behind.

Table 4.11 Zimbabwe and Africa Resilient and Sustainable Infrastructural Systems have well-built and researched indigenous Knowledge Management System?

	Respondents	**%**
Yes	3	13%
No	19	87%
Total	22	100%

From Table 4.11, above 87% of 22 the respondents concur that resilient and sustainable infrastructure indigenous Knowledge Management System are not researched and remain unexplored territory. The negative responses

would make implementation of Resilient and Sustainable Infrastructural Systems difficult because of the negative perception emanating from communities.

Table 4.12 Zimbabwe and Africa knowledge workers/lecturers are highly skilled in resilient and sustainable infrastructural development?

	Respondents	%
Yes	6	27%
No	16	73%
Total	22	100%

Table 4.12, above 73% of the respondents noted that most knowledge workers are not skilled in resilient and sustainable infrastructural development. This implies that comparably Zimbabwe and Africa lag behind the developed countries in terms of resilient and sustainable infrastructural development. This entails massive capacity building and provision of the needed research knowledge to actively participate in resilient and sustainable infrastructural development. 27% of 22 of the respondents had a positive perception about resilient and sustainable infrastructural development. This could attributed to members who may be directly involved in civil engineering and construction coordinators.

Table 4.13 Zimbabwean and Africa's resilient and sustainable infrastructural development have positive image locally and internationally?

		Respondents	Valid Percent
	Yes	13	59%
	No	9	41%
	Total	22	100%

From table 4.13, above it is noted that 59% of the respondents concur that resilient and sustainable development have positive image regionally and internationally. The considering the vastness of Africa the positivity of 59% cloud be as a result of few African countries that are transforming themselves due an enlightened leadership.

Table 4.14 Zimbabwe and Africa resilient and sustainable infrastructural development is just an academic theory and should not be taken seriously?

		Respondents	Valid Percent
	Yes	0	0%
	No	22	100%
	Total	22	100%

From Table 4.14, above 100% of the respondents considered the importance of in resilient and sustainable infrastructural development. This is quite significant and gives a positive launch pad for in resilient and sustainable infrastructural development in Zimbabwe and Africa. This gives credence to the importance to the acquisition of in resilient and sustainable infrastructural development through practical capacity building. With such positive confirmation governments can build on this solid and vibrant Knowledge Management System to create a resilient and sustainable infrastructural development agenda in Zimbabwe and Africa.

Table 4.15 Do you believe in resilient and sustainable infrastructural development Knowledge Management Systems in Zimbabwe and Africa?

		Respondents	Valid Percent
	Yes	22	100%
	No	0	0%
	Total	22	100%

As illustrated in the Table 4.15, above, 100% of the respondents had a concrete believe in in resilient and sustainable infrastructural development Knowledge Management Systems in Zimbabwe and Africa. One cannot phantom the derailment of implementation of resilient and sustainable infrastructure in Zimbabwe and Africa when such affirmation points to the importance of practical application of resilient and sustainable infrastructure knowledge management systems to enhance the construction of skills, competencies and knowledge.

Table 4.16 The skills acquired by Zimbabwean and African graduates are useful in the promotion of skills and competence for the development of resilient and sustainable infrastructure?

	Respondents	**%**
Yes	**15**	**68%**
No	**7**	**32%**
Total	**22**	**100%**

From Table 4.16, above, 68% of 22 of the respondents concur the skills acquired by African and Zimbabwean graduates are relevant for the implementation of resilient and sustainable infrastructure development in the promotion of skills and competence development among communities. 32% consider the skills to be inappropriate for the implementation of resilient and sustainable infrastructure.

Table 4.17 The current remuneration of Zimbabwean and African educational practitioners encourage them to adapt to resilient and sustainable infrastructure construction?

	Respondents	**%**
Yes	**2**	**9%**
No	**20**	**91%**
Total	**22**	**100%**

Table 4.17, demonstrates that 91% of the respondents concur that the current remuneration does not the implementation of resilient and sustainable infrastructures. This may be as a result that knowledge workers or lecturers would be having divided attention between augmenting their salaries and research on acquisition of resilient and sustainable infrastructure development.

Table 4.18 Clear policies are in place in Zimbabwe and Africa on the smooth application of resilient and sustainable infrastructure?

	Respondents	**%**
Yes	**4**	**19%**
No	**18**	**81%**
Total	**22**	**100%**

81% of the respondents in Table 4.18 above point to lack of policy clarity when it comes to resilient and sustainable infrastructure to ensure clear implementation. Policies provides clear guidelines on how particular procedures and processes are to be implemented or executed. The non- availability of such a policy creates a system dysfunctional and creates a chaotic approach to resilient and sustainable construction.

Table 4.19 Knowledge workers/Lecturers in Zimbabwe and Africa frequently participate in resilient and sustainable infrastructural workshops, seminars or conferences.

