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The Fourth Industrial Revolution: Implications, Opportunities and Risks

Nisaar Mahomed
Trade and Investment KwaZulu-Natal, PO Box 4245, Durban, 4000
Trade & Investment House, 1 Arundel Close, Kingsmead Office Park, Kingsmead Boulevard,
Stalwart Simelane Street, Durban, 4000
nisaar@tikzn.co.za

Abstract: This paper investigates the Fourth Industrial Revolution and in so doing, attempts to unpack the various debates around this current epoch. It is a conceptual paper that illustrates the various facets of the Fourth Industrial Revolution and outlines the new sectors and technologies that it has spawned, and highlights the pitfalls to avoid, particularly since it is being as a panacea for all society’s ills. It nevertheless makes a case for a robust engagement with both the concept of a Fourth Industrial Revolution and its practical implementation.

Keywords: fourth industrial revolution; internet of things; information and communication technology; artificial intelligence; soft skills

1. Introduction

At the 2016 World Economic Forum meeting in Davos, the Fourth Industrial Revolution (4IR) was heralded in rather grandiose terms as the convergence of the physical and digital worlds which represented a “fundamental shift in how we produce, consume and relate to one another” (Davis 2015), and which in the process has produced new trends and sectors such as the Internet of Things, robotics and artificial intelligence, which all have the potential to revolutionise industries in some parts of the globe while destabilising industries elsewhere (James n.d.). It has been argued that this 4IR will result in profound changes to the way society functions, and consequently, it is perhaps appropriate to take stock of what this all means, understand how we can be part of this change, how we can possibly influence it, and more importantly, benefit from it (Schwab 2016).

It is important to note that the world has witnessed these sorts of epochal shifts before. The First Industrial Revolution, which was mainly concentrated in Europe, spanned the 18th and 19th centuries as mass urbanisation took off. During this period, water, steam and coal power was harnessed to mechanise production and to transform factories and mechanised power
replaced animals as a central component of the production process. The Second Industrial Revolution occurred between 1870 and 1914 and was facilitated the rapid deployment of electrical energy. This period was characterised by the arrival of mass assembly lines, (James n.d.) the telephone and radio, which were combined with cheap oil, the widespread use of steel and the development of the internal combustion engine (Rifkin 2016). The Third Industrial Revolution started sometime in the 1960s when electronic and information technology was used to automate production. Often referred to as the digital revolution, its principal signpost was the advent of personal computers and later, the internet, which brought efficiencies that completely transformed the business of manufacturing. Unfortunately, these three industrial revolutions also witnessed global economic upheavals and widespread dislocation of labour markets, often to the detriment of the developing world. In fact, the developing world did not reap many benefits from these revolutions; actually, in many instances, a geographic site for the further expropriation of land, natural resources and labour while the net benefits were being experienced in the developed world. By fusing the technologies that appeared during the digital revolution, the 4IR is regarded as differing quite crucially from the previous ones, particularly since it is powered by innovation that is based on an agglomeration of technologies.

1.1. Innovation and change

The speed of the applications which drive this current epoch have ensured that entire systems of production, management and governance are being transformed while industries are being disrupted. This has also coincided with the emergence of new urgent challenges that are confronting a rapidly globalised world and these include massive population growth on the one hand and resource sustainability on the other. Subsequently, all manufacturers are faced with the need to invest in and leverage available technologies to maximise resource efficiency. This has ensured that tools such as artificial intelligence, robotics and the industrial Internet of Things, have become part of the 4IR's viable long-term growth plan.

The impact of innovation on economic activity hinges on a few factors, principally, its effect on growth and productivity; its longevity, dispersion, and long-term evolution. During the Second Industrial Revolution, these effects were most noticeable, impacting as they did on both productivity and living standards. Electricity became commercially viable around 1880 and combined with the development of the internal combustion engine to revolutionise transport and industry. This has also been dependent on the availability cheap oil, and by replacing animals and humans it increased power, reduced cost and improved efficiency. The internal combustion engine facilitated the creation of automobiles, the instant popularity of which served as a spur to drive the development and expansion of the steel, aluminium and
rubber industries. The ripple effect of this was felt in the supply and distribution of oil, petrol and diesel products as well as in the construction of large-scale road systems which all contributed to substantial employment over successive generations. This also had another more devastating consequence, namely the expansion of colonialism and the subjugation of indigenous populations in far flung corners of the globe, in order to satisfy the raw material needs of these new industries.

Arguably, the 4IR welds together the mechanisation, electrification and computerisation of the earlier epochs into the interconnectedness of everything, from automation and data exchange, to the Internet of Things and the rise of cyber-physical systems. The Internet of Things refers to the hyper connectivity of products and includes sensors, software and wireless connections which communicate with each other while they collect, store and send data. Affordable wireless access allows for the relatively seamless connection of people with devices while supercomputing and Cloud computing allow for the collection and storage of large data sets.

By changing the way industries operate, the 4IR has altered the models on which they are based. Perhaps, the best example of this is the electric power utility. Since their inception in the early 19th century, power utilities have maintained the same business model which consists of power generation, via coal plants, and the sale of electricity to residential and commercial users. However, with revenues of electricity sales plummeting globally, power utilities have been forced to innovate and consequently they are now at the nexus of an evolving technological ecosystem that allows them to offer a variety of new power generating options, which includes renewable energy (Schwieters and Moritz 2017).

The automotive sector is another one that faces enormous challenges. The manufacturers of tools, hardware, instruments and heavy equipment are adding sensors and connectivity to their products to deal more efficiently with maintenance and upgrades of motor vehicles and the impact of 4IR on the auto industry is already quite profound, particularly since 60% of the value of a car is to be found in its digital devices and tools (Blanco 2010). In 2015 when Apple announced its incursion into the automobile market, it inadvertently produced two distinct camps which resulted in their operating system being used by Mercedes-Benz, Nissan, BMW, Chevrolet, Jaguar and Ferrari while the Android system predominated within Audi, Honda, Kia and General Motors. Taken to its logical conclusion, and especially considering the current rise of the interconnectedness of everything, particularly via web-based applications and apps, there is every possibility that the operating systems of smartphones and home appliances will,
in some way, determine future car choices. The disruption of the automobile sector has been such that the future value of cars will reside more in the embedded digital technology than in the metal, thereby reversing a production paradigm that has existed for almost a century.

Although it has been around for a few decades, additive manufacturing or 3D printing has recently come on in leaps and bounds and toy makers have been quick to capitalise on this trend. The four-fold increase in additive manufacturing revenue this past decade has been attributed in part to the $85 billion in revenue from global toy sales, of which an increasingly large amount is due to the emergence of 3D printing (Manyika et al. 2013: 5). Finally, the 4IR allows industries and companies to adopt innovative financing models for large scale projects that have already witnessed a merging of innovative capital infrastructure (Schwieters and Moritz 2017).

The 4IR has wrought irrevocable change and one example of this is that 10 years ago the world’s five largest companies were oil or oil-related, while today, they have been replaced by information-based giants. Furthermore, seven out of 10 of these companies are based on platform business models, thus ensuring that data has become the new global commodity, the ‘new oil’. Not surprisingly, digital businesses such as Uber and AirBnb which have made the biggest strides, primarily due to their ability to remodel traditional transport and accommodation industries with Cloud-based and platform aligned services.

Currently, mobile services generate 6.7% of the Africa’s GDP, totalling around $150 billion in economic value (Dahir 2016). Smartphones have become synonymous with the 4IR and in 2016, they comprised 67% of handset sales in Kenya, and sub-Saharan Africa is predicted to have over half a billion smartphone users by 2020 (Dahir 2016). Africa’s mobile phone penetration has grown from 1% in 2000 to 54% in 2012 and sub-Saharan Africa currently has more than 754 million connections while the continent as a whole has and over 35 mobile network operators (Macharia 2014). In 2012, the number of connected devices (Internet of Things) worldwide reached 8.7 billion. Although only 1% of the world’s devices are currently connected, in 2017, the Internet of Things supported total services spending of $235 billion and it is estimated that by 2020, close onto 25 billion things will be connected (Fortino 2015).

In an interesting slant regarding some of the benefits of this new epoch, a recent report by the World Economic Forum and Accenture showed that close to 60% of the $100 trillion value from the digital stake in the next decade will accrue to society rather than to business.
In India alone, digital solutions will improve access to financial services for underfunded small business and in the process create $410 billion of value to society and 5 million jobs (Nanterme 2017). This fast-paced innovation has other advantages: in 1975 the fastest supercomputer cost $5 million, while today an iPhone 4, which has an equal performance, costs $400. Similarly, with Cloud technology there are numerous possibilities, especially when considering that there are currently 2 billion users of Cloud-based services such as Gmail (Manyika et al. 2013:5).

Some of the technologies associated with the 4IR have shown remarkable growth in a very short space of time. It is predicted that from 2018 to 2024, the global Internet of Things market will have an annual growth rate of 27% with the market is expected to grow to $6.5 trillion in 2024. This is driven in part by the falling cost of smart sensors and the increased demand for automated technologies, which in 2017 saw more than 430 million smart home devices being shipped worldwide (PYMNTS 2018). There is however, another technology which has garnered equally phenomenal headlines of late. Although first conceptualised in the 1950s, the phenomenal rise of artificial intelligence (AI) has coincided with the current stage of industrialisation that is driven by the systemic transformation of technology, information and innovation on a global scale, and at a pace faster than ever before. This is partly due to the exponential increase in computing power, the development of more sophisticated algorithms and the vast availability of data, which in turn has led to changes in consumer demand, behaviour and consumption. A recent PriceWaterhouseCoopers report predicts AI could contribute up to $15.7 trillion to the global economy in 2030, which dwarfs the current output of China and India combined (PWC 2019).

