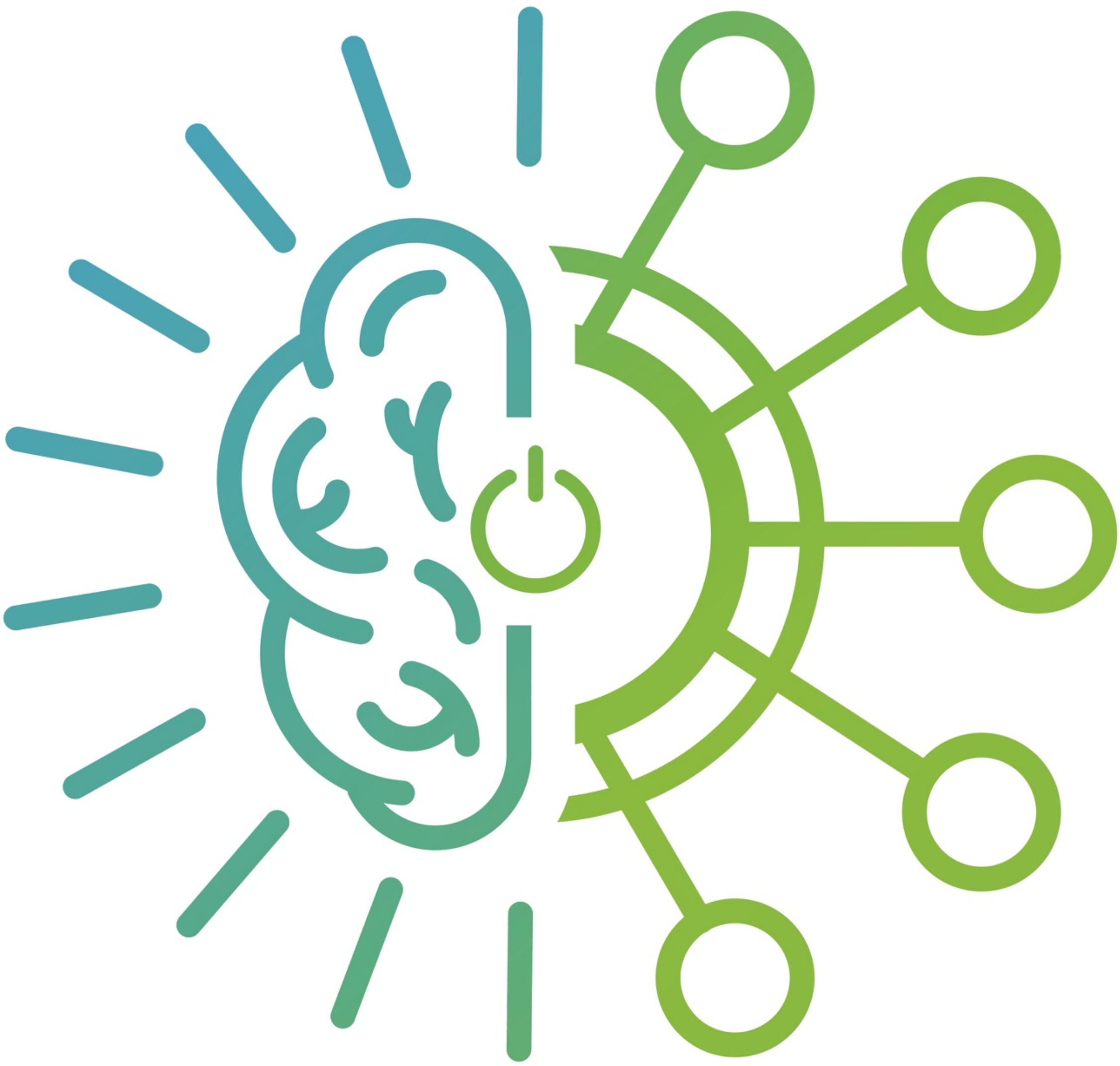

Knowledge Management and the Digital Native Enterprise

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Abstract

Technology will change the way people perform work and will therefore affect the operating model of organisations.

Bhalla, Dyrcks and Strack (2017) states "a tidal wave of change is coming that will soon make the way we work almost unrecognizable to today's business leaders. In an age of rapidly evolving technologies, business models, demographics, and even workplace attitudes – all shifting concurrently – change is not only constant but also exponential in its pace and scope." Rosen et al. (2017) concurs and explains, "Digital transformation has progressed to where it is now an existential concern for many enterprises." Digital transformation is the result of the Fourth Industrial Revolution and its associated emphasis on technological innovation and digital productivity in the digital native enterprise.

Clearly defined knowledge management strategies enable operational and business processes in organisations. These knowledge management strategies aim at the codification and personalisation of knowledge. In the digital native enterprise the operational and business processes will be dependent on knowledge processes aimed at transforming big data into knowledge. Data will be created by sensors, transmitted to actuators, and analysed in a cloud-based cyber-physical system. This requires a re-conceptualisation of the relevance and positioning of Knowledge management and strategies aimed at managing knowledge assets in digital native enterprise. Furthermore, data will be located in devices, equipment and more progressively in machines in the proximity of humans.

A literature review will provide insights into the positioning and manifestation of Knowledge management in a digital native enterprise. The findings of the literature review will be enhanced with the findings from three use cases reflecting on the infliction point between Knowledge management and work performed in the digital native enterprise. The aforementioned will enable early insights into the role and contribution of Knowledge management in an ecosystem where people and devices are seamlessly connected and strategic decisions are needed in respect of the positioning and manifestation of Knowledge management, as well as the skilfulness required by knowledge managers within the construct of the digital native enterprise.

Keywords: Artificial intelligence, Codification, Cyber-physical systems, Data, Digital transformation, Fourth Industrial Revolution, Knowledge management strategies, Machine learning, Personalisation

Introduction

Technology is changing the way people perform work, hence the operating models of organisations will need to be re-evaluated and adjusted within the predictable future.

Bhalla, Dyrcks and Strack (2017) states "a tidal way of change is coming that will soon make the way we work almost unrecognizable to today's business leaders. In an age of rapidly evolving technologies, business models, demographics, and even workplace attitudes – all shifting concurrently – change is not only constant but also exponential in its pace and scope." These changes result from the Fourth Industrial Revolution (4IR) and its emphasis on technological innovation and digital productivity in digital native enterprises (DNEs). Schwab (2016) continues by describing the extent and nature of the 4IR "In its scale, scope and complexity, what I consider to be the fourth industrial revolution is unlike anything humankind has experienced before. We have yet to grasp fully the speed and breadth of this new [fourth] revolution.

Although the impact of the 4IR on the operating models of organisations is not yet fully comprehendible it is evident that the expectations of clients and society at large will be such that organisations will need to be redesigned. Rosen et al. (2017) is of the opinion that "Digital transformation has progressed to where it is now an existential concern for many enterprises. Growing organisations strive to become "digital native" in the way they think, what they produce, and how they operate. Yet many organisations have difficulty in imagining what the new digital future could be."

Timperley (2018) indicates that although technological and digital productivity have been a gradual process it will require workers to acquire an altered state of skilfulness and mindfulness. Workers need to find a new "state of competitiveness" in the so-called gig economy simply because the rules of employment engagement has changed. In this economy, employment opportunities will not be awarded on the experience or qualifications of workers but rather on their ability to perform work which machines are unable to do. Furthermore, workers need to create and develop the ability to work alongside and collaborate with machines that are able to learn, make decisions and perform a variety of cognitive functions. The aforementioned is of particular relevance to the manifestation and sustainability of knowledge management functions in DNEs.

DNEs will be characterised by formalised and explicit knowledge management strategies that are seamlessly integrated with organisation wide systems and embedded within workflows. These knowledge management strategies combine codification and personalisation approaches and allow for knowledge management initiatives to enable the improved productivity of workers and encourage ecosystem wide innovation (Venkitachalam & Willmot, 2017). Knowledge management should therefore form an integral part of the construct of operational functions organisations. However, in the DNE, “knowledge” will be in the form of “big data” received by sensors and transmitted to actuators and can be analysed in a cloud-based cyber-physical system (CPS). The analyses of big data sets will enable the seamless integration of the products developed and services delivered by organisations and society. All with relatively little intervention from workers and a low dependency on their ability to apply their acquired knowledge and experience to perform knowledge work or physical labour.

The primary objective of this article is to develop insight into the positioning and manifestation of Knowledge management in a DNE. In an effort to achieve the aforementioned objective, Knowledge management in traditional organisations will be juxtaposed with the same in the setting of DNEs. This juxtaposition is augmented by a deliberation on the fundamental concepts that determine the nature of the relationship and the resultant expectancies between DNEs and Knowledge management. The afore is followed by an analysis of three use cases reflecting on the nature of the engagement between Knowledge management and the constructs of “work”, “work processes” and the “worker” in a DNE setting. The aim of the deliberation is to analyse the design principles of a DNE as well as the work that needs to be performed in the same in an effort to ascertain the relevancy and future manifestation of Knowledge management.