	Respondents	**%**
Yes	**16**	**73%**
No	**6**	**27%**
Total	**22**	**100%**

73% of the respondents in Table 4.19 above confirm that participation in resilient and sustainable infrastructure do occur. However, the lack of policies as alluded to in questionnaire number 11 above points to a system disconnection. Which then may mean participation is merely an academic exercise which has no bearing to policy implementation.

Table 4.20 Zimbabwe and Africa Higher and Tertiary institutions regularly host academic workshop and conferences on resilient and sustainable infrastructure development.

	Respondents	**%**
Yes	**16**	**73%**
No	**6**	**27%**
Total	**22**	**100%**

73% of the respondents in Table 4.20, above agree that workshop and conferences on resilient and sustainable infrastructure development are hosted regularly. The point to note is what then happen with the gathered knowledge, information or data during the conference. Again is there is no policy clarity it means that the result of the conference will go to waste.

Table 4.21 The practical application of research knowledge in Zimbabwe and Africa is not useful in the promotion and development skills and competencies required by industry and commerce.

	Respondents	**%**
Yes	**3**	**14%**
No	**19**	**86%**
Total	**22**	**100%**

In Table 4.21, above, 86% of the respondents disagreed that practical application of resilient and sustainable infrastructural knowledge in Zimbabwe and Africa is useful in the promotion and development of skills and competencies. This is vital for the implementation of resilient and sustainable infrastructures. 14% who agreed may point to those who are directly involved in construction related industries and teaching and learning faculties. 16. The practical application of resilient and sustainable infrastructure in Zimbabwe and Africa education system are useful in the promotion and development of skills and competencies

Table 4.22 Practical application of resilient and sustainable infrastructure in Zimbabwe and Africa

	Respondents	%
Yes	**21**	**94%**
No	**1**	**6%**
Total	**22**	**100%**

In Table 4.22, above 94% of the respondents concur that practical application of resilient and sustainable infrastructure in Zimbabwe and Africa are useful in the promotion and development of skills and competencies. This set a good starting point when it comes to capacity building in lecturers.

How do you view the resilient and sustainable infrastructure strategies in Zimbabwe and Africa education institutions as compared to international best practices?

Respondents generally considered Zimbabwe and Africa's resilient and sustainable infrastructural development to be below the expected level and is treated as a preserve of foreigners as most contracts for development are awarded to foreign nationals at the expense of locals. Comment demonstrate the level of treatment accorded to local companies when it comes to the implementation of resilient and sustainable infrastructure projects in Africa. Comment from participants A, "Zimbabwe is still a long way from being the best as the basics/foundation is still shaky. A lot of assumptions and miscommunication are rife". There is lot to be done to promote comprehensive resilient and sustainable infrastructure in our country. There is need for the development of sound policy which promote sufficient funding in resilient and sustainable development. The comments are is agreement with quantitative findings and those emanating from literature review. The system was found to be void of policies to guide and lubricate the channel of resilient and sustainable infrastructure.

How do you view the resilient and sustainable infrastructure strategies in Zimbabwe and Africa compared to international best practices?

The general comments received from respondents are, they are lagging behind due to poor infrastructure and prohibitive costs. Uptake in Zimbabwe and Africa are low mainly due to the prohibitive cost of research were funding is limited. This in turn limits the range and scope of resilient platforms or avenues. Lack of local research funding has negative impact on the development of resilient and sustainable system. This calls for African government to seriously craft laws and policies that promote local or indigenous solutions to local challenges.

How important is the role of resilient and sustainable infrastructure knowledge management systems to in Zimbabwe and Africa?
Respondents' general comments, International best educational practices require institutions to migrate to such platforms otherwise Zimbabwe will remain at the doldrums of any development. As world education system changes, especially with the coming of remote learning there is a need for institutions to reorient their teaching approaches in line with changes trends globally so that students are adequately catered for in all facets of resilient and sustainable infrastructure. Resilient and sustainable infrastructure learning can help in arresting that problem and making education a convenient experience, especially if the learners have access to internet. Globalisation and glocalisation are cited as key enablers in ensuring that resilient and sustainable infrastructures are constructed.

How will Resilient and Sustainable Knowledge Management Systems influence change in Zimbabwe and Africa education systems?
Currently global demands are fast moving towards resilient and sustainable technologies which are enhanced through acquisition of such skills, knowledge and practices which makes people more competitive in terms of knowledge generation, management and application. It reduces the technical aspect of foreign involvement since they must be practical. It teaches students and staff on how to manage time and develop a sense of responsibility by knowing the requirements of local needs. This will also facilitate quick service delivery to clients from local contractors. As one respondent comment.