Broadly speaking, artificial intelligence is a collective term for the development of computer systems that are able to perform tasks that requires human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages (Quora). It is based on disciplines such as Computer Science, Biology, Psychology, Linguistics, Mathematics, and Engineering and combines high volumes of data using intelligent and quick algorithms with iterative processing thus allowing itself to self-learn automatically from the characteristics of such data (Harris n.d.).

Deep learning is that part of artificial intelligence which applies large neural networks with multiple stages of processing units to compute complex data and to learn intricate data patterns using enhanced computing techniques. It is normally applied in image and speech recognition and is also used to identify patterns in the increasingly large data sets that are
being generated from sensors and associated applications. Amazon’s Alexa is propelled by deep learning networks which not only recognise requests but also sifts through data to answer questions and undertake actions. Machine learning produces systems that automatically learn and improve from experience. This is done through algorithms which discover patterns and generate insights from data thus enabling a machine to keep improving its performance with minimal human interference. It has shown itself to be especially useful in healthcare diagnostics, particularly in the recognition of illnesses.

Machine learning is increasingly expanding the technology’s applications to smart homes and cities, autonomous vehicles, wearable technology, and the industrial Internet of Things. Technology vendors including Google with TensorFlow Lite, Microsoft, Facebook (Caffe2Go) and Apple (Core ML) are creating software models with the ability to undertake tasks such as image recognition and language translation on portable devices. Not surprisingly, the seven biggest machine learning patent producers in 2017 were IBM, Microsoft, Google, LinkedIn, Facebook, Intel, and Fujitsu (IFIClaims 2020).

The current trend is to use AI enabled technology to automate financial tasks that were previously carried out by humans. The financial industry’s main challenge is sifting through its transaction and customer data in a timely fashion, thus leading to machine learning which is used to devise new business opportunities, deliver customer services and in some cases, detect banking fraud. JP Morgan’s Contract Intelligence (COIN) programme utilises machine learning to reduce the time taken to review loan documents and decrease the number of loan-servicing mistakes. However, there are inherent risks in a system where robo-advisors appear unable to effect the requisite precautionary measures when markets become volatile, particularly when millions of similar machines, operating at great speed, are trying to do the same thing, and perhaps the best example of this happened at Knight Capital Group when robo-stock traders lost $440 million in 45 minutes (Popper 2012).

A recent study revealed that the world currently only has 22 000 AI researchers with PhDs, and essentially the progress of this technology is within just 0.0003% of the world’s population (Kolakowski 2018). The demand for data scientists, robotics engineers and other tech specialists is clearly growing and as adoption of AI gathers pace, the value of skills that can’t be replicated by machines is also increasing. These include creativity, leadership and emotional intelligence.
Artificial intelligence depends on quality broadband and this means that people should be brought online in order to derive its benefits or participate on its platforms. In 2018, the number of broadband connections in Africa crossed the 400 million and this represented almost a twenty-fold increase from 2010. However, despite this, the regional average broadband penetration – including 3G and 4G connections was only 25% in 2018 and the continent’s mobile broadband coverage is still 70% of the population (The World Bank 2019). In Sub-Saharan, mobile internet adoption currently standing at 24% and the region also accounts for 40% of the global population not covered by a mobile broadband network (GSMA 2019). Coupled with the fact that African countries have among the most expensive broadband in the world, it is clear that as the AI race heats up, Africa’s governments have an enormous task ahead merely in trying to keep up with the rest of the world. Although AI has made phenomenal progress in recent years, it still lacks essential characteristics such as emotional behaviour. While current AI systems are trained to perform a human task in a computerised way, their main drawback is that they are trained to only perform one task, and one task alone. A system that can play chess cannot play poker, and unless programmed to do so (by a human) it will not acquire skills to do so. Similarly, the software that drives an autonomous vehicle cannot separate the clothes in a typical laundry basket.

2. Jobs, skills and the changing world of work

In much the same way that previous industrial revolutions altered the world of work and in some cases saw jobs being replaced by machines, so too this one will re(de)fine work, jobs and those skills that currently exist. Technological innovation could, if left unchecked, destroy jobs, and invariably low skilled vocations will be replaced by tasks that require creativity and a greater degree of social intelligence. It has been argued that job losses as a result of the 4IR, will have a disproportionately negative effect on women (Principa 2018). A study of the world’s 15 largest economies has shown that close to 7 million jobs will be lost through redundancy, with large numbers being recorded in white-collar office and administrative roles. However, these will be offset by the estimated creation of 2.1 million jobs mainly in computer, mathematical, architectural and engineering (Lowman 2016).

To get a sense of changing employment patterns across sectors, one need only look at how the various industrial revolutions affected the agricultural sector. During the Second Industrial Revolution, 41% of the US labour force was employed in agriculture. By the time of the Third Industrial Revolution, this figure had dropped to 4% and by the turn of this millennium it stood at 2% (Rotman 2013). It should be noted that in many industries, those skills that are the currently most in demand did not exist in the previous 10 years. In fact,
65% of children that started primary school in 2016 will invariably be employed in positions that do not currently exist (World Economic Forum 2016). The World Economic Forum (2016: 3) reports that "By 2020, more than a third of the desired core skills sets of most occupations will be comprised of skills that are not yet considered crucial to the job today." Interestingly, social skills (such as emotional intelligence) will persevere over narrow technical skills such as programming. As these technologies take hold, industry will undergo rapid change, business models will be disrupted, resulting in a simultaneous impact on skills sets for both current and emerging jobs across various industries. The impact of technological changes means that while robotics and machine learning will not completely replace existing occupations and job categories; there will be some substitution of specific tasks that were previously carried out as part of these jobs.

During previous industrial revolutions, the training systems and labour market institutions that were required to develop the major skills on a large scale were established over decades. However, things are different now; the pace of change is simply too rapid, and both the public and private sector will have to change their approach to education, skills and employment. Those education systems that continue with 20th century practices will find themselves out of kilter with current labour market trends and the demands of business. Table 1 provides some indication of the top 10 skills required to thrive in the 4IR.
Table 1. Top 10 skills.

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<th>2020</th>
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<td>1. Complex problem solving</td>
<td>Complex problem solving</td>
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<tr>
<td>2. Coordinating with others</td>
<td>Critical thinking</td>
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<tr>
<td>3. People management</td>
<td>Creativity</td>
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<tr>
<td>4. Critical thinking</td>
<td>People management</td>
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<tr>
<td>5. Negotiation</td>
<td>Coordinating with others</td>
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<tr>
<td>6. Quality control</td>
<td>Emotional intelligence</td>
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<tr>
<td>7. Service orientation</td>
<td>Judgement and decision making</td>
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<tr>
<td>8. Judgement and decision making</td>
<td>Service orientation</td>
</tr>
<tr>
<td>9. Active listening</td>
<td>Negotiation</td>
</tr>
<tr>
<td>10. Creativity</td>
<td>Cognitive flexibility</td>
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Source: Adapted from Gray (2016)

The future of jobs is not a linear process and will be influenced by different investments in technology adoption, and the skills availability and adaptability of the workforce. The extent of the impact will be determined by the nature of the industry that is affected. There is already evidence that mobile internet and Cloud technology are impacting upon current work and this will be exacerbated once artificial intelligence becomes more pronounced. While there are a few key industries such as robotics, 3D printing, nanotechnology, quantum computing, biotechnology, and genomics that will flourish during this period, the biggest change will undoubtedly be the birth of new areas of work which involves the creation of automated and online processes.

Advances in mobile internet will have a distinct impact in the Aviation, Travel and Tourism and also Financial Services industries, while advancements in connected devices and in Cloud technology, will stimulate growth in the Information and Communication Technologies industry (Nedlac 2019). This new digital economy will increase the need for ‘essential human skills’ commonly referred to as ‘soft skills’ that include creativity, complex problem solving, relationship building, communication, emotional intelligence, and critical thinking. In five years
time, more than a third of the skills that are currently essential for the current workforce will have changed and fast-paced technological innovations means that most workers of the future will share their workplaces with artificial intelligence enabled machines and bots (Marr 2019). According to Marr (2019), another interesting feature is that the half-life of a skill has dropped from 30 years to an average of six years and this has resulted in the creation of new and unexpected jobs, whether social media consulting, space law or data analysis (Bruce-Lockart 2106).

South Africa is one of the most unequal societies in the world with the majority of the country’s poor and economically marginalised (from the formal economy) living in spatially disadvantaged areas, rural areas and townships (Nkala 2019). Each year, 700 000 young people enter the job market and the country would require a growth rate of around 10% to absorb these new entrants into the economy. To make matters worse, it is forecast that with the impending disruption to jobs and skills brought about by the 4IR, 39% of core skills required across occupations in South Africa will be wholly different by 2020. Proficiency in both Science, Technology, Engineering and Mathematics (STEM) subjects but also digital literacy is crucial to ensuring that the country is equipped to deal with the demands of this new period. However, according to information provided by the National Education Infrastructure Management System (NEIMS), many of South Africa’s primary and high schools were still without Internet connectivity and unless this, and the rapid uptake and proficiency in STEM subjects is addressed quickly, the country’s future workforce could fall even further behind (Govender 2019).