The hypothesis is the proliferation of data in a DNE will contribute towards an increase in the relevancy of personalisation in a DNE as cyber-physical systems (CPSs) will largely make the need for codification redundant. Data will “flow” into organisations by means of actuators and will be analysed to direct and dictate business processes. Hence, personalisation strategies should aim at contributing contextualised knowledge and insights that can support decision-making. Furthermore, the current definition and manifestation of personalisation as found in the literature and embedded in knowledge management strategies needs to be altered resulting from the design principles of a DNE. It is evident that big data and the management of the same by means of automated technologies and robotic process automation will characterise DNE’s. However, the need for personalisation will become of far more prominence as data needs to be contextualised to become information and contribute to an increase in personal and organisational knowledge.

Background

The NDE and specifically the extent and nature of work that is performed in the aforementioned requires a reconceptualisation of the relevance of Knowledge management and additionally the manner in which it should be practised. The applicability and relevancy of knowledge processes will be critically evaluated in an organisation where workers are seamlessly connected through ubiquitous technologies. In future, data will be generated by sensor-enabled technologies and analysed by powerful business analyses tools that will inform decision-making in the workplace and in society.

The business criticality of Knowledge management is considered in organisations and societies where workers are increasingly made redundant because of the physical and cognitive ability of machines to perform both repetitive but also highly complex work. The manner in which Knowledge management can contribute to business value is questioned in an age where thousands of devices are connected in the cloud and are able to perform both simple and complex tasks without any or with only limited interaction with their human counterparts.

Reflecting on the applicability and relevancy of Knowledge management within the setting of a DNE is therefore necessary. Additionally, the article deliberates the nature and scope of the deliverables of knowledge management capabilities as well as the required skillset of knowledge managers. The article could also guide and inform the development of knowledge management curricula at institutions of higher education as it reflects on core skills that knowledge managers should obtain prior to entering the profession.

"Digital Native Enterprises will be characterised by formalised and explicit knowledge management strategies that are seamlessly integrated with organisation wide systems and embedded within workflows."

Deonie Botha

Methodology

Objective qualitative research was conducted to ascertain the nature and extent of the future of work in the setting of a 4IR organisation.

Van Maanen (1979) states that qualitative research is "at best an umbrella term covering an array of interpretative techniques which seek to describe, decode, translate and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world." Furthermore, deductive inferences were used to draw conclusions on the manifestation of knowledge management in a 4IR organisation Johannson (2003) explains: "When a generalisation is based on the deductive principle, the procedure is similar to an experiment: a hypothesis is formulated, and testable consequences are derived by deduction. By comparing the expected findings, which are deduced from a theory and a case, with the empirical findings, it is possible to verify or falsify the theory. As a result, it is possible to define the domain within which the theory is valid more exactly. Cases that are pivotal to the theory are selected. The testing of the theory is comprised of the emulation of experimental method in a naturalistic setting. From a theory and the facts of a case, generalisations are drawn concerning the domain of the theory." Additionally, the study will have a dual approach, whereby non-empirical or conceptual research is combined with empirical research. The non-empirical component will include a literature study while the empirical component will entail that case studies are conducted. In order to collect data a literature study is conducted to contextualise the subject of the study in a theoretical framework.

The significance of a literature study is apparent from the statement made by Mouton (2001): "A comprehensive and well-integrated literature review is essential to any study. It provides you with a good understanding of the issues and debates in the area that you are working in, current theoretical thinking and definitions, as well as previous studies and their results." The content of the literature review will be confirmed or refuted through a comparative analysis between the literature and actual manifestations or case studies of knowledge management in organisations with characteristics which reflect a 4IR organisation. Mouton (2001) confirms the necessity of a literature study but emphasises the importance of supporting the findings of the literature through empirical research: "Although literature reviews often lead to theoretical insights, we still need to undertake an empirical study to test our new insights." The empirical component will consist of descriptive case studies.

Digital knowledge management construct

Fourth Industrial Revolution

Digital transformation is a direct result of the 4IR. The 4IR has emerged circa 2010 and is characterised by the introduction of CPSs in organisations as depicted in Figure 1.

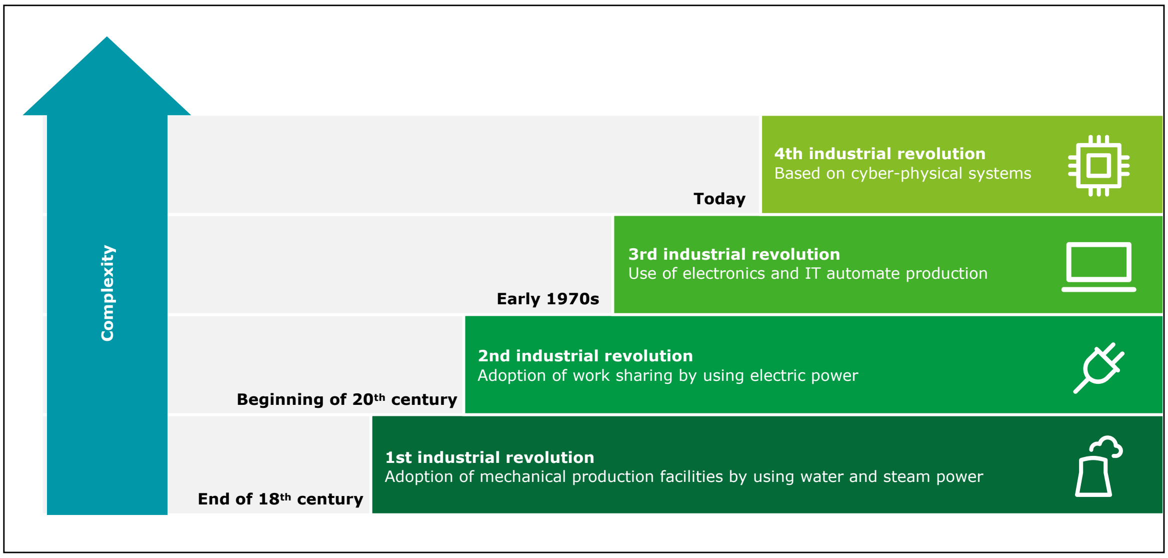

Figure 1: Industrial Revolutions (Van Herreweghe, 2015)

In its most fundamental form, the 4IR is the seamless integration of disparate devices on the cloud. The integration of disparate devices enables the flow of big data that needs to be analysed and contextualised to influence sense and decision-making. Schwab (2016) describes the 4IR by stating that "Characterized by new technologies fusing the physical, digital and biological worlds, the Fourth Industrial Revolution will impact all disciplines, economies and industries – and it will do so at an unprecedented rate." He (Schwab, 2016) continues "Consider the unlimited possibilities of having billions of people connected by mobile devices, giving rise to unprecedented processing power, storage capabilities and knowledge access. Or think about the staggering confluence of emerging technology breakthroughs, covering wide-ranging fields such as artificial intelligence (AI), robotics, the internet of things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing, to name a few." Colombo et al., (2017) concurs and states "Industrial Cyberphysical Systems are expected to empower the transformation of industry and business at large to a digital, adaptive, networked, and knowledge-based industry with significant long-term impact on the economy, society, environment, and citizens. In a more recent contribution Marr (Brar, 2018) explain that the 4IR represents exponential changes to the way we live, work and relate to one another due to the adoption of cyber-physical systems, the Internet of Things and the Internet of Systems. As we implement smart technologies in our factories and workplaces, connected machines will interact, visualise the entire production chain and make decisions autonomously."

Typical technologies that will result from the integration of physical and cyber systems within the 4IR are described by Schwab (2016):

- Implantable technologies in the form of mobile devices are increasingly becoming connected to the bodies of human. Devices are not just being worn, but also being implanted into bodies, serving communications, location and behaviour monitoring, and health functions

- Big data for decisions will allow for the first government to replace its census with big data sources

- Wearable internet and, increasingly, clothing and other equipment (like reading glasses) worn by people will have embedded chips that connect the article and the person wearing it to the internet

- Internet traffic in homes will be directed towards appliances allowing for home automation; enabling people to control lights, shades, ventilation, air conditioning, audio and video

- Tax will be collected for the first time by a government via a blockchain

- Large percentages of global gross domestic product stored on blockchain technology

- 3D printing and human health in the form of the first transplant of a 3D-printed liver

- Designer beings and the deliberate editing of human genomes

A CPS is characterised by the integration of computational and physical components and hence provide for computers to monitor and control physical work processes. Baheti and Gill (2011) defines CPSs as "a new generation of systems with integrated computational and physical capabilities that can interact with humans through many new modalities." Zanni (2015) describes the integration between sensors and actuators in a CPS in the following manner: "CPSs use sensors to connect all distributed intelligence in the environment to gain a deeper knowledge of the environment, which enables a more accurate actuation. In a physical context, actuators act and modify the environment where users live. In a virtual context, CPSs are used to collect data from the virtual activities of users."

The integration between sensed data and actuated commands is depicted in Figure 2.

