An Exploration of the Institutionalization of the Fourth Industrial Revolution (4IR) in South African Municipalities

Mpilo Ngubane*

Independent Researcher, Doctor of Administration from University of Durban-Westville and Doctor of Public Administration from University of Zululand, South Africa

*****Corresponding Author:** *Mpilo Ngubane, Independent Researcher, Doctor of Administration from University of Durban-Westville and Doctor of Public Administration from University of Zululand, South Africa*

ABSTRACT

The Fourth Industrial Revolution (4IR) is an era that is upon every country and will invariably change the technological and digital interconnectedness of the world. It therefore becomes inevitable that all countries regardless of their shape, size and stage of development should embrace the 4IR. Similarly, municipalities do not have a choice but to embrace the 4IR if they want to be technologically and digitally relevant and be on par with the rest of municipalities globally. It is for this reason that the study explored the institutionalization of the Fourth Industrial Revolution (4IR) in South African Municipalities. The study looked at the theoretical perspectives on the 4IR with specific reference to the benefits, challenges and drivers of the 4IR. Qualitative research methodology was employed where a sample of 30 senior managers were selected across South African municipalities and were interviewed according to their specific municipal functions. Responses to interviews were coded and categorized to eight (8) themes. The study concluded that all municipalities should embrace the 4IR. It further recommended that they should invest in technological infrastructure, digital tools and learning programmes for both the staff (and councillors) and communities to prepare them for the 4IR.

Keywords: *Fourth Industrial Revolution (4IR), Technology, Technological Infrastructure, Digitalization, Digital Competencies, Broadband, Connectivity, Fifth Generation (5G).*

INTRODUCTION

The age of the Fourth Industrial Revolution (4IR) is upon every country and it has become inevitable for countries not to embrace it. However, this era comes with a lot of challenges especially to the developing countries that may be at their infancy in terms of their technology development. It is therefore important for countries to have a clear understanding of what the 4IR is and how it is going to affect them so that they are ready to embrace it.

According to Liao, et al. (2017) the first industrial revolution is considered as one of the important advancements of humanity, which started by using water and steam-powered mechanical manufacturing facilities since the end of the 18th century. This was associated with increased diversity in work (Doll & Vondermbse, 1991).

This was followed by the application of the electrically powered mass production techniques from the start of the 20th century and it was marked the second industrial revolution. The third industrial revolution began around the mid-70[s] and popularized electronics and information technology (IT) in factories. Current literature on the 4IR expresses different opinions on exactly who the founder of the 4IR is. Some writers believe the concept of the fourth industrial revolution was firstly proposed by Rostow (1985) but was largely used in the forestry manufacturing industry. Before 2012 the concept was widely used in the development and application of nano-technology (Dai, 2006).

After 2012 the concept was used to refer to automation and machine era. Later in 2017 it was referred to as the use of the big data in the field of brain mind neurosciences. The other author credited with founding the 4IR is Schwab (2016) who defines 4IR as an era with unprecedented and simultaneous advances in artificial intelligence (IA), robotics, the internet of things (IOT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, quantum computing, etc which are redefining traditional boundaries and creating new opportunities. This definition emphasizes a fundamental shift from a traditional way of doing things to more robust technological era. Figure 1 below depicts the four industrial revolutions.
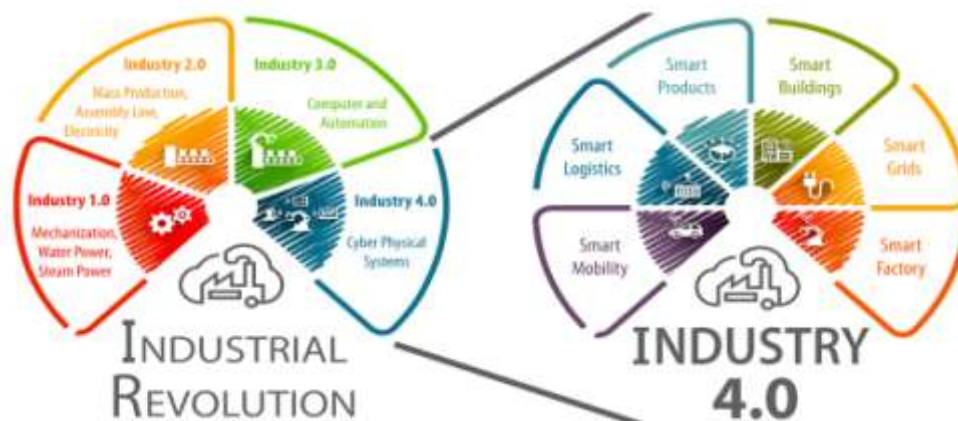
Figure 1. *Industry 4.0 vs 4IR*