It has become quite apparent that adaptive, flexible minds will be the most employable in the future, as they will have the cognitive agility to keep up with the fast-paced shifts in workplace projects (Kupe 2019). It is crucial though to acknowledge that countries must first develop a good set of complementary policies in order to derive maximum benefit from these increasingly pervasive advanced technologies. However, it is equally important to realise “layering these advanced technologies over the existing structural inequality in South Africa will exacerbate existing social, economic and political inequalities” at a time when South Africa can least afford it (Gillwald I 2019).

3. Africa and the Fourth Industrial Revolution

Africa did not really reap too many benefits from the previous three industrial revolutions which, in most instances, served to exacerbate inequality and wealth gaps between the developed and developing world. These were intrinsically Western revolutions and Africa’s
limited access to reliable electricity and connectivity hampered its ability to extract much value from them. As the 4IR begins to make its presence felt, not only will inequality increase between developed and developing countries, but automation will also squeeze unskilled and semi-skilled workers out from the formal workplace. Public policy and regulatory frameworks, especially that which evolved during the Second Industrial Revolution and which governed jobs and social welfare, has proven totally ineffective when dealing with the fast-paced growth of the current epoch, and currently there are very few sustainable solutions to deal with the predicted unemployment that will debilitate large parts of society. Those technologies which currently predominate in the 4IR seem to favour different skills sets which current education systems, particularly in the developing world, appear incapable of providing (Khathu 2019).

Africa’s experience of and interaction with the 4IR will, to a large extent, be dependent on the ability of the technology to adapt to its citizen’s needs, and also the speed and ease with which the continent adapts to this new environment. Most of Africa’s economies are still in the lower to middle income bracket and for these technologies to be widely adopted, they would need to be affordable. Nevertheless, changing global demographics could possibly work in Africa’s favour. By 2050, most of the additional 3.7 billion people on the planet will live in emerging economies, specifically Africa and Asia. Currently, 2 billion out of the earth’s total population of 7 billion are below 25 and 90% of those live in emerging economies and by 2040 Africa’s young population as a share of the global population will increase from 18% today to 28% (Nanterme 2017). A recent study by the McKinsey Global Institute indicated that by 2025 close onto “38% of the annual economic impact of IoT applications will derive from less developed regions” (Manyika et al. 2015).

It is often argued that the future of the 4IR in Africa would converge around mobile telephony, and in recent years, mobile phone penetration in sub-Saharan Africa has increased dramatically. According to the Global System for Mobile Communications (GMSA 2020), there are 747 million SIM connections in sub-Saharan Africa, representing 75% of the population. Another thing in Africa’s favour is the speed with which mobile technology has spread across the continent. While the sporadic rollout of Africa’s land line telephone network may have stymied development, this nevertheless served as a spur for the deployment of mobile phones, whose popularity led to the introduction of mobile money platforms which has brought incalculable benefits to sub-Saharan Africa. This region has more than 50% of the world’s mobile money platforms and has become a world leader in rolling out financial products to large parts of its population which previously had limited
access to the formal economy (Clark 2015). However, the continent’s technology infrastructure still needs some improvement, and the overall general lack of Maths and Science skills will make it that much more difficult for the continent to fully exploit the opportunities offered by this revolution.

4. Problems with 4IR

Before rushing off to embrace the 4IR as a panacea for all society’s ills, it is important to acknowledge that big data requires enormous budgets which very few countries in the developing world can afford. Furthermore, concerns about privacy and security have led to greater use of encryption, which in turn has severely limited the scope of products and business models which rely on capturing and extracting value from data which has proved to be easier to capture than to interpret (Rifkin 2016). Furthermore, there are also unintended, often negative consequences of new technology. The rapid rise of sophisticated cyber-attacks, malware and computer viruses have resulted in huge financial losses and personally or politically humiliating public disclosures. According to Das (2016), while robots designed for healthcare gave garnered much media space they remain restricted in terms of power source, locomotion, manipulation and sensory perception, and this has limited their use for non-routine tasks. A further criticism is that the technologies which determined the various industrial revolutions mentioned in this paper, such as mechanisation, electricity, computers and automation, and cyber-physical systems were all created to achieve specific purposes, mostly, it would seem, to make money. Considering the ways that they have been used there is nothing inherently altruistic about these technologies. Quite often, technology is designed to achieve very specific purposes and they can either be designed to serve the interests of a privileged few or to serve the interests of the poor and marginalised. Within the developing world this distinction becomes even more acute for instance, the technologies associated with so-called smart cities, can, if not properly utilised actually be used to marginalise both the urban poor and those in far flung rural areas. Advocates of the utopian view of the 4IR should be mindful of the fact that it is largely being driven by the same interests that drove socio-economic and political systems over the past 400 years, namely the utilisation of technology to effect market expansion and the reduction of labour costs (Unwin 2019).

5. Conclusion

Overall, the inexorable shift from simple digitisation (Third Industrial Revolution) to innovation based on combinations of technologies (Fourth Industrial Revolution) has forced companies (and countries) to re-examine the way they do business. This has profound implications for society and will alter, almost irrevocably, the way people work and more
importantly, the way people live. It is therefore important to grasp the consequences of this change and to prepare for it as failure to do may render entire industries irrelevant. This is doubly important for a developing country, as being cognisant of these trends ensures that the requisite mechanisms are in place to ensure that the bulk of its citizens benefit from it.

References


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Nanterme, P. 2017. "The real value of the Fourth Industrial Revolution? The benefit to society". World Economic Forum. [Online]. Available at: https://www.weforum.org/agenda/2017/01/the-


Rotman, D. 2013. "Automation is reducing the need for people in many jobs. Are we facing a future of stagnant income and worsening inequality?". MIT Technology Review. [Online].


The Status of South African Maritime Education: securing Africa's Blue Economy Future through introducing the 4th Industrial Revolution Technology and Online Learning in a Post COVID-19 Era

Jack Dyer
University of Tasmania, Inveresk Campus University of Tasmania Locked Bag 1362
LAUNCESTON TAS 7250 Maritime College, 100 Maritime Way, Newnham TAS 7248, Australia
Blue Economy Future SA
Jack.Dyer@utas.edu.au; www.blueeconomyfuture.org.za

Abstract: The African Union Maritime Strategy and South Africa’s Operation Phakisa are prioritising the ‘blue’ / ocean-based economy, as the next investment and development frontier. However, while several reports, manifestos and pilot projects exist, limited attention focuses on ensuring a maritime future via education, training and research. To overcome disruption from increasing automation and digitisation for shipping, logistics and the future of general work, the Fourth Industrial Revolution (4IR) should revitalise maritime education, research and training through IT access; Cloud computing, “Big Data”, simulators, resources and changing students / lecturer / labour sector processes, especially for maritime education and training. The COVID-19 pandemic has created unprecedented demand for remote work and education via online and distance methods, with few existing sectors prepared. In direct response, this paper summarises insights discovered from a speaker at Africa’s first 4IR Summit in Durban 2019, Durban University of Technology, who shared his lecturing experience and advice at a policy level on Establishing Operation Phakisa (Dyer 2017). This paper overcomes Africa’s existing constraints to achieving the blue economy by evaluating existing education in a conceptual Literature Review. It provides a conceptual exploratory framework method through existing desktop studies and surveying 250 students in a South African case study to overcome existing gaps and maritime education / training challenges related to the 4IR. It focuses on the need to transform education, students and the economy to online and digitisation techniques, while expanding it to consider other emerging blue economy sectors in South Africa and beyond; to ensure sufficient supply, overcoming a scarcity of demand. Pragmatic and policy implications include redirecting maritime education to assist stakeholders, minimising disruption costs and ensuring a sustainable blue economy future as a prototype. As COVID-19 has provided unprecedented demand and new funds pledged it remains essential to redirect these resources so maritime education, training and research can future-proof the local economy and people against increasing 4IR global disruption.
Keywords: maritime education and training; blue economy; fourth industrial revolution, maritime industry innovation, ocean economy education

1. Introduction

Global attention, pledges and resources are being increasingly committed to attaining ocean / blue and green economies. Yet, global and local African / South African maritime education fails to equip participants for an ever evolving, maritime economic future and destiny. It remains based on rote learning, failing to capitalise on the Fourth Industrial Revolution (4IR), emergent research areas, risks and opportunities. Research could prioritise amending / drafting related policies, legislation, local textbooks and case studies. Businesses could work with maritime education to overcome scarce skills and constraints to existing employment. Maritime education would further flourish by centring on student and faculty aptitudes, maritime interests and encouraging supervisory-academic and other professional relationships, where current academia fails in being publication / ranking / reputation oriented. Africa differs from other areas as many inhabitants are yet to be as familiar with its ocean’s presence, influence and value for ocean economies.