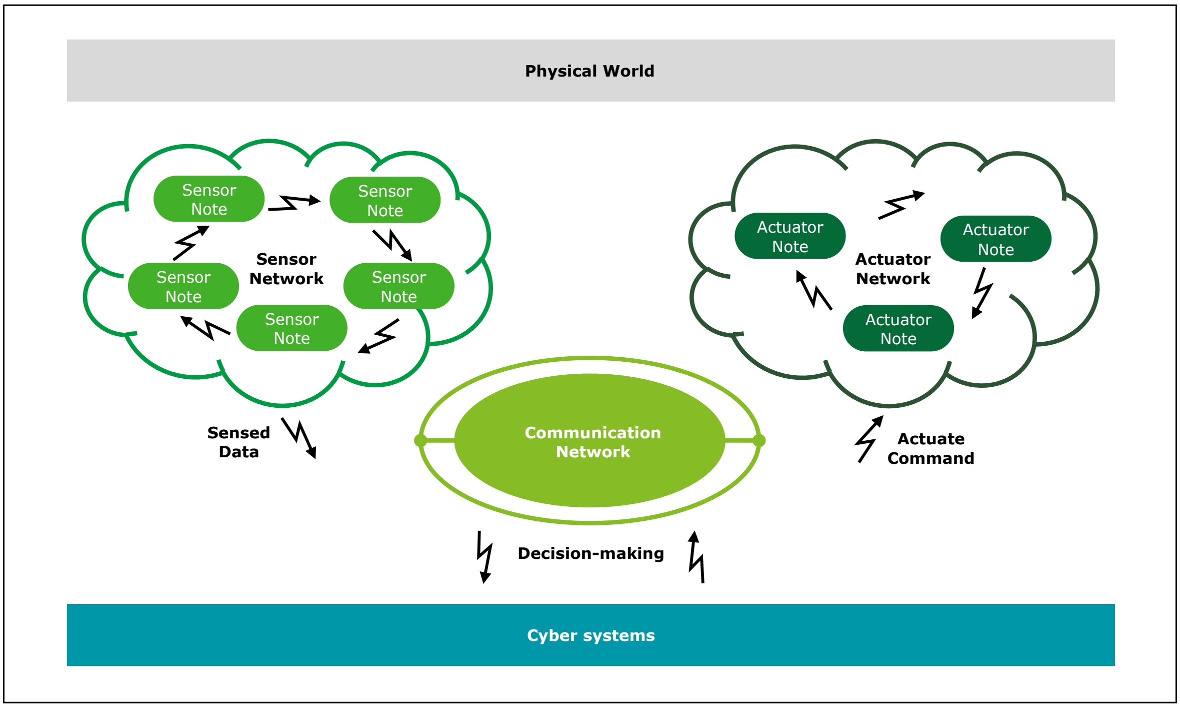

Figure 2: Holistic view of CPS (Gunes et al., 2014)

The ability of CPSs to control and monitor physical processes by means of behavioural sensor-enabled or "smart" technology have created a fundamental shift or a digital transformation in the way that work is conducted in DNEs. CPSs will improve technological and digital productivity but organisations need to revisit and if necessary adjust operational processes to ensure that they continue to create value for customers. Technological and digital productivity can create inefficiencies or waste if not characterised by "simplicity and agility" (Bhalla, Dyrcks & Strack, 2017). Digital technologies will only increase revenue, lower cost and add value to customers if these technologies are integrated in a well-sequenced way with the operating model of the organisation (De Smet, Lackey & Weiss, 2017). Küpper et al. (2017) reports on the necessity of integrating CPSs with lean production principles and indicate that such an approach can reduce costs related to poor quality by 20% and work-in-process inventory by 30%."

Colombo et al., (2017) describes the nature of the industrial environment or ecosystem in the following manner:

- "The workforce is not only interacting with CPSs but also becoming an integral part; i.e., transforming into another CPS that, in turn, interacts over Internet technologies with the industrial cyber-physical system (ICPS) ecosystem.
- Subject matter experts transform into knowledge workers that analyse complex information at the right time in the right place and make decisions.
- Although the subject matter expert continues to be autonomous, via the CPS interaction, his capabilities and effectiveness are increased.
- The workforce now collaborates and offers its services, which can be requested by any other CPS (including other machines).

The aforementioned explicates the highly connected nature of the work environment and the seamless flow of information between the cyber and physical world.

Bhalla, Dyrcks and Strack (2017) state "Advanced analytics, in turn, makes it possible to analyse enormous amounts of unstructured data, improving forecasting and decision-making as never before." Additionally, Shaler-Shwartz and Ben-David (2104) indicate the importance of the "automated detection of meaningful patterns in data to enable machines to "learn". This illustrates that the term "continuous learning" will increasingly also be used to imply continuous learning by machines. Machine learning should also be based on experience and state that "we wish to program computers so that they can "learn" from input available to them. Roughly speaking, learning is the process of converting experience into expertise or knowledge" (Shaler-Shwartz & Ben-David, 2104). However, the availability of big data requires "mechanisms for capturing, cleaning, aggregating, and analysing data" to enable value-adding decision-making in organisations (Bhalla, Dyrcks & Strack, 2017). Nagle, Redman and Sammon (2017) are of the opinion that: "Bad data wastes time, increases costs, weakens decision-making, angers customers, and makes it more difficult to execute any sort of data strategy." The aforementioned emphasises the importance of managing the five characteristics of big data as depicted in Figure 3.

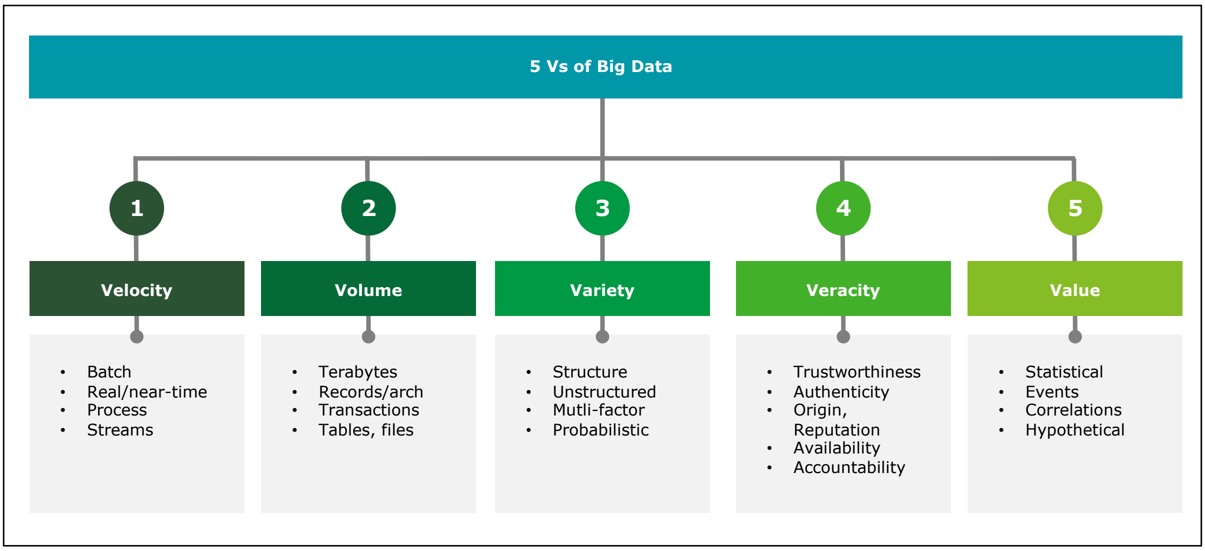

Figure 3: The five characteristics of big data (Ishwarappa & Anuradha, 2015)

The Digital Native Enterprise

The DNE will be fundamentally different from current manifestations of organisations. Essentially, the changes will be visible through pervasive digital transformation driving an increase in technological and digital productivity and an altered state of thinking regarding generating value.

- Technological and digital productivity due to the incorporation of automation, big data and advanced analytics as well as access to information and ideas.

- Shifts in ways of generating business value due to simplicity in [organisational processes and procedures, agility and innovation in an effort to attract and retain clients.

Rosen et al. (2017) describes the impetus for the DNEs by stating that: "Digital transformation has progressed to where it is now an existential concern for many enterprises. Growing organisations strive to become "digital native" in the way they think, what they produce, and how they operate. Yet many organisations have difficulty in imagining what the new digital future could be."

DNE's differentiates itself from other enterprises in the manner in which data is optimised to serve clients in a novel way. The differentiating factor is the way in which data as opposed to knowledge become the primary commodity. The responsibility and requirement is for DNEs to ensure that data displays the necessary characteristics in order for it to be integrated into systems and enable commercial transactions and interactions. Rosen et al. (2017) explains that "a DNE creates and delivers innovation at speed. Clients are at the core of its existence. Employees are its assets. Technology and data are its lifeblood. Ecosystem is its ally."