Source: *Ashwell, E.C. (2016)*

The move to the 4IR reflects a historical trajectory that is in some senses inevitable (Fuchs, 2018). The key words that describe this revolution best are hyper connectivity, hyper analysing and digitalization (Park, 2017), a combination between real and virtual space and more interactions between man and artificial intelligence (Lee, et al., 2018).

According to Xu, et al, (2018) there are three reasons why today's transformations represent not merely a prolongation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: velocity, scope, and systems impact. When compared with the other revolutions, the Fourth one has current breakthroughs that are unprecedented in history and is evolving at an exponential rather than a linear pace. It is disrupting almost every industry in every country and the breadth and depth of these changes herald the transformation of entire systems of production, management and governance (Schwab, 2015).

Belvedere, et al., (2013) support the 4IR idea by stating that the advances in science and technology have continuously supported the development of industrialisation all around the world and have helped to bring more specific and explicit measures to this term over the years. The Fourth Industrial Revolution has lately been known as industry 4.0, a commonly accepted name given by German practitioners and researchers (Rojko, 2017) who aimed to increase the competitiveness of the current manufacturing industry by integrating cyber-physical systems into the production processes.

Although the 4IR is focused on industrialisation, there is also a need for government to embrace it as part of its vehicles in the delivery of services to its people. It is therefore inevitable that South African municipalities, if they want to be counted amongst the best in the world, should also embrace and implement the 4IR concept. It is for this reason that this study looked at how South African municipalities can institutionalize the 4IR.

AIM AND OBJECTIVES OF THE STUDY

The aim of the study was to explore the institutionalization of the Fourth Industrial Revolution (4IR) in South African municipalities.

The objectives of the study were to:

- Establish the theoretical and conceptual framework informing the 4IR.
- Examine the institutional benefits of the 4IR.
- Examine the challenges of the 4IR.
- Examine the drivers of the 4IR.
- Propose mechanisms for institutionalization of the 4IR.

LITERATURE REVIEW

Institutional Benefits of the 4IR

The Fourth Industrial Revolution, particularly from an institutional point of view, is bringing opportunities and challenges. Some of the opportunities include improvement on organizational efficiencies and effectiveness thus improving productivity. The 4IR has the capacity to enhance and improve the quality of life of citizens and that is a high possibility if municipalities embrace it. Over and above that, the worker life quality of employees in general can improve resulting to organisations meeting their targets better by employing more efficient and effective production systems and digital

platforms. Generally, employees enjoy being innovative and trying new things at work. The new paradigm shift in technology brings with it development, deployment and exploitation of technology but this depends on how creative and adaptable the organization wants to be.

According to Corfe (2018) the use of big data and data analysis brings with it a wide range of productivity benefits including:

- Lost savings: using data to identify sources of wastage within supply chains, such as underutilised labour, investments that are not yielding significant benefits and energy and water leakages.

- Time savings: for example, through being able to analyse real-time data rather than having to wait for it to be collated. In the retail space this can include real-time analysis of barcode scanner data to identify trends in demand and potential supply shortages for different products.

- New product development: using data to inform product design and improvement.

- Understanding market conditions: such as predicting potential upturns and downturns in product demand and adjusting business behaviours accordingly.

- Being able to provide more bespoke, targeted products for individuals rather than one size fits all solutions.

- Artificial intelligence and machine learning are gaining prominence in many businesses or organisations and use statistical techniques that are computerised to make intelligent decisions. Artificial intelligence is also used by organizations to improve their product offerings, reduce costs and also to improve productivity. Robotics improve productivity since production is automated and that improves efficiency. Drones have also proven to be very beneficial for organizations for they are able to travel in the air to avoid road traffic and can offer efficient solutions for challenges of the 4IR.

- In e-government field, the socio-technical perspective increases as well, due to the realization that the adoption of technology in government is affected by complexity of social, organizational, technical, policy, political and other factors (Pardo, Nan & Burke 2012). These challenges are even worse at the local government level where communities especially those that are struggling financially find it difficult to prioritize technological development over service delivery priorities. Sometimes it is not about service delivery but about political choices for politicians (councillors) would also opt for projects that will help them be re-elected. There are however specific challenges that are brought about by the arrival of the 4IR.