While maritime education opportunities are being promulgated across South Africa as part of Operation Phakisa, no existing facility exists. Operation Phakisa aims for 1 000 000 maritime-related jobs by 2033 in aquaculture, education, tourism, offshore oil and gas, ports and ocean governance (Zuma 2014). Few stakeholders have considered the need for specialised maritime / general education professionals, research and qualifications to enable these to happen. Across Africa, students, researchers, faculty, administrators, businesses and other vocations are enrolling students abroad at great expense, rather than improving existing institutional capacity for maritime / general education. Few specific courses exist and generally focus on vocational skills / seafaring without considering maritime education implications for all areas outlined in this paper’s proposed curriculum and others (Dyer 2017). These courses focus only on practical outcomes rather than theory, developing students, general life skills or employment in the real world. However, even specialised maritime universities generally fail to evaluate, develop and prioritise maritime education for their own countries, let alone consider needs of the African continent and its future.

Therefore, this paper seeks to specifically investigate Key Research Question I (KRQI): “What is the existing status of African maritime education?” It seeks to address this through reviewing existing sources, factors required and industry characteristics. Subsequently, it also seeks to answer Key Research Question II (KRQII): “How can maritime education be
transferred in Africa and globally, to capitalise on the 4th Industrial Revolution, emergent opportunities and changing stakeholder priorities?"

In response, this paper specifically focuses on the 4IR opportunities through online / distance learning, simulators and other techniques in education as one core area of focus in a Literature Review (Section 2). Section 2 also identifies core challenges / constraints to formalising an African / global maritime education restructured towards the 4IR and blue economies. Both areas focus on establishing existing education demand and supply, 4IR applications, stakeholder requirements and the need for subsequent human, technological and physical capacity building. Section 3 identifies the survey, desktop study and exploratory framework method used. Section 4 focuses on a South African case study to empirically validate this hypothesis, findings and discussions relating to curriculum renewal, changing demand, supply and approaches to education to indirectly relate to the 4IR. Section 5 outlines the results, discussions, and analysis of other maritime education innovations, emergent risks and opportunities including growth into Africa / globally.

Significant chances exist for maritime education to aid existing and future, maritime economic prospects. From the Benguela Current Commission to SA’s Operation Phakisa, Seychelles and Mauritius Blue Economy Road Maps, 2020 African Union Blue Economy Implementation Strategy and African Development Bank Package for Climate Resilient Ocean Economies; governments and port authorities seek to invest in the future of Africa. (Dyer 2013; Zuma 2014). This necessitates investment in scarce skills and maritime education. These illustrate potential to transform local, regional and national economies from a maritime perspective through associated expenditure, improved infrastructure / services; training and related employment, productivity; revenue, trade, investment and other potential benefits. Yet, there are always significant social, environmental, opportunity and other associated development costs. The African Integrated Maritime Strategy identifies eight ocean / blue economy opportunities. These include maritime law, safety and security, fisheries / aquaculture, tourism, leisure, disaster risk management, human resources, trade, security and governance (AU 2012). Each of these exists only under this general framework without examples of specific projects, research, initiatives, finance, education, training and other practical outcomes. It aspires to illuminate the potential contribution, maritime scholarship and economies could make to the future of Africa, its states and individuals.
2. Current literature review: existing state of global and African maritime education

Africans face their own maritime challenges aside from inefficient ports and scarce skills that it is essential to resolve. They have no maritime stock exchange or insurance sector. Africa is characterised by archaic maritime infrastructure, technology and services for most ports, paralysing developments. Many terminals and ports are leased to foreigners. The continent has far too few equipped academics and professionals, few maritime lawyers, few shipyards, no specialised maritime banks and not even local shipping companies and vessels, when compared to other global regions. Despite Liberia having the largest flag of convenience registry in the world, as a maritime power it remains mostly non-existent. Africa’s blue / maritime economy, sovereignty and trade remain conditional on external factors. To resolve this, stakeholders need to resolve all of these through a physical commitment to invest in the opportunities; research, educational training, technology and other resources necessary to make Africa a true Blue Economy Power in this forthcoming age.

According to Dyer (2017), few maritime academics exist; as such, they remain underutilised and there is need to devise textbooks, curriculum, training, research and funding in maritime studies. This paper recommends establishing international networks with those outside the African continent. This will equip potential African graduates to succeed in a world where over 90% of global commerce is seaborne based. The future will be ever increasingly dependent upon the maritime sector for economic development and sustainability, amid uncertain climate change and other surfacing risks. The logistics sector, (primarily maritime) directly contributed 8.2% to South Africa’s 2018 Gross Domestic Product and 5.8% of its national employment. Indirectly, it connects and influences virtually every other economic sector. To invest in its scarce skills will assist sustainable economic growth. If Africa and those abroad were interested in funding profitable, sustainable returns for our continental and individual economies, certain advantages exist. It overcomes an existing scarcity of maritime education providers. At the moment, nations often resort to hiring international consultants from abroad. The cost of these and educating students / academics abroad (whether to another part of Africa or outside) are substantial. Although it is better and more cost-efficacious to support, train and develop local research capabilities, this is actually overlooked.

Although MET institutions in South Africa are not directly mandated or required to consider elements of web, simulation, blended and other forms of electronic learning, this section will identify the extent to which certain institutions have implemented or are considering technology to assist traditional courses. However, limited research is available for most institutions except for Durban University of Technology (DUT); core information about
performance and approaches could not be ascertained or verified. The Maritime, Ports, Transport and Logistics Academy including other short course providers, do not employ online learning management systems, focusing on class videos, PowerPoints, lectures and recommended reading. The UKZN focus on postgraduate studies in Law, Customs, Maritime and Port Economics delivered traditionally with only partial access to Moodle (UKZN 2019).

Various sources have indicated the scarcity of maritime education and training relative to the needs of Operation Phakisa and the local / global maritime economy (SAMSA 2011; CSIR 2017; Dyer 2017). Insufficient training berths, employment opportunities and locally flagged vessels exist requiring even greater pressures on existing institutions to training increasing student numbers, especially seafarers with limited resources with no improvements in 20 years (Bonin and Woods 2002; Bonin et al. 2004). No cabotage incentives exist unlike in many other nations (Dyer 2017). To compensate, more have turned towards embracing online learning, learner management systems and simulators. These could assist will providing even more courses to overcome existing deficiencies / scarce skills. The Transnet Maritime School of Excellence, DUT and CPUT all use virtual reality and simulators in their seafarer, Nautical Science, Marine Engineering and port-related curriculums for areas such as navigation, engineering, naval architecture, seamanship and ship technology. Recognising the increasing digitisation trend of global shipping, computer skills are integrated into first year courses. Nonetheless, 12 months of sea service is still necessary.
Table 1. South African maritime education and training institution stakeholders.

<table>
<thead>
<tr>
<th>Institution</th>
<th>Programme / Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cape Peninsula University of Technology</td>
<td>Marine Engineer / Seafarer</td>
</tr>
<tr>
<td>Durban University of Technology</td>
<td>Degree / Diploma in Nautical Sciences</td>
</tr>
<tr>
<td>False Bay TVET College</td>
<td>Short courses / Vocational</td>
</tr>
<tr>
<td>Maritime, Ports, Transport and Logistics Academy- University of Stellenbosch</td>
<td>Short courses in ports and terminals</td>
</tr>
<tr>
<td>Nelson Mandela Metropolitan University</td>
<td>Degree / Postgraduate Diploma</td>
</tr>
<tr>
<td>South Africa Maritime School and Transport College</td>
<td>Various courses / Diplomas</td>
</tr>
<tr>
<td>STC-SA, SAMTRA, SA Naval College</td>
<td>Various courses and naval officers</td>
</tr>
<tr>
<td>Transnet School of Maritime Excellence</td>
<td>Port related courses</td>
</tr>
<tr>
<td>UKZN, Unit for Maritime Studies</td>
<td>Master of Maritime Law, Master of Commerce Maritime Studies</td>
</tr>
<tr>
<td>Others are minor course providers listed by SAMSA, TETA</td>
<td>Diplomas, Certificates and miscellaneous courses</td>
</tr>
</tbody>
</table>

Source: Dyer (2017)

Technology also serves continuous professional development for shorter courses such as in STC-SA, SAMTRA and the SA Maritime School and Transport College. Examples include pilot, tug and VTS (Vessel Traffic System) training with simulators and professional SAMSA. Transnet’s Maritime School of Excellence incorporates technology into its seafarer deck and engine ratings, tug, pilot, STCW, Master, Skipper and VTS courses among others. It offers 20 classrooms but also reach stacker, crane, VTS, logistics supply chain and trailer suction hopper dredging simulators. These are providing safer and more cost-effective substitutes to actual vessel experience to a partial degree similar to the Dutch who used it to reduce average seagoing time by two months in 2002. Simulators remain expensive although they need specialised skills. In contrast, the South African Navy provides very limited evidence in considering the utilisation of technology at its Gordon Bay Cape Town campus.