To this end the design principles of a DNE can be described as:

- Data as the catalyst for processes: Data and the utilisation thereof is core to success. Cognitive and artificial intelligence technologies and information drive improved engagement, new products, optimised operations, and enhanced decision-making (Rosen et al., 2017)

- Consumer engagement and scale are mandatory: Whether your enterprise touches consumers directly or indirectly, competing increasingly requires connecting value to consumers, their homes, and lifestyle (Rosen et al., 2017)

- Ecosystems are as important as knowledge: Maximise leverage through communities – developers, partners, and customers around industry collaborative platforms will determine much of the DNE success." (Bhalla, Dyrcks & Strack, 2017; Rosen et al., 2017).

Rosen et al. (2017) continues by suggesting a model of the five dimensions of DNE effectiveness and identifies the core components that need to be present for sustainability.

> "Digital Native Enterprises differentiate itself from other enterprises in the manner in which data is optimised to serve clients in a novel way."
>
> **Rosen et al.**

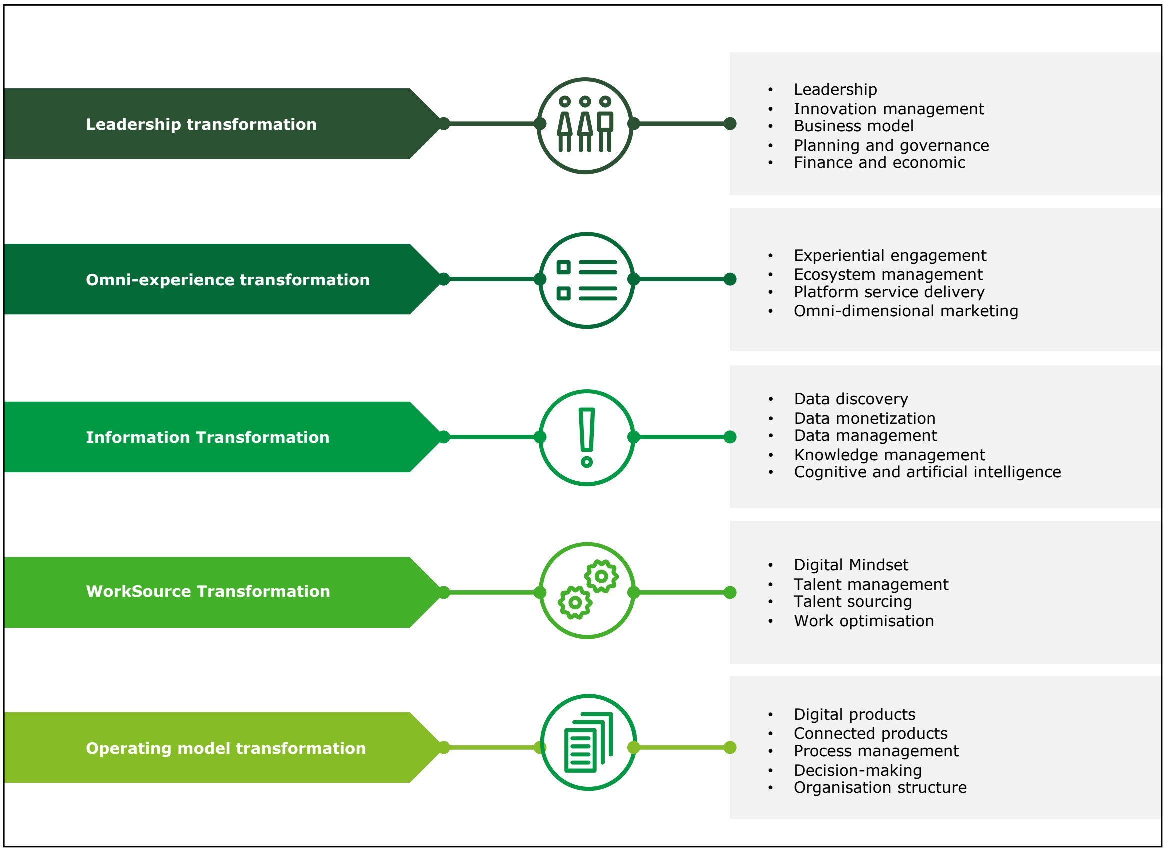

Figure 4: Five dimensions of DNE effectiveness (Rosen et al., 2017)

From the deliberation on the design principles of a DNE is evident that a new state of skilfulness and mindfulness will be required by workers in the 4IR.

Cognitive augmentation and human skills

It is evident that the analysis of big data will enable the automation of repetitive tasks like assembling parts in a factory, and in addition to complex tasks that have traditionally been the domain of humans. Mortensen (2017) indicates that the role of machines is not to replace humans but merely for humans and machines to work alongside humans. Humans are thus enabled to perform tasks that machines cannot learn or automated. This co-existence with machines would necessitate humans to develop or strengthen skills that cannot be transferred to machines by means of machine learning, cognitive computing and eventually artificial intelligence (AI). Essentially, a DNE would be characterised with an ecosystem in which the "knowledge" or big data "fed" to machines will need to be managed while the non-replicable skills of humans would need to be optimised.

The nature of the co-existence between machines and humans has been an ongoing discourse and have given rise to various schools of thought on the juxtaposition between man and machine. Already in 1968, Martin Luther King presented a sermon on "Remaining Awake Through a Great Revolution" and stated: "There can be no gainsaying of the fact that a great revolution is taking place in the world today. In a sense it is a triple revolution, with the impact of automation and cybernation; then there is a revolution in weaponry, with the emergence of atomic and nuclear weapons of warfare;

then there is a human rights revolution, with the freedom explosion that is taking place all over the world. Yes, we do live in a period where changes are taking place." (Ford, 2015). Mortensen (2017) concurs: "the debate between artificial intelligence (machines replace us) versus intelligence augmentation (machines help us) has been raging for decades. One side wants to engineer humans out of the equation, while the other thinks the role of machines is to help people perform better." Clarification is needed on the nature and extent of the "new" roles for humans within Fourth Industrial Revolution organisations."

It is evident that the inherent nature of the various dimensions of the DNE will require new competencies and capabilities of workers. The cognitive ability of workers will be augmented with intelligent and automated systems, processes and procedures.

The World Economic Forum (2016) divides the drivers of change that will necessitate workers to develop and enhance their existing skillsets in order to prepare for and accommodate a new world of work in two categories. These two categories are demographic and socio-economic change. The World Economic Forum (2016) states: "Developments in previously disjointed fields such as artificial intelligence and machine learning, robotics, nanotechnology, 3D printing and genetics and biotechnology are all building on and amplifying one another. Smart systems – homes, factories, farms, grids or entire cities – will help tackle problems ranging from supply chain management to climate change. Concurrent to this technological revolution are a set of broader socio-economic, geopolitical and demographic developments, each interacting in multiple directions and intensifying each another. While these impending changes hold great promise for future prosperity and job creation, many of them also pose major challenges requiring proactive adaptation by corporations, governments, societies and individuals."

The World Economic Forum (2016) describes the nature of changes influencing the manifestation of work in a DNE as follows:

Demographic and socio-economic:

- Changing nature of work environments and flexible working arrangements.
- Rise of the middle class or the so-called economic centre of gravity is shifting towards emerging markets.
- Climate change, natural resource constraints and the transition to a greener economy.
- Rising geopolitical volatility with an impact on global trade and talent mobility.
- New consumer concerns about ethical and privacy issues.
- Longevity and ageing societies and the resultant need for new products, services and business models.
- Young demographics in emerging markets and the resultant need for education and training systems.
- Women's rising aspirations and global economic power.
- Rapid urbanisation with a projected increase of double the current world population between 2010 and 2050 from 2.6 billion to 5.2 billion.
- Technological:
- Mobile internet and cloud technology enabling more efficient delivery of services and opportunities.
- Advances in computing power and big data.
- New energy supplies and technologies
- The Internet of Things
- Crowdsourcing
- The sharing economy and peer-to-peer platforms
- Advanced robotics and autonomous transport

- Artificial intelligence and machine learning.

- Advanced manufacturing and 3D printing.

- Knickrehm (2018) explains that it is "critical for companies to understand the range of opinions on this issue because implicitly or explicitly, they will influence the way business leaders create the workplace of the future."

- Five schools of thought shape discussions and decisions in respect of the future world of work and specifically the debate between the positioning of AI vis-à-vis humans.
- Dystopian view: The dystopian view describes a scenario in which "man and machine will wage a Darwinian struggle that machines will win. AI systems will take on tasks at the heart of middle- and high-skill jobs, while robots will perform menial work that requires low-skill labour." The effect will be considerable levels of unemployment with resultant economic and socio-economic effects."

- Utopian view: Machines will be responsible for work however positive synergy will exist between man and machine. This synergy will enable productivity and lead to economic growth. In this scenario: "Human brains will be "scanned" and "downloaded" to computers and billions of replicated brains will do most of the cognitive work, while robots will do all the heavy lifting."