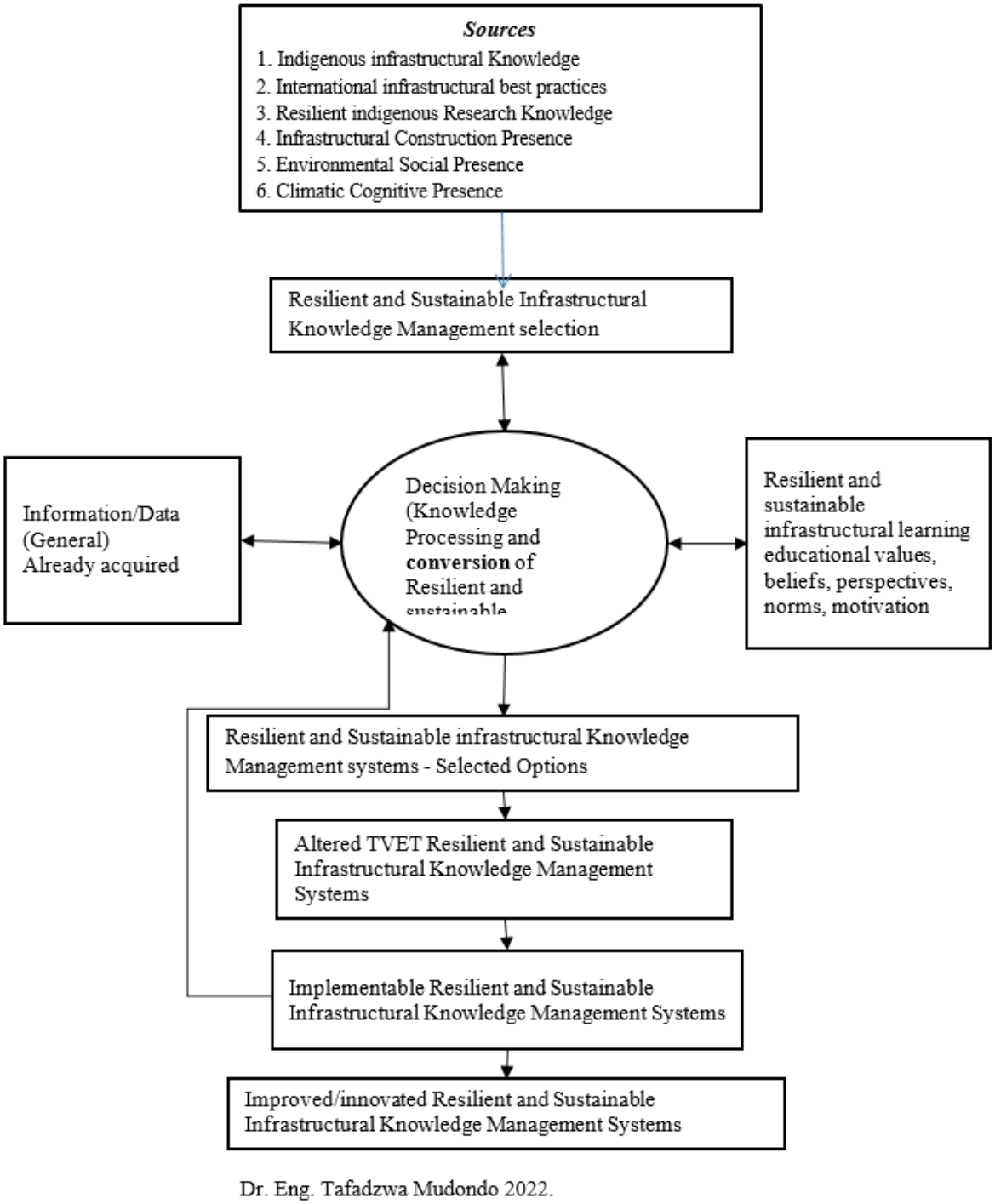
"Resilient and sustainable infrastructure will influence change in Zimbabwe's construction eco-system through allotting more time to research as technology provides flexibility on lecturer interaction with students. Also technology makes it easy for collaboration with other academics in other parts of the world in the comfort of your office or home through platforms such as zoom. Zoom conferences and seminars will make Africa and Zimbabwe to be abreast for trends the world over to benchmark"

Recommendation from Respondents for the Implementation of the Programme.
Resilient and sustainable infrastructure must be taken seriously. Use of resilient platforms and systems in higher and tertiary education, that way information is shared anytime and anywhere and information can be managed easily.

There is need to put clear policies in place, ensure availability of the e-resources and gadgets for staff, training on a regular basis for both staff and students, allocation of a specific budget towards resilient and sustainable infrastructure. The systems need to be enhanced and made accessible to a wider population. The comments concur with what come out of literature and quantitative research.