In reviewing technology and 4IR prospects, comparatively few African sources have focused specifically on maritime education and training (MET). Ngcobo (2018) in a thesis titled "Response to Technological Advancement in Maritime Education and Training: A Case Study of the South African National Maritime Institutes" focusing on introducing technology to MET, affirms the lack of existing South African maritime and technological
capacity at present. One of DUT's current faculty, Dr Bauk, investigated Cloud-based learning in South Africa and Montenegro via MET Maritime Study departments with 40 students from each (Bauk 2019). Cloud education extends to Moodle, Blackboard, emails, social media and video conferencing options. The students appreciated flexibility, user friendliness, ability to collaborate virtually and accessibility of services. It argues students can become more independent and capable thinkers and fosters further innovation from online discussions. It cautions that cybersecurity remains paramount to ensure data safety and privacy. This identifies how the motivation to favour Cloud or Internet-related education can be conditional upon certain innovation, economic, organisational, usage and technical factors which were reinforced by the study.

This paper differs from existing literature in specifically focusing on applications to other blue economy areas and in arguing how COVID-19 funds could be further motivated and channelled towards online, distance, simulator, Cloud computing and other 4IR learning. It could simultaneously address blue economy needs. Durban University of Technology (DUT) are heavily investing in MET and eLearning, targeted on the Blackboard platform. Its navigation, naval architecture and ECDIS courses depend on simulators. With sufficient investment it could apply to engine rooms, electro-technology and marine environmental / risk awareness courses. Simulator training especially aims to assist females, who have far fewer local and global prospects for securing berths. Since eLearning and simulator-centred training was established, Maritime Studies at DUT recorded significant improvements in progress or performance indicators such as the enrolment rate, pass rate, success rate, graduation rate and department investments. Student numbers increased 69% from 2014 to 2018 (Figure 1). Student success rates increased from 94 to 96% (Figure 2). DUT undergraduate students experienced a significant decrease in dropout rates from 52 to 25%. First year dropout rates decreased from 14% to 4%. Graduation rates increased from 12% to 20% in Figure 3.
Figure 1. 2014 versus 2018 student number growth rates.

Source: Manqele (2018)
Figure 2. Student success rates.

Source: Manqele (2018)

Figure 3. DUT MET student undergraduate dropout rates.

Source: Manqele (2018)
One of the most crucial limitations of South Africa’s existing CSIR Road Map is that it ignores other nations’ and areas’ parallel dedication to pursue, advance and exploit the maritime knowledge sector. It specifically targets maritime research (postgraduate research) not maritime education (undergraduate, high school curriculum, vocational maritime skills); which has yet to receive any guidance from TETA, Department of Education, Operation Phakisa under the Presidency or any core stakeholders supposedly committed to either a blue maritime economy; maritime education and training or the 4IR in South Africa. Others across Africa have similarly neglected this area. This paper recommends the following international examples to those also committed to forming a maritime economy, although few have specifically established a clear maritime research and education vision.

The European Commission in a 2010 report proposed a "Green Paper Marine Knowledge 2020". It recognises industry, public authority, scientists and communities each have different requirements and factors which they can contribute. Its priorities include climate change adaptation, environmental reporting, a unified direct database for fisheries management, a GMES Marine Service and a European Marine Observation and Data Network (EMODNET). Its first priority creates a digital seabed map to improve sustainable resource management, maritime security, risk management and ocean governance. It is improving MET and curriculum design to be more practical. One core constraint it noted for existing research is the fragmentation of data across multiple stakeholders, duplicating resources unnecessarily. Therefore, it is concentrating on connecting all in a coordinated network and database. The report estimated a minimum of €300 million would be saved. The European Commission is also working on private sector agreements, partnerships and incentives to release more of its separately funded/established research data.

This paper on the future of MET under the 4IR and post COVID-19 extends the role of universities to include a revitalised curriculum; greater use to augmented and virtual reality; digitisation; online and distance learning and other factors, improving design, performance, capacity, training and maintenance. It proposes improved materials and analysis tools / software, elevating maritime technology into traditional curricula. Potential exists in consultancies, partnerships, research access, technical knowledge and skill, experience; institutional capacity, teaching, commercialisation, resources and stakeholder requirements. It could consider changes in technological progress, competition, demography, supply, demand, climate and fleets as implications for maritime research. Through investing in these emergent maritime research areas, South Africa through local campuses, African growth expansion, international partnerships, exchanges and competitiveness; can assist various
stakeholders to achieve the UN 17 Sustainable Development Goals (2015-2030). It can further aid the African Integrated Maritime Strategy for 2050. Developing maritime education and research for the African continent and Southern Hemisphere aids others placing hope in blue economy opportunities both in Africa and globally. For example, it could offer choices for the European Union 2020 Strategy aiming to extend beyond its current estimated contribution of nearly €500 billion and 5 400 000 jobs per year (European Commission 2012). The core strategy objectives include aquaculture, coastal tourism, marine biotechnology, ocean energy and seabed mining. None overcome the existing literature gap of how maritime education can specifically be reformed to attain a sustainable blue / green economy future under the 4IR (AU 2012; SAMSA 2013; Ngcobo 2018).

In reviewing the existing status of global and African maritime education, it aims to assist all cooperative stakeholders given time, financial, externality, delay, and other opportunity costs of ignoring the 4IR and blue economy innovation potential. It outweighs potential financing costs and supporting maritime education to enable the quality of skills development not just in South Africa but across the African continent and globally. It is facilitated by alignment to various plans and policy objectives (October 2015; SA Department of Transport 2008 / 2011 / 2015). The right curriculum and maritime education could facilitate the progress of blue / green economy; especially in the transport / maritime sector and promote sustainable opportunities through skills development in a key scarce area. Related courses in maritime education would mirror conventional training but from a maritime context, empowering students, teachers and others to satisfy stakeholder requirements and the needs of policies with skills, theory, knowledge, experience and examples. Yet, it must consider global maritime risks, to ensure generations of resilient, confident, capable individuals, able to contribute and prevail against uncertain risks including climate change and international competition. This aims for a more secure, safe and certain future. It would inspire traditionally land-oriented Africans and international students / partnerships and alliances to value and consider the ocean’s future survival amid mutual prosperity. Courses would concentrate on developing critical thinking, debating and research skills on core maritime related issues, looking at possible solutions, new ideas, novel technology and entrepreneurial proposals constructively, seeing how blue economies can further be enshrined as a reality across forthcoming generations.

2.1. Literature review

To transform blue economies and benefit from the 4IR, educators, students, policymakers and others will face numerous constraints and challenges to establishing African and global,
maritime education. This has been identified in not only desktop studies but also by the sample survey of 250 students as outlined in Table 2. This paper considers significant education, economic, research and training prospects are obvious including Operation Phakisa, the 2017 CSIR Road Map, Benguela Current Commission plan for the blue economy, African Union Blue Economy Strategy and AIMS (AU 2012) and other initiatives. According to Dyer (2013), Durban’s $25 billion port and logistics corridor expansion has no connection to equivalent maritime research and training facilities requiring simultaneous integration, to maximise economic multiplier effects. The Maritime Knowledge Road Map has already identified scarce valuable skills (CSIR 2017).

Table 2. Constraints to developing African maritime education and economies.

<table>
<thead>
<tr>
<th>Land / Geophysical</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>Political</td>
</tr>
<tr>
<td>Communication</td>
<td>Administrative</td>
</tr>
<tr>
<td>Labour</td>
<td>Technical / Technological</td>
</tr>
<tr>
<td>Capital</td>
<td>Lack of coordination</td>
</tr>
<tr>
<td>Financial / Funding</td>
<td>Lack of cooperation</td>
</tr>
<tr>
<td>Commercial: Profits</td>
<td>Education / Training</td>
</tr>
<tr>
<td>Fixed costs</td>
<td>Planning / Zoning</td>
</tr>
<tr>
<td>Variable costs</td>
<td>Transport</td>
</tr>
<tr>
<td>Demand / Supply</td>
<td>Uncertainty of climate change</td>
</tr>
<tr>
<td>Enforcement capacity, legal and policy</td>
<td>Other</td>
</tr>
</tbody>
</table>

Source: Dyer (2017)

Psychological barriers identified in the informal survey of existing students as highlighted in bullet points below inhibit direct action as to whether projected benefits of investing in maritime education exceed certain costs. Other challenges to establishing blue economies include potential uncertainty of domestic and foreign stakeholder reactions. These depend on the extent to which stakeholder requirements can be continuously adequately sustained and quality of education maintained. Additionally, any African maritime company / education experience risks of significant, potential foreign competition and experience. Foreign competitors could always swiftly retaliate as users change direction. Political-economic instability, reputation costs and racial-cultural-other factionalism schisms in Africa’s higher education sector including student riots may discourage those we need the most. Many simply wish to get on with advancing the continent. Other risks include a lack of dedicated / accurate, research and information, business plans and case studies upon which academics, companies and policy stakeholder can learn from to mitigate potential uncertainty. South Africa
Africa’s infrastructure, stakeholders, education capacity, funding sources and policies are obsolete. In addition, they are not currently designed to prioritise developing most recommendations and maritime research ideas in this paper.

3. Psychological factors clarifying stakeholder reluctance to prioritise maritime education

The psychological factors clarifying stakeholder reluctance to prioritise maritime education include the following:

- Access to capital / finance – or awareness of options,
- Asymmetrical information / climate change uncertainty,
- Lack of concern,
- Lack of incentive / legal uncertainty,
- No investment / information criteria,
- Originality-novelty-resilience to chance and change,
- Other priorities – finance, risks, business operations,
- Perceived relevance,
- Risk ambiguity,
- Scepticism,
- Timing,
- Uncertain short run profitability and benefits,
- Uncertainty over cost effective, sustainable adaptation responses, and
- Unknown inaction, maladaptation and opportunity costs.