- Technology optimist view: Technology optimists have embraced intelligent technologies and a "burst of productivity" has begun. AI is perceived as positive since it can create economic growth and improvements in living standards but would require an "investment in education and training alongside investments in technology."

- Productivity sceptic view: AI will not be able to achieve the perceived productivity gains. Together with global challenges such as "aging populations, income inequality, and the costs of dealing with climate change" it will not succeed in make a fundamental difference to economic growth.

- Optimistic realist view: AI can enable productivity that equals previous technology and replicate previous trends where demand rose for both high- and low-skill workers whose jobs could easily be automated, while demand for middle-skill workers fell." (Knickrehm, 2018).

It is therefore evident that the design principles of the DNE and the resultant co-existence between humans and machines necessitate a reconsidered skilfulness.

Mortensen (2017) therefore confirms the view of the World Economic Forum (Gray, 2015) as it relates to the importance of the following skills that will be prominent in a 4IR organisation: complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgement and decision-making, service orientation, negotiation and cognitive flexibility. Mortensen (2017) states: "One implication for all of this is that for humans to succeed in the Artificial Intelligence-powered future, we need to double down on our humanity. Technical skills will no doubt remain important in the future of work, but as AI allows us to automate repetitive tasks across many industries, these will in many cases take a back seat to soft skills. Communication, emotional intelligence, creativity, critical thinking, collaboration, and cognitive flexibility will become the most sought-after abilities. To prepare for that future, we need to emphasize developing higher-order thinking and emotional skills." Furthermore, Mortensen (2017) explains: "One implication for all of this is that for humans to succeed in the Artificial Intelligence-powered future, we need to double down on our humanity. Technical skills will no doubt remain important in the future of work, but as AI allows us to automate repetitive tasks across many industries, these will in many cases take a back seat to soft skills. Communication, emotional intelligence, creativity, critical thinking, collaboration, and cognitive flexibility will become the most sought-after abilities. To prepare for that future, we need to emphasise developing higher-order thinking and emotional skills." Mortensen's views (2017) is largely confirmed by Gustein and Sviokla (2018) when indicating seven core skills that will ensure employability in a DNE.

These skills are:

- Communication: The ability to engage and to deliver a message in a compelling manner.
- Content: The ability to understand a specific topic combined with the ability to be innovative and to provide eminence or thought leadership in the same topic.
- Context: The ability to have a contextual understanding or understand the dynamics of a specific situation or event, interaction or engagement.
- Emotional competence: The ability to:
  - Recognise the emotions at play in the context of analysis and action
  - Successfully intervene in an emotionally complex situation
  - Persuading individuals and groups by evoking emotion
- Teaching: The ability to teach and train others by having a highly contextualised understanding of the environment where skills and knowledge need to be applied.
- Connections: The ability to create strong professional ties and in addition develop a large network of weak ties. Additionally, it is also necessary to develop a network of weak ties in a variety of professional domains.
- Ethics: The ability or capacity for moral judgement. Gustein and Sviokla (2108) describe the value of moral judgement in a DNE and states: "However, the essence of moral judgement is that there is no easy algorithm to maximize "value", so systems that rely on algorithms are inadequate in situations involving judgments."

The seven core skills that will ensure skilfulness in the 4IR are also iterated by Curtin (2018) when stating that employability is enhanced by: "Cognitive flexibility; Negotiation skills; Service orientation; Judgement and decision-making; Emotional intelligence; Coordinating with others; People management; Creativity; Critical thinking; Complex problem-solving.

It is therefore evident that in addition to the ability to master "technical" skills there will be an increased focus in the DNA on capabilities and competencies that surpasses the scientific, technical, engineering and mathematical level.

Knowledge management

DNEs necessitate a repositioning of Knowledge management in an age where humans are seamlessly connected through ubiquitous technologies. What will the role of KM be in organisations and societies where humans will become redundant because of the ability of machines to perform both repetitive but also highly complex work?

Pushpa (2109) deliberates the question "what exactly does organizations do with knowledge" in an effort to develop insights into the manner in which Knowledge management should be repositioned. Pushpa (2109) explains "Organizations perform different kinds of tasks, and their success and competitiveness depends on their maturity in performing critical tasks, as well as where they stand with respect to industry in this. Tasks are performed by employees and machines, who take input information about the task, process the same based on knowledge (know-how and know-why) and complete the task". Pushpa (2019) continues by stating that "in the case of humans, they can process large variation in the input information with respect to a task, even if the input information is not clear, they can remove the noise and if they do not have the relevant knowledge to process the information, they do further study, discuss with others, gain further knowledge and work on the information." It is evident that humans contribute know-what (procedural knowledge), know-why (causal knowledge) as well as highly contextualised and strategic know-how. Venkitachalam and Willmot (2017) explains the importance of strategic know-how when stating that "Knowledge strategies involve the use of different types of know-how linked to the operation of business processes that are orientated towards the improvement of competitiveness. Such know-how includes knowledge of suppliers, customer knowledge, employee knowledge, competitor intelligence, industry knowledge, firm innovation through exploration and exploitation of organisational knowledge capabilities and so on."

Knowledge management is the scientific discipline that aims at managing information (explicit knowledge) and knowledge (tacit knowledge) to ensure a competitive advantage for the organisation. Janus (2016) contributes a further "form" of knowledge when stating that knowledge can also be implicit or experiential. Implicit knowledge is intangible and can be converted to a tangible or explicit form.

Davenport and Prusak (Dalkir, 2005) describes the requirement of organisations in respect of Knowledge management and states: "Increasingly companies will differentiate themselves on the basis of what they know. An organisation that knows how to do things would define a business firm that thrives over the next decade as an organisation that knows how to do new things well and quickly." The proliferation of information and knowledge have placed an additional requirement on Knowledge management in the sense that companies do not only differentiate themselves on "what they know" but also on their ability to effective identify and make knowledge assets available and accessible.

There are various definitions of Knowledge management but in its most fundamental manifestation it is "the deliberate and systematic coordination of an organisation's people, technology, processes, and organisational structure in order to add business value through the reuse of knowledge. Recently, it has become evident that Knowledge management is also an enabler of governance principles and it often facilitates compliancy to management systems and practices. This is achieved through the promotion of creating, sharing, and applying knowledge as well as through the feeding of valuable lessons learned and best practices into corporate memory in order to foster continued organizational learning." (Dalkir, 2005). The American Productivity and Quality Centre (APQC) (2018) adds four more knowledge processes as an extension to Dalkir's (2005) rather limited view of the full knowledge process value chain. End-to-end or the full knowledge processes value chain includes creating, identifying, collecting, sharing, accessing and using or applying knowledge.

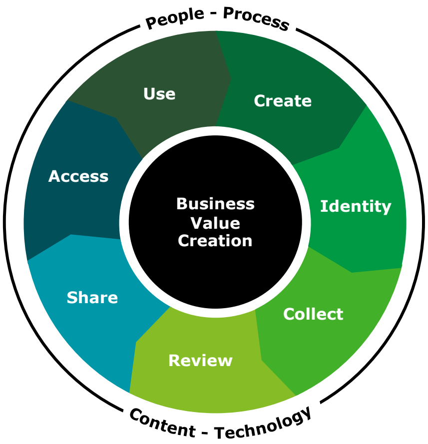

Figure 5: Knowledge processes (APQC, 2018)

Furthermore, Knowledge management is characterised by a people, process and a supporting technology or methodology component.

The APQC (2018) alludes to the necessity of a clearly defined and articulated knowledge management strategy to guide and inform organisational Knowledge management efforts. They state (2018): "Whether an organization is starting a new Knowledge management effort or evaluating an existing program, it is crucial to have a documented Knowledge management strategy. A clearly-articulated strategy provided alignment and credibility to the work of the Knowledge management team, helps secure stakeholder buy-in, and keeps the Knowledge management group focused on business-relevant goals."

Knowledge management strategies are focused on codification and personalisation and it is evident that the organisations that derive the most competitive and sustainable value from Knowledge management are those that have a balanced approach towards codification and personalisation (Hansen, Nohria & Tierney, 1999; Van der Spek, Hofer-Alfeis & Kingma, 2003; Venkitachalam & Willmott, 2017). Codification focuses on codifying and capturing knowledge in the form of information in databases while a personalisation strategy enables communication and person-to-person or person-to-team dialogues as opposed to codifying and capturing knowledge objects in a database. Personalisation ensures that the tacit knowledge (experiences, narratives, stories, heuristics, mental models, values) of employees can be leveraged in teams and between teams and hence make provision for highly contextual knowledge.

The majority of organisational Knowledge management initiatives are biased towards a technological approach and hence support a codification strategy. Organisations should guard against an overemphasis on a technology driven and in some instances a compliancy driven approach towards knowledge management. The quantity and frequency of knowledge management processes should neither dominate nor dictate the quality and value of the same. This implies that a focus on how "much and how often" knowledge is shared should not be more important than the value and practicality of the contextualised knowledge that is shared. Natarajan (2018) explains: "While Knowledge management practises and tools achieved considerable success across industries more specifically in knowledge driven industries such as Consulting, IT, legal, pharma, life sciences, etc. they are mostly focused on codifying explicit knowledge artefacts and providing search and retrieve capabilities to discover the artefacts from the repository."