Challenges of the 4IR

Job Losses

There is a prediction that 25 million jobs will be lost due to the 4IR, however there is high likelihood that corresponding 5 million new jobs will be created during the advent of the 4IR. This prediction was made before the Covid-19 pandemic that engulfed the whole world which on its own resulted into millions of job losses. The World Economic Forum (2016) predicted that many of the major drivers of transformation currently affecting global industries are expected to have a significant impact on jobs, ranging from significant job creation to job displacement and from heightened labour productivity to widening skills gaps.

Skills Shortages

Skills, innovation system and knowledge communities provide the much-needed intellectual guidance in the development and implementation of smart and digital initiatives (Abdoullaw, 2011). It is apparent that a lot of conventional skills will be obsolete and new skills will be required which will then mean that not only the workforce but also communities will have to be provided with new technological skills.

Poor Infrastructure

In South Africa, poor broadband penetration was found to be one of the barriers hindering transformation to the so-called smart society driven by digital connectivity, advanced technology, skills, knowledge and innovation to institute economic and social development (Manda & Backhouse, 2016). Social inequality and disparities will impact negatively on social technological infrastructure since developing countries such as South Africa, which has an average of 65% rurality of its communities, are struggling with connectivity even for simple things like cell phones.

Cyber Insecurity

Security and data privacy issues have arguably become one of the most significant concerns in the 4IR where technology has become a driver

(Waidner & Kasper, 2016). Hacking and other dark web activities are prevalent during the era of technology and institutions need to be vigilant (strengthen their firewalls) to protect their data and privileged information. Integration of systems in the 4IR requires the development of new security and protection mechanisms for the faster and more flexible collaborative value networks and smart production systems (Waidner & Kasper, 2016). Having everything attached to everything else in the IoT is going to monumentally increase the vulnerabilities present in any given network (Xu, etal, 2018). Companies will therefore need to assess their cyber risks and put mitigation measures in place.

Low Adaptation

Countries must acquire mechanisms to help their citizens to be quickly and easily adapted to the new reality. In technologically advanced countries such as Japan, South Korea and Singapore, men are increasingly working with robots in order to be highly adapt to automation reducing in this way unemployment rate in comparison with other countries where adaption is slower (Zavoudi, 2020). Low adaption is high risk in developing countries such as South Africa which inherently equates to slower employment rate in the technological sector. Therefore, governments need to ensure that they adapt to the 4IR as early as possible to also improve employment rate.

South Africa, like many other developing countries, was hard hit by the 2008/2009 global recession and this will surely have a negative impact on its ability to embrace the 4IR. The latest hit by Covid-19 pandemic has also resulted into very stagnant economic growth which has resulted into a loss of 2 million jobs and the unemployment rate that has hit a record high of 42%. There is also a high possibility that the current form of capitalism is going to be changed during the 4IR. Mason (2015) suggests that because of new technology, capitalism as we know it, is in decline and is likely to be replaced by an entirely new socio-economic system: post-capitalism. This new global system will be championed not only by the organized labour or working class, but also by the networked class who will harness zero marginal cost production, use massive amounts of real time data to understand, model and test ideas for change, promote collaborative, non-profit forms of work and answer that everyone is paid a basic income. In addition to challenges discussed

above the following are other issues of concern around 4IR in South Africa:

- The power of trade unions: South Africa is one of the countries that are often criticised for having very stringent labour laws that provide a lot of protection to labour unions like the right to strike, protest, picket, etc. With the potential loss of up to 35% of the current skills due to the 4IR, there is a possibility of strikes or protests by labour movements against the potential loss. Reacting to the question whether there will be massive unemployment as a result of computers and robots replacing manpower, Hajkowz (2016) is emphatic that countries will not enter into an era of job destruction but rather one of rapid transaction.

- Skills: There is no doubt that the advent of the 4IR will need a young population with agile skills and knowledge to use telecommunication technology effectively and efficiently. South Africa therefore needs to have very powerful telecommunications networks. Cronje (2016) and Rossi (2015) accept that the exponential and unprecedented speed at which the revolution is taking place has a disruptive effect on the entire systems including the production, management and governance of the entire industry. There is going to be a skills gap between what the country has as skills-base and the future skills requested by the 4IR. It therefore means that government should take more responsibility for skilling, upskilling and reskilling its workforce.