E-Learning / ODL and digitisation is becoming increasingly more cost effective to provide for institutions. Students may have to sacrifice more time as they adapt to ODL rather than formal campus-directed education (Takalani 2008). With less monitoring and evaluation conducted for ODL, participants still remain concerned about the extent to which provided courses remain at the same level of quality as traditional pedagogical approaches. eLearning cannot substitute for every skill and experience, no matter how sophisticated the technology. High dropout rates continue to plague existing experiences with limited research being conducted to assess these potential deficiencies. Certain content is also less suitable for online learning. Various developing nations also experience a shortage of qualified IT / online educational professionals, occasionally dependent on foreign companies to service software / hardware problems experienced. Systems may fail from too many users simultaneously. Another challenge exists in ensuring access to content when lecturers leave or are fired. They may asset ownership and remove core material or be denied ownership of
intellectual property as disincentives or seek to use the same material when employed at other institutions and face theft charges. Few developing nation studies have empirically confirmed the financial and educational performance improvements of eLearning for students and academics over convention-based education. One Nigerian ODL student experience focused on undergraduate mathematics and the complications of grasping mathematical concepts without face-to-face learning as practical demonstrations (Reju 2016).

Lecturers have found it easier to physically motivate student participation and satisfaction, than virtually. Social experiences are easier to provide and overcome isolation and resultant emotions of fear, anxiety, tension, wrath, depression, apathy and others. Technophobia remains entrenched among some students who prefer physical campus education and may suffer in the transition if they are or feel compelled and pressurised to participate. Face-to-face lecture delivery can convey emotions more effectively. Students can remain far less focused on educational tasks if not self-disciplined. Certain students frequently do not understand web-based instructions. Many find it easier to plagiarise material. A survey of postgraduate black students across UNISA for all courses, indicated that 58% registered for ODL as the course was only provided online and not face-to-face; while 20% only valued eLearning as an incentive (Takalani 2008). Ninety seven percent of the students mentioned technical challenges when utilising eLearning for tasks and accessing material. Eighty three percent of the students indicated they faced minimal communication with their lecturers and delays to respond rather than instant feedback. Sixty six percent indicated they still preferred physical contact for instructions. Only 14% mentioned feeling empowered and confident enough to finish the course without dropping out. However, 98% mentioned how they improved IT skills and 32% improved their capacity to self-learn. The source advised clear training, expectations and course requirements need to be provided, courses need regular updates and communication and face-to-face teaching is still needed. Fiscal incentives would motivate more staff.

A study conducted at three divergent South African universities for 43 workshop participants mentioned issues of legal/copyright access, infrastructure access, the need to form and provide pertinent materials, along with psychological, social and cultural factors (Cox and Trotter 2017). In Ghana, there are reports of challenges related to eLearning which include delayed feedback, plagiarism in assignments and high traffic for certain websites (Arkoful and Abaidoo 2014), along with high congestion and traffic for certain websites. Lecturer decisions to utilise online and open educational resources remain a matter of personal preference rather than a majority decision. Another Ghana case study pointed to
challenges of learning and focusing from friends and family who simply do not understand the
need to focus on studies from home (Kotoua, Ilkan and Kilic 2015). Pursuing online and
distance learning can divert students from other work commitments and students need
computers. The physical costs can be challenging given poor income levels, chronic poverty,
computer and actual illiteracy and unemployment. These challenges are often replicated
across Sub-Saharan Africa presenting difficulties in implementing eLearning and web
learning. Employers also need to provide funding, time support and recognise the merit of
these qualifications and consider how skills and development training can be subsequently
adapted (Kumar 2017). Any course including ODL, needs to consider how to practically attain
its learning outcomes, preparation for the maritime sector along with the cognitive, affective
and psychomotor domain (Nippon Foundation and International Association of Maritime
Universities 2020).

This further challenges new entrants in education and the blue economy. Currently, it is
unknown as to whether stakeholders are interested in this primarily government-initiated
proposal. Yet their consultation and involvement are pivotal if it is to be efficacious. While
global seaborne trade has outgrown GDP growth; on average 4-5% since 1990; another
potential financial crisis could occur. This raises the question of whether sufficient volumes of
coastal trade justify significant resources devoted to establishing, coordinating, retaining and
ensuring a maritime education policy. This paper identifies perhaps the most significant
challenge is reputational. Given Africa’s past and its developmental challenges; it is expected
to fail. Supply chain stakeholders, academics, governments and investors internationally are
highly likely to remain sceptical towards attempts at asserting maritime economic, educational,
political, legal, environmental, safety and military sovereignty, aside from seeking to protect
their own historic interests. Participants will need to consider whether any potential risks can
be managed and resolved, primarily targeting our own continent through the following factors
needed for maritime education not relying on outside.

3.1. Method and factors needed for maritime education and training

For maritime education to be successful, this paper contacted a sample size of 250 related
stakeholders of students in MET. These were drawn from a sample study of 150 DUT
students, 50 South African Maritime School/Transport College and 50 UKZN students as an
informal basis sample to supplement the desktop and exploratory framework study. Table 3
outlines the identified requirements via qualitative content analysis. Table 4 identifies the
optimal curriculum needed to establish all aspects of the maritime sector and blue economy
sector. Section 5 will identify existing South African capacity to undertake these subjects.
### Table 3. Aggregated maritime education stakeholder requirements.

<table>
<thead>
<tr>
<th>Expectations of a maritime education provider</th>
<th>Commercial / Community expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>To consistently update information.</td>
<td>Availability / Reliability.</td>
</tr>
<tr>
<td>To provide sufficient information.</td>
<td>Swift services / effective infrastructure.</td>
</tr>
<tr>
<td>Cost competitive.</td>
<td>Direct transport / Service connections exist.</td>
</tr>
<tr>
<td>Productive / Efficient – swift and accurate processing.</td>
<td>Functions are modernised as much as possible.</td>
</tr>
<tr>
<td>Reliable / Frequent functions of sufficient quality.</td>
<td>Productive, trained labour responsive to needs.</td>
</tr>
<tr>
<td>Sufficient quantity of functions exists.</td>
<td>Commercially profitable.</td>
</tr>
<tr>
<td>It satisfies marginal caller requirements.</td>
<td>Equitable in satisfying the user pays principle.</td>
</tr>
<tr>
<td>It avoids delays / strikes.</td>
<td>Minimises negative externality / congestion costs.</td>
</tr>
</tbody>
</table>

Source: Dyer (2017)
Table 4. Overview of the ideal maritime university curriculum for Operation Phakisa.

<table>
<thead>
<tr>
<th>Antartic Science</th>
<th>Maritime Health#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquaculture, Fisheries</td>
<td>Maritime History</td>
</tr>
<tr>
<td>Aquatic Security, Conservation and Engineering</td>
<td>Maritime Law and Diplomacy, Admiralty Law, Customs, Carriage of Goods by Sea, Charterparties, Environment</td>
</tr>
<tr>
<td>Astronomy and Space / Space Economy</td>
<td>Maritime Law Enforcement / Coastguard#</td>
</tr>
<tr>
<td>Cabotage / Registration</td>
<td>Maritime Security#, Cybersecurity, IT</td>
</tr>
<tr>
<td>Climate, Climate Change</td>
<td>Maritime Philosophies#</td>
</tr>
<tr>
<td>Cruise, Marine# and Ecotourism</td>
<td>Maritime Psychology#</td>
</tr>
<tr>
<td>Human Factors – Skills etc</td>
<td>Maritime Technology#</td>
</tr>
<tr>
<td>International Trade, Logistics, Business and Administration – (Maritime Business#)</td>
<td>Naval Architecture, Shipbuilding, Salvaging and Ship Repair</td>
</tr>
<tr>
<td>Maritime Archaeology</td>
<td>Navy / Merchant Navy</td>
</tr>
<tr>
<td>Maritime Art#, Cuisine#, Culture#, Vocational#</td>
<td>Oceanography, Ocean Physics, Ocean Chemistry</td>
</tr>
<tr>
<td>Maritime Communications#</td>
<td>Ocean Literacy, Popular Enlightenment#</td>
</tr>
<tr>
<td>Maritime / Port Economics / Port Pricing#</td>
<td>Uncertainty and Maritime Futures#</td>
</tr>
<tr>
<td>Maritime Education#</td>
<td>Seafaring, Pilots, Tugboat Operators, Navigation</td>
</tr>
<tr>
<td>Maritime Finance</td>
<td>Surveying and Hydrography</td>
</tr>
<tr>
<td>Maritime Geography</td>
<td>Underwater photography and diving</td>
</tr>
<tr>
<td>Maritime Hazards, Risks and Failures#</td>
<td>Watersports, Maritime Sports Research / Training#</td>
</tr>
<tr>
<td>4th Industrial Revolution and Technology</td>
<td>Yachting / Recreational Boating</td>
</tr>
</tbody>
</table>

# Emergent research areas several authors developed neither taught in Africa nor professionally / thoroughly established abroad proposed by this research.