As "knowledge" in the form of data will be embedded in seamlessly interconnected devices, equipment and machines it is evident that the existing relationship between codification and personalisation knowledge management strategies will need to be reconfigured and aligned with the digital "maturity" of the organisation.

It is generally accepted that in a DNE "knowledge" will be in the form of "big data" that is received by sensors and transmitted to actuators and which can be analysed in a cloud-based CPS. The analyses of big data sets will enable the seamless integration of the products developed and services delivered by organisations and society. All with relatively little intervention from humans and a low dependency on their ability to apply their acquired knowledge and experience to perform knowledge work or physical labour. However, it is noteworthy that although Knowledge management has traditionally focused on managing information and tacit knowledge as organisational resources and excluded the domain of data management. In the DNE the fusion and integration between data, information and knowledge is unmistakable.

Natarajan (2018) states "the key challenge for Fourth Industrial Revolution organizations is to harness the real potential for digital transformation by having an integrated strategy and a holistic approach towards knowledge management, building internal systems and processes to streamline information exchange and data analytics, along with a strong culture of data-driven decision-making."

This is also evident from the five dimension model of a DNE as proposed by Rosen et al. (2017). This model clearly indicates the necessity of including Knowledge management in a DNE but also emphasise the need for a "transformed" manifestation of "knowledge". In a DNE Knowledge management needs to embrace the following:

- Knowledge that is hidden in limitless data that can be unlocked, processed, and eventually embedded in products, services, or systems (Rosen et al., 2017)
- An absence of barriers and boundaries to accelerate the flow, development, and sharing of knowledge." (Rosen et al., 2017)
- Large volumes of structured and unstructured data across organisational value chains
- The inclusion of sensors as the conduit of data as opposed to the human worker as the "owner" of intellectual property in the form of knowledge and information
- The incorporation of an ecosystem of advanced technologies (cognitive search; enhanced discovery and predictive recommendations; chatbots and intelligent assistants) to enable the automation of routine knowledge processing and analysis (APQC, 2018).

Pushpa (2019) confirms the role of Knowledge workers in a DNE when contextualising the benefits and limitations of AI in a DNE. He states that AI will contribute to the ability to identify and make knowledge assets available and accessible hence contributing to the findability of assets. However, AI "cannot leverage existing knowledge: This is another great drawback of AI. AI is data driven and creates insights from data to improve. It is not able to leverage knowledge generated from other sources, bring them together and create a new know-how with respect to the task it is performing." It is therefore evident that Knowledge management will remain relevant in respect of creating an environment in which contextualised and strategic know-how is managed.

Analysing knowledge management in a digital native enterprise

Three settings, which are representative of a typical DNE setting, are included in the research. These settings were specifically chosen to examine the dynamics between the dominant two types (personalisation and codification) of knowledge management strategies. Furthermore, the chosen settings facilitate the identification of "typical" work that needs to be performed in a DNE.

Subsequently, each setting is analysed in terms of the type of knowledge management strategy that it supports, the individuals responsible for knowledge management activities, the dominant knowledge process(es) and technology or methodology that are utilised as well as an indication of the project lifecycle which is supported by the knowledge management activities. The cases were a Smart City (Case A), an intelligent mine (Case B) and a typical AI environment (Case C).

> "the key challenge for Fourth Industrial Revolution organizations is to harness the real potential for digital transformation by having an integrated strategy and a holistic approach towards knowledge management".
>
> **Ganesh Natarajan**

Case A: Smart city

Steinmetz (2018) described the contribution of knowledge management to transform Tel Aviv into a smart city. Smart cities "are smart (thoughtful, people-centric), digital (driven by data acquisition, measured, analysed and sometimes exchanged) and virtual (experiential). And, as a result, they are connected, creating more potential interactions between people and their place." The City of Tel Aviv is using focus groups and unique knowledge management processes to feed municipal data into the DigiTel platform. DigiTel cardholders have access to the DigiTel platform, which is a personalised web, and mobile platform that provides residents with individually tailored, location-specific services delivered via email, text messages and personal resident accounts." According to the Chief Knowledge Officer of Tel Aviv "daily updates inform residents about road closures in their area, registering for school, local events, development or heritage conservation proposals requiring feedback, community greening initiatives, recycling, and invitations to public surveys are contained in the DigiTel platform. Furthermore, it gives residents access to discounted rentals of beach equipment, theatre and movie tickets, car-share rentals, and a variety of other services. The DigiTel platform enables two-way communication between the users of the platform and the municipality of Tel Aviv. Users tell the municipality what is happening in their area. They can give back information about, for example, broken city signage or playground fixtures needing attention. The municipality sees the community members as having "wisdom": they are the most informed about what is happening in their local area."

The case study portrays the importance of contextualised knowledge in a hyper-connected Smart City environment and hence is indicative of the continued relevancy of Knowledge management in a DNE.

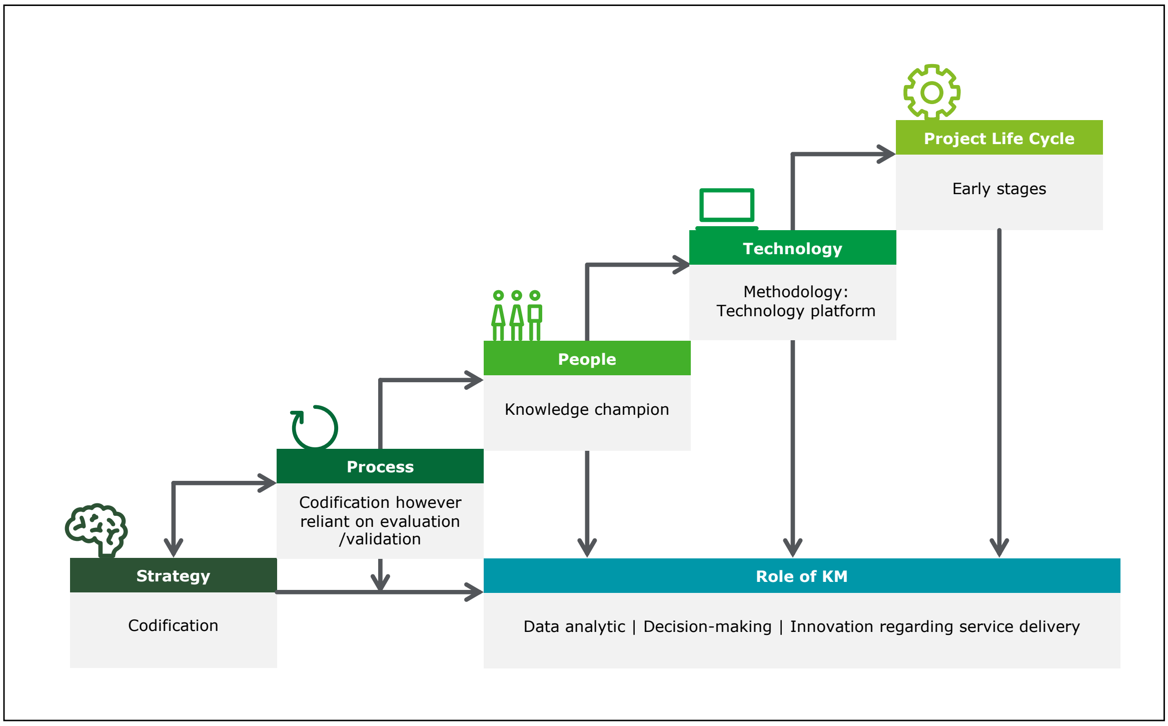

Figure 6: Smart City KM process mapping

Strategy: A codification strategy was followed since information about the municipal services in Tel Aviv is captured in the DigiTel platform. The codification and capturing of data regarding municipal and related services ensures that residents are informed about services, infrastructure and the community in which the city is located. This results in an increase in productivity for residents (Venchitachalam & Willmott, 2016). Knowledge managers and champions are responsible for making data accessible to residents and should eventually also become involved in the analysis of the data to ensure optimisation of services and infrastructure, better decision-making and an increase in revenue for the municipality as improvements in service delivery is related to cost savings. The codification strategy is enhanced with contextualised knowledge and additionally connect people to personalised content.

Process: The knowledge processes of codifying, capturing, organising, sharing and the application of information or explicit knowledge are enabled by the DigiTel platform. However, the sustainability of the DigiTel platform is dependent on the evaluation and validation and hence the personalisation of the information contained in the system.

People: The codification and the capturing of the information is the responsibility of the "knowledge champions". The task of codifying and capturing data could potentially be replaced by sensor-enabled equipment and technology, which would monitor and report on the availability and condition of infrastructure in the municipality. However, it is evident that information contained within the platform makes provision for a level of customisation as it includes content on the manner in which residents perceive and experience municipal services. The ability of the platform to include content, which relates to the perceptions and feelings of the residents are a determining factor in the continued utilisation of the platform as a sensor would not be able to capture and codify and analyse subjective and personal perceptions and feelings.