- Corruption: The unprecedented and rising corruption levels in South Africa are a huge concern and this is likely to stunt the country's economic growth and the implementation of the 4IR will be similarly affected. South Africa is now ranked number 61 on the Transparency's International's rankings as of 2018 (it is likely to be worse after the Covid-19 corruption scandal. Sera (2016) offers that rigged and inflated contracts, absenteeism, pension scams and unnecessary consultancy were among the common ways in which public money was filtered away.

- The digital gap: South Africa, as a developing country, is still characterized by a huge gap between the rich and the poor. This gap is also prevalent to access to technology where rural community, poor households, women, low levels employees do not have direct access to technology because it is expensive and, in

some cases, there is poor connectivity in their respective areas.

- Cyber-crime: It is inevitable that the advent of the 4IR will come with security threats to the networks and telecommunications systems used especially by government which is highly vulnerable. The government information technology systems, for example, host the biggest persal system linked to the biggest payroll in the country and already there have been numerous hacking attempts in the system and in some cases with success although in a minor scale. There is also a growing trend of stolen personal information of clients from the database held by the private sector.

Drivers of the Fourth Industrial Revolution

Pardo, et al., (2012) maintain that the successful adoption of the 4IR will rely on the ability of governments, business and citizens to commit in supporting the transformation of society into a modern and smart society driven by advanced technology, skills, innovation and responsive policy. Emphasis is put on the fact that no matter how technologically advanced the institution is, it will not successfully adapt to the 4IR if it leaves its people behind. The following drivers will support the adoption of the 4IR:

Responsive Policy Innovation

Innovative policy and legislative reforms are key in digital transformation for they allow the government to put in place measures and resources in response to the challenges and opportunities brought by the digital era (Cordella & Lannacci, 2010; Fan, Zheng & Yen, 2014;). Municipalities, apart from IT policies, will rely on the Smart Digital Strategies to adopt and implement the 4IR.

Technologies Infrastructure

Technologies such as cloud computing, the internet of things (development of smart products), the internet of services (smart mobility and smart logistics) and internet of energy (efficient use of natural resources) have assumed an important role (Lom, Pribyl & Svilek, 2016). Telecommunication technologies and infrastructure such as broadband and other internet technologies provide digital connectivity for effective communication, collaboration and integration of people, systems and machines (European Commission, 2015). South Africa has been severely criticized on its inadequate broadband which is key to digital connectivity and therefore needs to invest heavily on this technology infrastructure. In emphasizing the reliability of telecommunications infrastructure, Zhou, et al., (2015) assert that the 4th industrial revolution requires the establishment of a comprehensive and reliable industrial broadband infrastructure.

Research and Innovation

Innovation is primed as one of the trump cards of the 4th industrial revolution and there is no better way it can be done other than through research and development. Deloitte's (2016) survey done in Switzerland on the impact of the 4th industrial revolution in manufacturing companies found that about 78% of the surveyed companies ranked research and development as a critical component of the 4th industrial revolution. The recent and increasing emphasis on sustainability and inclusive growth suggests that strategies should ensure that the returns from digital transformation should not only benefit the society but also address human and development challenges.

Smart and Responsive Strategy

South Africa has very good strategies and some cities have developed very good Smart City Strategies, but the problem is implementation. Ndou (2004) attests to this by arguing that the challenge is not the absence of strategies but rather the failure of strategies to respond to the local context.