Source: (Dyer 2017)

Maritime scholarship equally requires extension of traditional research and vocational institutions into more research-intensive facilities. These need to focus on enhancing graduates’ vocational prospects and employability skills into commercialisation as per the South African case study. Research becomes more pragmatic in seeking to minimise risks and facilitate opportunities. This paper argues if blue economy / education
strategies are to become more than convenient spun rhetoric to win voters and investment; its stakeholders must actively seek to master uncertainty. They need to consider all risk types, scenarios and implications as maritime futures. Every blue economy sector, every research and training category and participant needs to improve awareness and speculate over risks. Shore-minded beings can out-survive and out-prosper only by ruminating on these risks and futures and by anticipating our competitors’ actions, inactions and reactions. South Africa and Africa’s maritime choices need to take into cognisance the consequences of every action. The following factors are likely to influence risk and uncertainty regardless of any plausible scenario including those linked to the 4IR:

- Automation / Robotics versus human-centred employment / age,
- Climate change, environment,
- Economic (demand versus supply / resources available / funding / human capital),
- Political / social stability, strikes,
- Implications of space,
- Changing migration,
- Increasing / ageing global population / changing demographics,
- Investment and business cycles, and
- Religious fundamentalism, uncertain rates of changing technology / research.

Africa cannot afford inaction, maladaptation and opportunity cost. Prioritising ecological sustainability and climate change ensures Africa has that chance. This paper contends this reality can exist through understanding these maritime futures, learning from past success, failures and efforts. Other nations mention a ‘blue / ocean / marine’ economy and education future but do not provide concrete detail about the end they seek and how to pragmatically attain it. They also do not mention the risks and uncertainty involved – and how to surpass them. Global maritime education is essentially static for most institutions, oblivious to the realities of the world, the changing nature of stakeholder requirements and expectations. It fails to provide concrete directions to propel future maritime research. No evidence indicates risk and uncertainty are been factored in. It does not focus on the major problems and issues. In contrast, South Africa has a credible alternative despite present political, civic and economic turmoil (CSIR 2016). This paper already identifies how stakeholders can further counter maritime sector uncertainty through credibly channelling education, research, resources, training, ideas, funding and experience. Maritime risk and uncertainty along with climate change, needs to be effectively mainstreamed into public, private, community and individual sector decision making / policy.
4. Results / Findings

Existing institutional capacity remains limited for the local maritime knowledge economy. The existing road map and other MET research have not investigated the actual numbers of undergraduate, postgraduate, courses, staff places and research output available. Figure 5 and Figure 6 outline the comparatively few maritime research areas and limited numbers of students in which institutions can provide training for South Africans. There is limited capacity to capture the demand for a local maritime economy before investing and supporting other African and foreign students. Therefore, maritime education’s expansion is imperative to sufficiently satisfy the local demand, supply, research, economy and stakeholder requirements. This will provide the experience, funding, networking, human and other resources necessary to create and expand alternative campuses outside its borders. As evidenced by Figure 7; South Africa is missing out as the foremost provider of African maritime education, research, consultancy services, training, capital and economic opportunities. Growth into Africa has not even been identified as an eventual let alone, intermediate research or policy objective for Operation Phakisa, its maritime economy and research roadmap strategy.

Of all African nations, South Africa has the greatest capacity to contribute towards the existing African demand prospects for maritime education and these other services. Figure 7 identifies a maximum annual total 3 429 students demanding and actually receiving a place. Institutions can provide for 1 935 at most including local students. Yet, South Africa’s target is 1 000 000 jobs by 2033 (Zuma 2014). Four hundred and three African students managed to secure a place at the World Maritime University in Sweden. These figures exclude those at other maritime related universities, colleges and courses globally. These figures specifically exclude demand generated by Africans who lacked the resources, capacity and qualifications / experience to go abroad. This ignores the demand of prospective African students lacking the marketed career awareness of South Africa’s maritime education / economy prospects offered. In 2014, 23 South African postgraduate students funded by TETA (Transport and Training Education Authority) graduated. Each Master’s degree cost $28 800 in fees per year excluding $35 000 living costs. Each PhD cost $34 600. The University of Tasmania is now targeting Africans with specific marketing strategies. Although this author was fortunate to receive a tuition waivered scholarship, Australia still benefitted from partial costs subsidised from the South African state. A PhD costs $100 000 for those who have to pay.
Figure 5. Existing South African supply prospects for Operation Phakisa Part I.

Significant commercial opportunities exist if South Africa were to invest in maritime education and training abroad and expanding local capacity and facilities for African students / researchers. Even charging lower or similar prices would have dual benefits. First, it would be aiding the local economy and graduates to seek employment. It would benefit from African ideas, contributions and experience. Secondly, it diverts exorbitant capital outflows away from affluent, foreign maritime universities and training providers. The first priority would be to work with local governments / corporations / individuals to establish formal education alliances and partnerships. They could offer scholarships, legal, fiscal and other incentives.
Stakeholder implications could expand existing places and opportunities in phases. Given scarce staff and other resources we could expand more distance / online and virtual courses, minimising the need / time for physical presences. This paper then proposes investigating existing African market conditions through surveys and other techniques. Strategic marketing could then assess the demand and other requirements to establish offshoot
campuses / branches of existing South African institutions, seeking professional SAQA, regional African and international registration / accreditation. Eventually if these flourish, entirely new devoted maritime education centres, consultancy, pilot projects and other economic investments could be formed especially in key African economies, education markets and port developments such as Senegal, the Ivory Coast, Mozambique / Tanzania, Morocco and Algeria. Even landlocked countries might be interested in improving customs, dry ports, logistics, law and other expertise.

Current maritime education institutions in South Africa / Africa remain qualification not innovation and research-oriented. Student capacity for maritime education was tested with an initial sample size of 250 students during a three-month semester at the Durban University of Technology Maritime Department as a lecturer. This used a stratified sampling strategy over 1-3 years. Students were tasked to identify their requirements; existing constraints to education and were subject to practical experience and insight over eLearning via Blackboard, the 4IR and various blue economy sector opportunities. Students had previously received an overview of blue economy definitions, risks and opportunities, basic advice in business plan formation, marketing, communication, presentation and employability skills. They indirectly contributed to many of the perspectives and experiences. Delayed feedback, poor student-lecturer interaction and contact times were regarded as barriers incompatible with total success. Systems needed to be more user responsive, interactive and context specific. They valued the flexibility; time advantages; ease of communication and value of diverse learning approaches attempted from online assignments to podcasts; simulators, remote cloud computing and identification of the employability skills / vocational guidance necessary to support them in the transition to the 4IR. This was reinforced by this author participating in the first Africa 4IR Summit in Durban 2019, invited as a guest speaker by the Moses Kotane Institute, on which this paper is based.

An era of Operation Phakisa and African maritime sovereignty accepting greater digitisation and the future of work in a post COVID-19 and 4IR era will only dawn when graduates are able to participate and be globally competitive as employees, creators or employers. Students therefore need maritime education that develops their employability skills and vocational guidance. This paper focuses on these as the epicentre of a maritime centred curriculum, coordinating centre and campuses. It proposes means to improve these areas. Africa’s graduates need greater maritime vocational guidance and awareness. Aside from centralised, digital student recruitment, publicity, qualifications, general information, careers advice and funding systems; it needs all supporters from industry to teachers to the media and private
sector to promote it. Existing and future stakeholders from alumni networks to professional associations, faculty and visitors could all be encouraged to inspire others. Those in a township, a thousand kilometres from the coastline may never even think, let alone dream of such a path, unless they are conscious of it. The purpose of the course: Ocean Popular Understanding aimed to re-orientate people to believing in the ocean economy as their vocation and future.

Findings from surveying 250 students showed essential employability skills for future blue economy graduates include proactive risk management. It is never too early to start preparing for the future, to developing the skills, experience, qualifications and connections required. While most institutions leave this to student initiative, they really could benefit from some orientation. Students should be encouraged to develop their autonomy, flexibility, persistence, effort and self-motivation. They should be prompted to research their prospective employer and career. They should be enlightened over funding sources covering multiple career options across a maritime value chain. Other skills include mastering time management, productive usage of meetings, basic organisation, teamwork, report writing, IT and communication skills, multi-tasking and self-discipline. Rarely taught skills include the abilities to intensely focus, to blot out distractions, to survive adverse feedback, counter stress / pressure, bureaucracy; conflict, fatigue, boredom and neurotic colleagues. Learning how to publish, present, network, remain creative and motivated is also essential. Being able to listen, write, read and speak convincingly can avoid the above issues to a high extent, with issues over miscommunication and misunderstanding. It is important to emphasise what you can personally contribute with sincere conviction, where possible.

Learning how to become more flexible yet preserving personal physical, emotional, mental, spiritual and psychological health is vital to remain even fractionally productive and recognise limits, identify that which works and can work. It is important to focus on the solution or outcome not the problem. It is also crucial to be wary of what you reveal about yourself. Consider how factors might be used against you or for you. Research potential competitors if possible, of the company/employer and how you can propose suggestions to brighten its future. Consider consequences of actions over various scenarios. What are the alternatives or opportunity costs if it fails? None of the skills required are once off events. Other survey findings confirmed for Africa’s maritime education and economy to flourish its graduates increasingly need to consider which skills and traits are necessary to remain, which will become obsolete and which will change continuously. Also consider how labour markets will change with automation, technology and other possible risk, distinguish the graduate who
determines their vocation from those for whom it is decided or are not invited to take part. This paper also proposes that these skills should be taught across Africa. It also proposes African online and physical labour exchanges, employment services, qualifications, competitions, websites, employee-employer-researcher-student networks and events should be formed across the ocean economy.