Technology/Methodology: The codification strategy was enabled by a technology platform.

Project life-cycle: The codification and capturing of the information in the DigiTel Platform activated the smart city initiative as the application and utilisation of the platform was dependent on the codification and capturing of the information in the platform.

Natarajan (2018) explains the manner in which codified and captured knowledge could be further enhanced by adding a layer of artificial intelligence and machine learning to a database such as the DigiTel platform. This would give effect to the need for contextualised or personalised knowledge in a DNE. Natarajan, 2018) explains "Essentially, artificial intelligence/machine learning and KM are two sides of the same coin. An advanced KM platform with a built-in AI engine can bring contextual knowledge and predictive models for a business problem and help practitioners discover effective solutions faster." This statement by Natarajan (2018) confirms Pushpa's (2019) view that AI will contribute to "Knowledge findability and Employee productivity: One of the most popular use cases with AI has been the ability to find relevant content faster. AI can improve searches drastically and give employees the information and the knowledge most relevant to them. This in turn will improve employee productivity and overall productivity."

Case B: Intelligent mine

Data analytics were utilised to improve productivity and the availability of mining equipment at a North American open-pit mine. This resulted in substantial cost savings due to improved productivity and availability of the equipment. Durrant-Whyte et al. (2105) explains: "Historically, the mine had been achieving an average maintenance performance, running a maintenance schedule based on the equipment manufacturers' recommendations and on simple metrics such as mean time between failures. Nevertheless, it was still running into equipment failures that caused shortfalls on production targets and incurred expensive overtime charges from the maintenance teams, while at the same time falling commodity prices were forcing cuts in the mine's operating budget. By applying advanced analytics techniques, the mine was able to transform its maintenance approach through two initiatives, both based on analysis of the large quantities of data. The mine is now working on automatically incorporating inputs generated by advanced analytics into its maintenance processes."

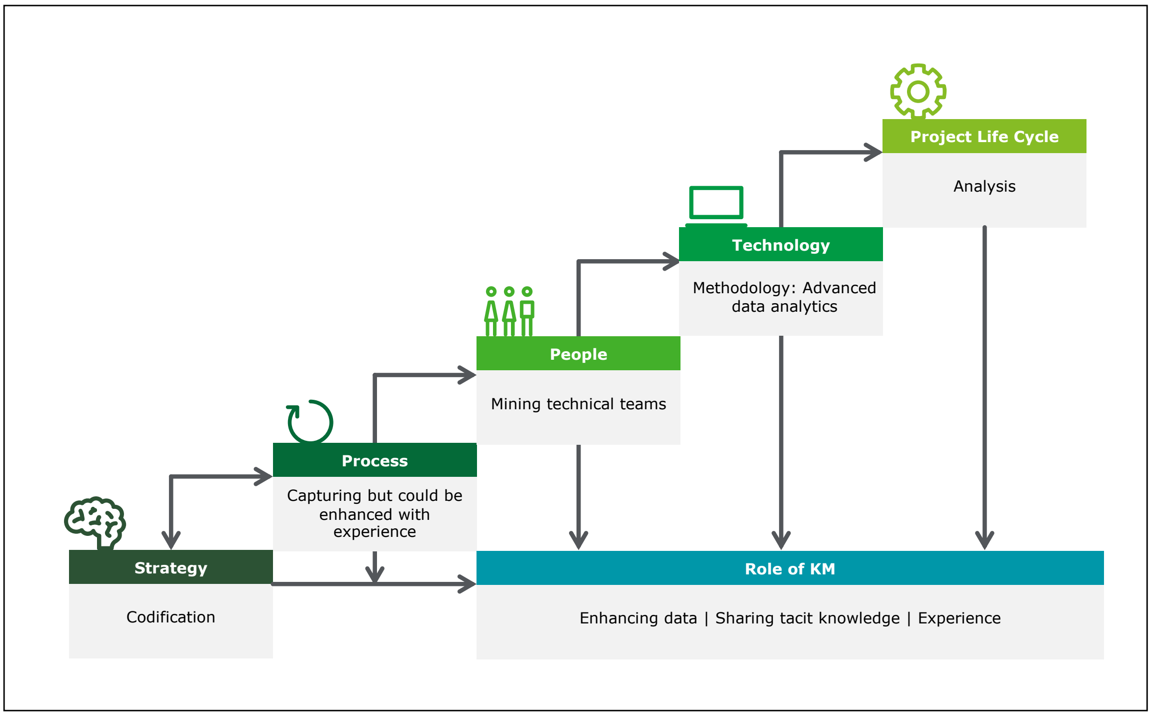

Figure 7 Smart mining KM process

Strategy: A codification strategy was followed since the improvements resulted from the analysis of large quantities of data.

Process: The mine captured large quantities of data within a system. On completion of the aforementioned process, the data was organised to enable advanced analytics and applied or utilised to enable production improvements. The data became information when captured in the system. Although substantial improvements have been made in terms of equipment maintenance and management Klein (1999) indicates that decision-making can be optimised when combining data analytics with the experiences, narratives and mental models of experienced individuals. Information becomes insights when data is codified and captured in a system and analysed. Matzler, Bailom and Mooradian (2007) concur and explain the necessity of incorporating the tacit knowledge of individuals in decision-making and explain that decision-making based on experience is a "highly complex and highly developed form of reasoning that is based on years of experience and learning, and on facts, patterns, concepts, procedures and abstractions stored in one's head." Knowledge transfer and specifically the leveraging of technical knowledge could potentially have made a further contribution to the production improvements and could have enabled even more savings. Trees (2015) states that "augmented cognition – human cognition augmented by computers and smart technology will accelerate as a trend affecting the KM profession over the next three years and will continue to change how people and organizations incorporate technology into the decision-making process."

People: The case study does not report on the involvement of individuals in knowledge management roles in the process of codifying and capturing the data. Embedded sensors transmitted the data.

Technology/Methodology: The codification strategy was enabled by means of the data that are codified and captured in a system and which support advanced data analytics. However, facilitated knowledge sharing and transfer sessions could have supported the analytics of the data and improved decision-making processes relating to the maintenance and management of equipment.

Project life-cycle: The analysis of the data is dependent on the codification and capturing of the same in a system. However, the decision-making process could be enhanced by comparing the results of the analysed data with the tacit knowledge of workers involved in equipment maintenance and management. This would ensure that decision-making is supported by contextualised tacit knowledge.

Rosen et al. (2017) confirms the importance of data as a precursor to decision-making and observes, "knowledge is hidden in limitless data that can be unlocked, processed, and eventually embedded in products, services, or systems. DNE's enterprise intelligence vision leads to a focus on comprehensive awareness, augmentation of the human decision maker, and automation of machine decision making." Pushpa (2019) confirms the view of Rosen et al. (2017) when stating that the DNE will be reliant on data to be successful. However, Pushpa (2019) confirms that the availability of data would need to be enhanced with contextualised knowledge to elevate it to know-how. He (2019) states "AI cannot leverage existing knowledge. This is another great drawback of AI. AI is data driven and creates insights from data to improve. It is not able to leverage knowledge generated from other sources, bring them together and create a new know-how with respect to the task it is performing." Evidently, AI will need to be augmented by humans and hence require an intervention from knowledge managers to ensure that "contextualised" know-how is created.

Case C: Contextualising knowledge

Davies, Fidler and Gorbis (2011) explains the shortcomings of robots and machine learning as observed by IBM's supercomputer known as Deep Blue. Deep Blue defeated chess grandmaster Gary Kasparov and hence it was perceived that Deep Blue has superior thinking skills. Davies, Fidler and Gorbis (2011) explains that "Deep Blue had won with brute number-crunching force (its ability to evaluate millions of possible moves per second), not by applying the kind of human intelligence that helps us to live our lives. A computer may be able to beat a human in a game of chess by sheer force of its computational abilities, but if you ask it whether it wants to play pool, it won't be able to tell whether you are talking about swimming, financial portfolios, or billiards."