Learning and Development

This is the only vehicle that organisations can use to skill, upskill and reskill their workforce to be ready for the 4th industrial revolution. Figure 2 below depicts how technology, space and pedagogy are going to be made flexible to accommodate the 4IR learning. The digital transformation and innovations in the 4th industrial revolution demand a new breed of a worker, one that is skilled, innovative and technological savvy (Manda & Backhouse, 2017). This new future worker will have to be an entreployee who monitors and plans his or her own skills acquisition, work schedule and clientage (Pongratz & Voβ, 2002). The ability to anticipate and prepare for future skills requirements, jobs content and the aggregate effect on employment is increasingly critical for businesses, government and individuals in order to fully seize the opportunities presented by these trends and to mitigate undesirable outcomes (World Economic Forum, 2016).
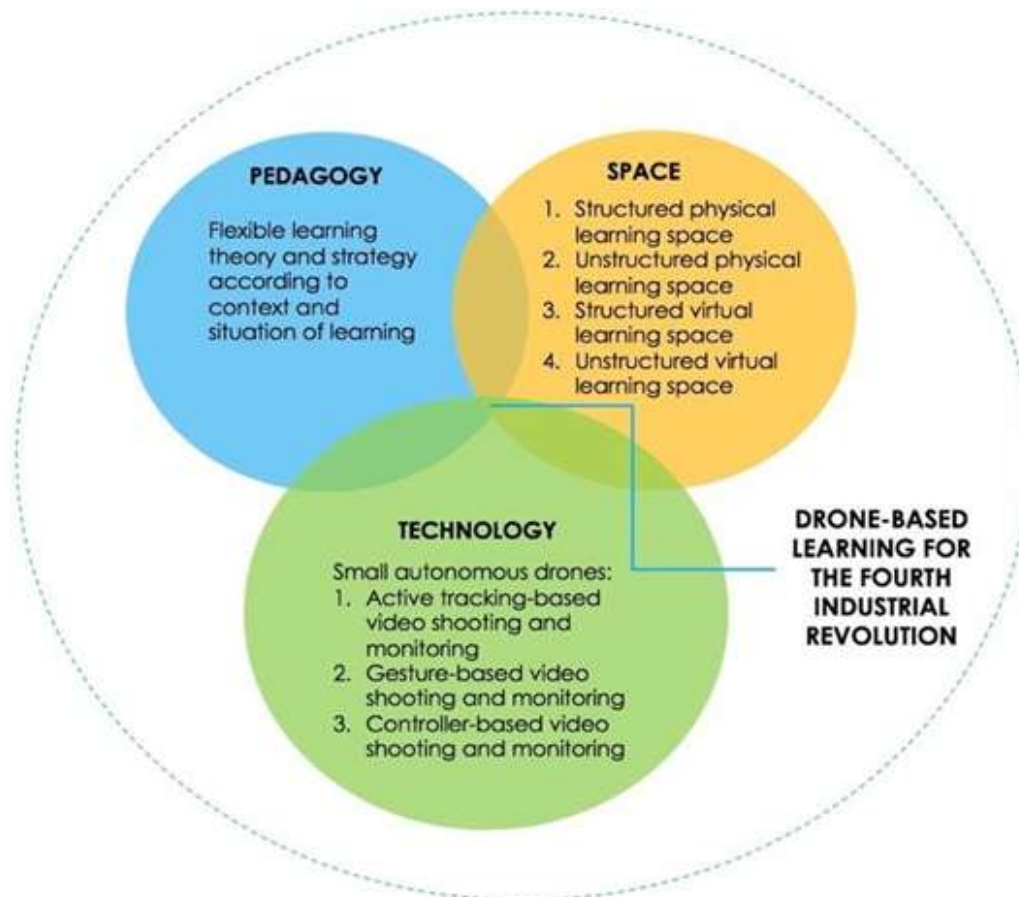
Figure2. *A Framework of Drone-based Learning (Dronagogy) for Higher Education in the Fourth Industrial Revolution*

Source: *Norman, H. et al. (2018)*

Successful implementation of the 4IR also depends on its linkages and integration with the sustainable development agenda. The United Nations Sustainable Development 2013 Agenda contains 17 Sustainable Development Goals (SDGs) and 169 targets intended to help guide all sectors of society to improve lives and to make the world a more comfortable place to live and work in (Pollitzer, 2018). The most relevant SDG for education is Goal 4 which is stated as: "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". There are countries that have started to link the 4IR with the SDGs. Malaysia, for example, has identified initiatives to use 4IR technologies for learning and development (Ally, Norazah & Norman, 2019). For successful implementation and achievement of the SDGs, educational systems have to provide education for all (Doncet & Evero, 2018). Education will become self-organizing; technology will play a major role in institutional delivery and in providing support to learners (Mitra, 2014). Learning will move towards individualisation and learner centredness, due to 4IR technologies such as artificial intelligence (IA), learning analytics and internet of things (IOT) (Chai & Kong, 2017; Mitra, 2014; Pepinici & Kerr, 2017). The 4IR era will dramatically change the role of teachers, who will become "4IR" or Digital teachers using deep learning technologies such as artificial intelligence, robotics, big data, internet of things, etc (Ally, 2019).