Model Formulation
The suggested model for resilient and sustainable infrastructure Knowledge Management System are central to the implementation process. As established in this research study and also supported by resilient and sustainable infrastructure Knowledge Management literature, the model is anchored in the findings the best approach to implementation of resilient and sustainable infrastructure.

The model demonstrates that the main goal Resilient and Sustainable Knowledge Management Systems to improve efficiency and effectiveness within an organisation or society through cross-pollination and cross-fertilisation of ideas and sharing. The researcher contend that the design and model may be improved with further empirical investigations in various institutions in Africa as well as being rigorously tested to validate for operational applicability.



Resilient and Sustainable Infrastructure Knowledge Management System Model developed from the Research Study: Adapted from Mudondo 2020: IEOM society page 2499.

5. Findings, Recommendations, Way **forward and Conclusion**

5.1 Empirical findings

- Africa's resilient and sustainable infrastructure ecosystem is rooted is foreign centric discourse.
- Most projects are done without community engagement or consultations
- Africa infrastructure is not resilient because it was designed and developed with colonial philosophy and it did not take in account demographic projections.
- Most construction projects and mining ventures are given to foreigners who only look at the economic benefit to their countries leaving the host country in a poor state.

- Resilient and sustainable infrastructural knowledge acquisition is characterised by low conversion, under-utilisation and mis-utilisation, with limited collaborations and networking.
- Resilient and sustainable infrastructural Knowledge Management System is hampered by lack of Afro-centric policies that promote research and investment in resilient and sustainable infrastructure.
- Indigenous Knowledge Systems could play a key determining factor as an enabler and facilitator to the acquisition, sharing, networking and generation in resilient and sustainable infrastructural Knowledge Management Systems.

5.1.1 Recommendations

Emanating from the implication of the research study, the researcher make the following recommendations for effective and efficient resilient and sustainable infrastructural development.

- Develop clear policies and philosophies that repurpose and support the implementation of national resilient and sustainable infrastructural Knowledge Management Systems in Africa embedded in Indigenous Knowledge Systems.
- Understand and emphasise practical approaches and solutions to create indigenous resilient and sustainable Infrastructural Knowledge Management Systems as a competitive edge.
- Have a holistic approach to capacity building and consultation with communities when it comes to building resilient and sustainable infrastructure.
- Acquire appropriate ICT technologies to enable implementation of programs for using resilient and sustainable infrastructural.

5.1.2 Way forward

This study opens opportunities for future research due to limited resources and time. Further research to validate the developed model can be explored to determine if there is an optimal interrelationship of indigenous knowledge processes when it comes to resilient and sustainable infrastructural in Africa.

5.1.3 Conclusion

This research study has managed to satisfy the research objectives and come up with findings and recommendations. Zimbabwe and Africa need to integrate Technical and Vocational Education and Training and Industrial Engineering and Operations Management to reassert the philosophy of resilient and sustainable infrastructural development for national reskilling, industrial engineering and technology transfer. Adequate budget provisions, public policy orientation, and curricula reorientation must be put in place for resilient and sustainable construction. African Governments must institutionalise and embody resilient and sustainable infrastructural development that promote and enhance indigenous philosophies.

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Biography

Dr. (Ph.D). FZwIE. PrEng. Tafadzwa Mudondo is currently the Principal of Harare Polytechnic in Zimbabwe. Harare Polytechnic has a staff compliment of about 700 members and a students' population of about 10000. He is a holder of, Ph.D. in Business Administration, specializing in Knowledge Management Systems, Executive Masters in Business Administration Degree, Bachelor of Technical Education Honours in Electrical and Electronics Engineering all from National University of Science and Technology Zimbabwe. Higher National Diploma in Computer Engineering from Xi'an Telecommunication Institute (China), Full Technological Certificate in Telecommunications Engineering, City and Guilds (UK), Class 1 Journeyperson in Aircraft Radio and Telecommunications Engineering done with the Air force of Zimbabwe. Tafadzwa Mudondo is a registered professional Principal Telecommunications and Avionics Engineer, Fellow of Zimbabwe Institution of Engineers. Tafadzwa Mudondo has 10 years working experience in the aircraft industry and 22 years' experience in managing engineering education, learning and training at a polytechnic. An author in Building Resilient and Sustainable Competitive Practices in Organisations, Technology Enabled Learning and has more than peer reviewed publications in Knowledge Management Systems. Tafadzwa Mudondo has a passion for Knowledge Management Systems and Learning Organisation. Member of Society for Research into Higher Education (UK), Member and Executive Board member of Zimbabwe Institution of Engineers and Executive Board member of Association of Technical Universities and Polytechnics in Africa ATUPA, Vice Chairperson ATUPA Southern African Region, member Higher Examination Council Pre-Ratification Committee-Zimbabwe and current Chair of Polytechnics and Industrial Training Colleges Association in Zimbabwe.