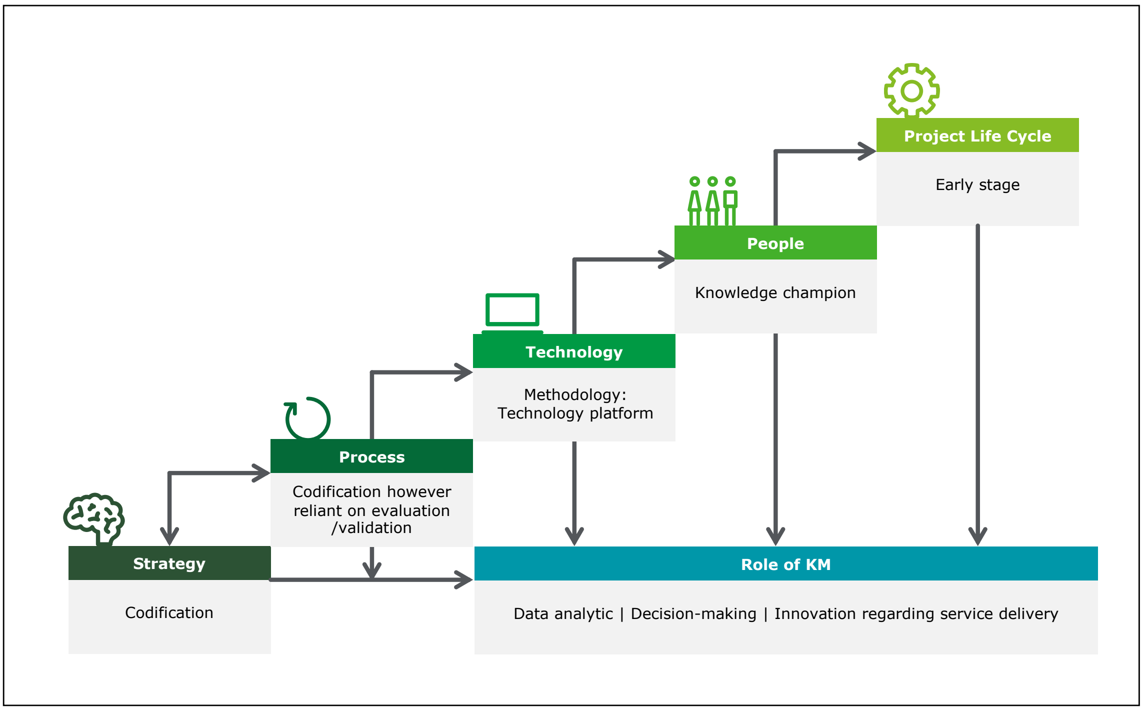

Figure 8: Contextualising knowledge

Strategy: Machine learning is almost completely based on a codification strategy. Data is analysed by means of "brute number-crunching force". There is no evidence of the sharing of contextualised knowledge and hence a personalisation strategy as it relates to knowledge management.

Process: Machine learning is the ability for computers to learn and act without being explicitly programmed. However, in the use case learning is not contextualised and hence Deep Blue would not be able to apply "knowledge" in a different context. The use of machines is therefore limited in terms of sharing or transferring knowledge between projects with different variables. The robot or machine would need to be provided with a certain set of variables within which it would be able to apply learning.

People: There is no evidence of the involvement of knowledge workers in machine learning as it relates to the case study. It is challenging to identify the role of the knowledge worker in a machine-learning environment, as the inability to contextualise knowledge has always been the domain of knowledge management. Hence, the opportunity for knowledge workers to work alongside and collaborate with machines necessitates further research. The aforementioned is confirmed by Adams (2017) when stating that machines can learn, predict and understand natural-language questions and requests without the necessity of facilitated knowledge sharing interventions.

Technology/Methodology: Machine learning is based on mathematical models and algorithms.

Project life cycle: The interaction between knowledge management and machine learning within the context of the project life-cycle needs more research and remains a topic that necessitates further research.

Knowledge remains highly contextualised hence, knowledge managers would need to work alongside individuals responsible for creating mathematical models and algorithms.

The three use cases clearly indicate that the codification and capturing of big data and the subsequent analyses thereof would not necessarily create knowledge in the form of know-how in addition to decision-making. Insights will be created once AI and ML have been added to information codified and captured in systems and contextualised by means of personalisation. These insights enhanced with tacit knowledge will enable effective and informed sense and decision-making.

Solutions and recommendations

It is evident that "knowledge" and the ecosystem in which work is performed will differ radically between traditional organisations and digitally transformed organisations in the form of DNE's. DNEs will be characterised by the limitless influx of data and information as "DNEs have removed barriers and boundaries to accelerate the flow, development, and sharing of knowledge." (Rosen et al., 2017). Hence, the need for just-in-time or highly contextualised and validated knowledge will become increasingly relevant in a DNE. The aforementioned emphasises the importance of personalisation strategies. Personalisation strategies aim at the exchange of insights, opinions, experiences and expertise between users, employers, customers and suppliers. The aforementioned knowledge assets are non-replicable and hence affects the sustainability of the organisation. However, Natarajan (2018) is of the opinion that personalisation strategies should be supplemented with knowledge management systems enabled with cognitive engines that can gather meaningful insights and contextual knowledge. Natarajan (2018) explains: "An advanced Knowledge management platform with a built-in artificial intelligence engine can bring contextual knowledge and predictive models for a business problem can help practitioners discover effective solutions faster."

The altered state of KM in a DNE will require Knowledge workers to have the ability to:

- Assist in contextualising big data into insights in an effort to facilitate effective decision-making
- Identifying and "contracting" sources of knowledge or crowd resourcing
- Localising global knowledge
- Creating central employee-centric knowledge hubs
- Sourcing of relevant data and ensuring that data verified and clean prior to analyses
- Ascertaining the relevancy and the value of capturing and sharing experience
- Social innovation and sustainability of knowledge
- Social networks and empowering the global employee
- Ensuring that devices are connected to the Internet of Things and that knowledge can be created from the connectedness of devices
- Ensuring the safety and privacy of employees

- Ensuring system simplicity and hence limiting complicatedness in knowledge flows

Essentially, KM in a DNE will be characterised by the proliferation of data that will have a radical impact on primarily two knowledge processes (sharing, validation) and has additionally created the need for a further knowledge process (contextualisation).

Future research direction

The findings from the literature review in addition to the analysis of the three use cases clearly indicate the changing landscape of KM in a DNE. However, it is evident that many existing knowledge management capabilities will need to be reviewed and altered to remain aligned with business strategies that are increasingly transformed from a digital perspective.

O'Dell (2018) states "But many Knowledge management programs are still grappling with their role in digital transformation and how to change their processes in light of technological developments." O'Dell (2018) explains there are primarily four drivers that are accelerating the pace of change in Knowledge management. These four drivers are:

- Enterprise digital transformation initiatives
- The rise of robotic process automation
- Mass migration of enterprise systems to the cloud (where software is hosted on a vendor's servers and accessed through the web)
- An increase in affordable technological options for experimentation

In addition to the need for repositioning Knowledge management in an increasingly digital environment it is evident that both codification and personalisation strategies should be recognisable in a DNE. The use cases indicated that data in a digital environment are strategically enhanced by adding a personalisation layer to data "entering" the DNE by means of the CPSs in a highly connected ecosystem Furthermore, Venkitachalam and Willmott (2017) cautions that a biased approach towards codification in a DNE could be detrimental to the innovation capacity of a DNE. This is because codification necessitates the organisation of knowledge assets while personalisation is aimed at the leveraging of highly contextualised knowledge. Venkitachalam and Willmott (2017) explains 'that overemphasised codification efforts can result in 'knowledge structuration' and in this process dilute the purpose, meaning and contextual relevance of knowledge work in such situations. We further suggest that such 'knowledge structuration' (i.e. extreme codification that can be considered as information end') can impede idea generation. Novel insights and radical innovation due to hyper controls and structures in the organisation. This could lead to so many ideas lost/knowledge leakages."

Conclusion

The world of work will change fundamentally within the DNE. CPSs will enable the seamless integration between humans-and-machines, machines-and-machines and machines-and-humans. Increasingly, work that was performed by workers will become the "responsibility" of machines. This does not only relate to manual and repetitive tasks but includes cognition and highly complex tasks. Data analysis will enable decision-making and will result in production improvements and hence also cost savings and increased revenue. Workers will need new skills.

This article deliberates the relevance of knowledge management strategies aimed at codification and position that the same will be replaced by embedding sensors in equipment and related devices and hence the codification and capturing of information in systems will become irrelevant. In DNEs where machines will be seamlessly integrated with almost all operational and business processes, it is becoming evident that humans will have to develop and enhance skills that will enable them to co-exist with machines. Hence, the role of the knowledge worker will increasingly focus on personalisation and on sharing highly contextualised and validated knowledge or insights in an effort to support digital transformation.

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Definitions

Big data: Data sets created by the convergence of various devices, equipment and systems and that are too complex for traditional data processing software.

Codification: A knowledge management strategy aimed at capturing and organizing knowledge in a database.

The integration of the physical and technological environment. This environment is in most cases cloud based and it regulated, controlled and monitored by computer-based algorithms.

Decision-making: The process of identifying the best or preferred course of action.

Digital Native Enterprise: An organisation in which processes, transactions and interactions are largely technology enabled.

Fourth Industrial Revolution: An economy characterised by digital transformation, digital disruption and trends such as the Internet of Things, Virtual reality, machine learning and artificial intelligence.

Knowledge management: The discipline concerned with creating an environment in which both the tacit and explicit knowledge of organisations can be managed. The aim of Knowledge management is to increase productivity and support innovation.

Knowledge management processes: Knowledge management strategies focus on identifying, collecting, sharing, accessing, applying and validating knowledge.

Personalisation: A knowledge management strategy aimed at sharing and leveraging highly contextualised knowledge and insights that can support decision-making.

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