The World Economic Forum (2018) lists the following top 10 skills as those that will be in demand during the 4IR:

- Complex problem solving
- Critical thinking
- Creativity
- People Management
- Coordinating with others
- Emotional Intelligence
- Judgement and decision making
- Service orientation
- Negotiations
- Cognitive flexibility

These are largely generic skills that every employee or manager should possess and apply during the 4IR, however there is still a need for technical skills or qualifications in relation to specific fields and job requirements to be attained by the workforce and this is where organisations will need to invest in the reskilling of the workforce.

RESEARCH METHODOLOGY

The study used the qualitative research approach and design and used individual interviews to establish the views of different municipalities on the implementation of the Fourth Industrial Revolution (4IR). The choice of the qualitative research approach was based on the assertion by Xing & Marwala, 2017; Davies, Fidler & Gorbis, 2011 that knowledge management and the ability to discriminate and categorize informationis fundamental in qualitative data analysis. It also helped to discover new thoughts and individual views. Qualitative research methodology is considered to be suitable when the researcher either investigates new field of study or intends to ascertain and theorize prominent issues (Corbin & Strauss, 2008). A total number of 30 senior managers from various departments in municipalities were selected so as to ultimately understand how they would implement the 4IR in their respective departments. Senior managers were selected according to their respective functional areas as per general municipal functions which are corporate or support services; financial services; planning and economic development; community services and technical or engineering services. The suggested 4IR digital competencies were therefore categorized and packaged along these municipal functional areas. The sample size was selected on the basis of the recommendation by Creswell (1998) that, for grounded theory, 20-30 interviews are sufficient. According to Oakley (1998) qualitative interviews are a type of framework in which practices and standards be not only recorded, but also achieved, challenged as well as reinforced. Semi-structured interviews were used since, although questions were prepared beforehand, respondents were allowed to expatiate on and motivate their responses and follow up questions were also posed to respondents. As no research interview lacks structure most of the qualitative research interviews are either semi-structured, lightly structured or in-depth and are generally suggested in conducting long-term field work and allow respondents to express their views (Mason, 1994). Once all the interviews were transcribed coding was effected. Austin & Sutton (2015) define coding as the identification

of topics, issues, similarities and differences that are revealed through the participants' narratives and interpreted by the researcher. This confirms Creswell's (2015) assertion that coding is the process of analysing qualitative text data by taking them apart to see what they yield before putting the data back together in a meaningful way. Codes were therefore themed together in terms of their similarities.

RESEARCH FINDINGS AND RECOMMENDATIONS

All respondents were senior managers responsible for respective departments (functional areas). These senior managers were selected because they have intimate knowledge of their respective departments and are in a good position to recommend the required digital tools and digital competencies (4IR training programmes) in their respective departments. The interview transcripts were analysed and then categorised according to eight (8) themes which are:

- Theme 1: Structures
- Theme 2: Strategies
- Theme 3: Policies
- Theme 4: Processes
- Theme 5: Infrastructure
- Theme 6: Digital Tools
- Theme 7: Digital Competencies (according to functional areas)
- Theme 8: Attitudes and Values

Coded responses were then grouped according to themes and interview questions.

Theme 1: Structures

Respondents were asked to state the kind of structures they would recommend for successful transition to the 4IR. Respondent 1 (R1) recommended*"Reviewing current municipal structures to integrate both the Information Technology (IT) and Digital Offices."*It is clear that in terms of organisational structures municipalities need to move away from conventional IT Offices to include the digitalization function.R2 *"The ICT Strategic Committee is the oversight committee with a helicopter view on digitalization (4IR) in the municipality and its terms of reference include approval of all 4IR strategic projects. The Committee also needs to approve the Technology Investment Decision Framework."* There is consensus among respondents that each municipality needs to have an ICT Strategic

Committee to drive transition to the 4IR. Other respondents provided a different name for this Committee. R27 *"Municipalities must establish Digital Economy Governance Committee that interfaces with the Management Committees regularly so that all decisions are taken in the light of this approach."* It does not really matter what name is given to the Committee but the bottom-line is that all municipalities must have these Governance Committees. Schwab (2015) summarised this by suggesting that the whole system of governance needs to change.

Theme 2: Strategies

When respondents were asked to recommend strategies for successful transition to the 4IR, the ICT Strategy or ICT Strategic Plan came out very strongly. R4 *"The Strategy around information, communication and technology (ICT) for the City must be reviewed and a definite ICT Strategic Plan must be put in place which must be evaluated and also monitored in terms of implementation."* The reason for motivating for review of current ICT Strategies is to ensure that they are aligned with the 4IR. It is also important to align the ICT and Digital Strategy with other strategies in the municipality. R8 *"The Digital Strategy must talk to the overall Human Capital Strategy of the municipality which I assume includes strategies for skilling, reskilling, culture of learning, knowledge management, etc."* This alignment will ensure that employees will have the necessary digital skills (competencies) and tools to transcend to the 4IR. R8 *"4IR without any doubt affects many employees, and as such Corporate and Human Resources must provide leadership in terms of appropriate policies to deal with the impact of 4IR in the organization."*

Theme 3: Policies

When asked to recommend policies for successful transition to the 4IR, all respondents recommended that each municipality must have an ICT and Digital Policy. R10 *"The ICT Framework needs to be operationalized through the adoption of an ICT and Digital Policy to guide and enforce the implementation of new technology."* Those municipalities that already have ICT Policies are encouraged to review their policies to include the digital aspects. R7 recommended *"A review of the current policies around ICT and updating these in line with the requirements of the 4IR environment, and which are required to be inclusive, adaptive, sustainable and dynamic."* However other respondents did encourage those municipalities that do not have ICT and Digital Policies to start

developing them. R11 *"The municipality needs to develop a 4IR Municipal Policy to guide and ensure that it embraces new technology."* There is still an argument whether municipalities will need to develop and adopt specific 4IR Policies or they can include 4IR provisions within their ICT and Digital Policies. It also became clear that there will be other municipal policies that will have to be reviewed to be in line with the 4IR requirements. For example, R27 states *"Our policies will have to be reviewed to take into account remote working; flexible working hours; productivity and performance management, etc."* This corresponds with the assertion by Cordella&Lannacci (2010) that responsive policy innovation and legislative reforms are significant, and government should therefore put measures and necessary resources.

Theme 4: Processes

Respondents were also asked to recommend processes that will help their municipalities transcend to the 4IR. Many respondents combined processes and policies in their comments. R7 suggested *"A review of the current processes around ICT and updating these in line with the requirements of the 4IR environment, and which are required to be inclusive, adaptive, sustainable and dynamic."* Respondents were all of the view that current municipal processes need to be reviewed so that they are aligned with the demands of the 4IR. R15 *"The gaps in our current processes, which are really vast, which will enable the municipality to move to the 4IR space need to be addressed."* The other most important process that was also identified by respondents is the technology infrastructure procurement or development process. All respondents recommended that all municipal processes should be automated or done online. Linked to this is the suggestion by Pardo, et al. (2012) that successful implementation will rely on the ability by government to support transformation of the society into smart and modern society.

Theme 5: Infrastructure

When respondents were asked to recommend the required ICT and Digital infrastructure to be able to embrace the 4IR successfully and effectively, all of them recommended that municipalities must invest in technology infrastructure that will improve the broadband connectivity. This is in line with the suggestion by Zhou, et al. (2015) that the most important task of government is the establishment of a comprehensive and reliable industrial broadband infrastructure. Although respondents did not

understand the difference between technology infrastructure and technology or digital tools it became very clear that they would like to see improved connectivity which can be enabled by the acquisition of the Fifth Generation (5G). R20 suggested *"Upgrading IT hardware and software infrastructure to the latest versions, review the outdated technologies to improve and upgrade."* The other technologies that were highly recommended were Drone Technology and Blockchain Technology. R25 recommended *"Drone technology to verify information and for evaluation purposes, blockchain technology for the municipality's amount of transactional systems."* R27 *"The introduction of drones would alleviate the expenses of travelling between regions, centres and office buildings just delivering the mail."* R27 *"Drones to verify projects."* e-Learning Technology was also identified by many respondents as the kind of infrastructure they would like to recommend for municipalities. R27 *"The e-Learning Infrastructure will help employees learn at their own pace."* It was also clear that respondents were fully aware that the main challenge with the IT infrastructure in South Africa is broadband connectivity. R29 recommended *"A robust, resilient network or connectivity infrastructure that is designed to accommodate both IT and Operational Technology platforms."*

Theme 6: Digital Tools

Respondents were also asked the kind of digital tools they would need in their respective areas of operation to be able to embrace the 4IR successfully and improve efficiencies. Quite a lot of tools were enumerated by respondents. R21 recommended '*Software for streaming videos into social media platforms, digital flip book software, website development software.* This was also linked to tools that could improve municipal processes. R23 recommended *"Digital platforms for submission of tenders; video-conferencing equipment in the boardrooms."*

Theme 7: Digital Competencies

The generic 4IR soft skills recommended by literature and respondents are:
- Complex problem solving
- Critical thinking
- Creativity
- People management
- Coordinating others
- Emotional and social intelligence
- Judgement and decision making

- Service orientation
- Negotiation
- Cognitive flexibility
- Diversity and cultural intelligence
- Professionalism
- Anti-corruption and ethics
- Systems thinking
- Virtual collaboration
- Novel and adaptive thinking
- Sense-making

All municipal employees need to learn these digital generic skills irrespective of the technical areas they are working in because these are general competencies that will help them understand and work in a 4IR workplace.

The technical or function specific 4IR digital competencies that were recommended by literature and respondents were grouped according to different municipal functions. The following are some of the 4IR digital competencies (learning programmes) recommended in the Finance Functional Areas:

- Advanced analytics
- Finance automation
- Financial leadership
- Digital finance
- Agile finance
- Artificial intelligence (in Finance)
- Intelligence finance
- Finance transformation
- Finance intelligence technologies
- Cyber finance
- Predictive data analytics
- Data science

The following are some of the 4IR digital competencies (learning programmes) recommended in the Information and Technology Areas:

- Cyber security
- Data science
- Data analytics
- App design and development
- Systems integration
- Programming
- Coding
- Cloud computing

The following are some of the 4IR digital competencies (learning programmes) recommended in the Human Capital Areas:

- Data analysis
- Data analytics
- E-Planning (HR Planning)
- Systems analysis
- Online recruitment
- Business consulting

The following are some of the 4IR digital competencies (learning programmes) recommended in the Built Environment:

- Robotics
- Drone piloting
- Programming
- Coding
- E-Project management
- 3D printing
- Digitization (digital designing)
- Data science
- Bio engineering
- Modular fabrication
- Simulations
- Block chain
- Ambient mobility
- E-logistics
- Adaptive urban management systems

The following are some of the 4IR digital competencies (learning programmes) recommended in the Economic Development and Planning areas:

- E-Planning
- Drone piloting
- E-Media marketing
- Circular economy
- Data analytics
- Automation and manufacturing
- Machine learning
- Artificial intelligence
- Digital development
- Innovative finance (capital funding)
- Smart factories
- Smart cooperatives
- 3D printing
- Emissions reduction

The following are some of the 4IR digital competencies (learning programmes) recommended in the Community Services Areas:

- E-Traffic management
- E-parking
- E-logistics
- Drone piloting
- Number plate recognition
- Road safety technologies
- Driver simulation
- Cyber crime
- Data analytics
- Smart emergency response systems
- Innovative healthcare
- Nanotechnology

The following are some of the 4IR digital competencies (learning programmes) recommendded in the Governance and Administration Areas:

- E-Governance
- E-Public participation
- E-Council meetings
- E-information or data management
- Drone piloting
- E-Records management
- E-Legislation
- New media ecology/literacy
- Global connectivity
- Global citizenship
- E-Customer relations management
- 3D Presentation

Theme 8: Attitudes and Values

When asked about the attitudes and values that respondents would recommend for municipalities to embrace the 4IR successfully they listed the following:

- Transparency
- Integrity
- Trust
- Accountability
- Ethics
- Efficiency and effectiveness
- Adaptability
- Willingness to change

- Willingness to learn
- Flexibility
- Customer centredness
- Innovativeness

CONCLUSION

The aim of the study was to explore the institutionalization of the Fourth Industrial Revolution (4IR) in South African municipalities. Senior managers of municipalities were selected as the sample of the study and were interviewed on the institutional arrangements (structures, strategies, policies and processes) for successful transition to the 4IR; the 4IR infrastructure and digital tools; digital competencies required by the 4IR and the attitudes and values required to embrace the 4IR. Literature review was based on the definition of the 4IR, benefits, challenges and drivers of the 4IR. Interviews transcripts were done and responses coded and categorized into different themes. The study revealed that there is a need for South African municipalities to embrace the 4IR. It was therefore recommended that municipalities should invest in technology infrastructure, digital tools and learning programmes to embrace the 4IR successfully.

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