Lectures and seminars provide valuable presentation experience for the speaker; the chance to gain constructive feedback and modify affairs appropriately. It might also provide the chance to gain recruitment, networking, funding, events or research awareness and other opportunities. More significantly, it allows research to matter in reality! It empowers it to have greater impetus than confined to an obscure journal, dusty shelf or remote Internet search, consulted and cited by (at most) a handful of truly dedicated academics. It publicises research to those who might be able to gain from it. This helps others who might otherwise be totally clueless about it, despite the gargantuan potential. Presenting openly allows the chance for debates and further development. It may lead to influencing the public, media, business, government policy, research or any manner of unexpected outcome. Given the exceedingly low probability that even quite illustrious academics can face in publishing, it can really advance knowledge.

Local case studies and experience can be assigned and recorded as research projects and exams / tests. Anything of direct, local interest could assist far more than dependency upon foreign material. Past tests and exam papers could also be electronically provided for practice. The future of lectures and seminars could endorse digital innovation far more. It allows for greater virtual / electronic presences via Skype and other means; the entire process could be online. Greater use of holograms and 3D models could complement this or aid the speaker in presentation. More interactive audience participation with effects, displays and a backdrop could be considered. These techniques could allow for greater flexibility and even economise from a logistics perspective. The implications are that even the most distinguished foreign academics or CEOs could participate in lectures to African maritime institutions and stakeholders.

Official lectures could be established, depending on sponsorship and resources available on specific maritime topics / research areas, for example, ‘Maritime Risks’ or ‘The Future of Maritime Education and Training’, ‘The Future of Maritime Research’, ‘The Future of Ports, Shipping and Supply Chains’, ‘Opportunities,’ or ‘Employability Skills and Vocational Guidance’. Hosting seminars and lectures is advised not just for introducing innovation in
research but also to persuade and motivate others when proposing a new project, funding application, facility, course or qualification. Lectures and seminars offer a chance to support awareness of blue economies. Policy and stakeholder implications of these findings can create or renew greater support, passion, interest and commitment to investing in maritime education and economy future for Africa. It creates the chance for academia to transform into reality, with tangible evidence of assisting stakeholders. It can provide maximum publicity and public relations if skillfully executed. It empowers it to mean something more personal to the engaged, connected audience.

5. Discussions: expanding into Africa and managerial / stakeholder policy implications

With 54 countries (15 of which, are landlocked), 1 billion inhabitants and 315 official ports, Africa has proclaimed its intentions to invest in a forthcoming maritime economic dawn (Figure 8). The African Union have ratified its Integrated Maritime Strategy. However, only South Africa, Egypt and Ghana offer devoted maritime universities. Nigeria and Kenya offer limited maritime training courses. However, port expansion projects are expanding from Dakar to Mombasa, Dar es Salaam, Port Victoria and Port Louis. The institutional capacity however, relies on foreign consultants with a limited maritime industry or knowledge economy. When it moves beyond rhetoric, only South Africa has actually invested in a clear manifesto with formal resources, access to capital, devoted researchers, strategies, field projects, legislation policies, a specific research road map, student career awareness and recruitment drives. This section therefore briefly identifies the future of maritime education once the ideas implemented in this report and the road map are progressing. If it wishes to target 1 000 000 jobs, prosper and utilise a growing surfeit of maritime education capacity, it can pursue growth into Africa.

Internationally, global demand exists in this evolving market. International Chamber of Shipping estimates a global shortage of 16 500 marine officers (supply of 774 000) and surplus of 102 500 seafarers (supply of 873 600). However, these figures completely ignore the requirements if Africa were to enhance our merchant, naval, law enforcement, fishing, research and other cabotage registered fleets. By 2030, demand prospects are forecast to improve based on 3-4% average, annual seaborne trade growth (1990-2015) (UNCTAD 2015) to a shortage of 147 000 officers internationally, given blue economy growth opportunities if sustainable. South Africa’s Society of Master Mariners identifies each oil rig could recruit over 100 crew. It identifies a reasonable turnover rate for Transnet, Unicorn Shipping, Sea Harvest and I&J. Other maritime education opportunities in Africa include assisting Nigeria with its recent cabotage initiatives, training its seafarers, engineers and shipyards.
In 2014, the Association of African Universities President specifically challenged African universities to promote maritime training and education to capture ocean value creation: "Today, our water bodies are facing challenges ranging from human wickedness through piracy, and other unexplainable phenomena such as climate change, for which we need a well-trained work-force to help us unravel. We need to ensure a safe and secured maritime and riverine environment, managed by well-trained maritime professionals" (Ruppel and Bian 2016). The willingness of international shipping companies to contribute was noted. He called for specialised African Professorships and research chairs, devoted funding and targeting African problems with initiatives. It could link to professional associations, governments, companies, society, individuals, local media and other stakeholders. Kenya’s Institute of Chartered Ship Broker's branch chastised the Kenyan government for not catering for local maritime education demand. It represents a major concern that local maritime education strategic advantages are not internationally recognised. They developed interest in courses in seafaring, maritime finance, ship broking, logistics, port terminal operations and marine insurance. They had to extract 23 internationally trained deck officers and 16 marine engineers as lecturers for Mombasa Technical University. Managerial and stakeholder
policy implications include growth into Africa would further solidify South Africa’s reputation as the premier emissary of African maritime education, research and the economy.

6. Conclusion, recommendations, policy implications and directions for future research

Key Research Question I stated: “What is the existing status of African maritime education? In conclusion this paper investigated how an existing scarcity of African maritime education sources could be transformed to utilise 4IR concepts. It provides a maritime education and training digitised model for global academics and policy stakeholders to follow. Pragmatic and policy implications include implementing a sustainable, ocean economy future, climate-proofed against emerging disruption risks, through maritime education innovation. It subsequently seeks to answer Key Research Question II (KRQII): “How can maritime education be transformed in Africa and globally, to capitalise on the 4th Industrial Revolution, emergent opportunities and changing stakeholder priorities?” Citizens will need to be trained to be entrepreneurs, innovators and company creators – not just employees. Financial / Business and marine eco-literacy are essential along with investing in core skills. To reward this effort, myriad maritime opportunities exist as this report states. Examples range from marine recreation, to businesses related to new port expansions, consultancies, maritime education, financial credit and insurance to technology and security. Its existing fishing fleet is also rapidly aging. The task of future maritime education will be directed to evaluating each citizen and helping them to achieve their potential. Research limits include an existing scarcity of blue economy and maritime education/innovation research, methods and verifiable case studies. Tangible funding remains scarce despite recent pledges at the Mombasa 2018 Blue Economy Conference / European Bank, Blue Economy Sustainable Finance Principles.

Future research directions include the development of prototype innovation and blue economy finance hubs, reviving curriculums and embracing simulators / other online and distance learning technology solutions such as cloud computing, IT access, Big Data, automation, sensor diagnostics and algorithm / app developments utilising post COVID-19 era funding. It includes utilising technology, pragmatic experience and pursuing new scholarship directions to resolve core global challenges. Maritime education needs to focus on risk management and opportunity. It must emphasise how it can enhance resilience, improve employability and life skills. Education should not just focus on mere simulators but immerse in real risks, vessels and experiences. It needs to consider entrepreneurship and technology implications. For example, this paper advised investigated implications of increasing automation on crews and pressures upon existing seafarers as a maritime health / psychology priority. The consequences of maritime robotics offer another. Greater flexibility / part-time
degrees, more customised research, courses and skills development, to stakeholder concerns is something South Africa’s model can reinforce for existing and future maritime institutions. Education may need to start earlier from installing ocean popular awareness and understanding as a core course to our development of three initial maritime high schools.

Findings identify myriad opportunities for maritime education and a marine economy, for example, options from underwater mining and floating habitat cities, ecologically sustainable vessels and synthetic marine based fuels. It could include maritime security and technology applications for submarines, desalination and ocean renewable energy. The greatest opportunities arise from those first willing to act on the recommendations summarised in this report. Given the potential value, contribution, significance and African vision for its future, users understand so comparatively little. They under-appreciate even more. Project Nemo would invoke underwater cartography to charter the oceans. Operation Arion would be the first to establish regular maritime interspecies cooperation, contact and understanding. Africa could establish Transfrontier Marine Parks defended by voluntary armadas, hovering observatories, drones and our own operated constellation of satellites. As it embarks on a maritime path, it becomes more imperative to consider true ocean health status, especially for neighbouring Indian, Atlantic and Polar Oceans. This involves accurately determining its ecosystem, environment and climate condition; then climate change / risks. Only then can users determine a sustainable ocean economic potential. It should focus on marine biodiversity databases, experiment on marine value adding / medicinal properties; establish marine plant and fauna sanctuaries and consider tides, currents, oceans, maritime geography. It should also aim for a more responsible role in research, education and community development. Furthermore, it should identify maritime heritage asset registers and climate-proof supply chains. If the planet needs to restore its ocean health, users could aid rather than callously suppress it, as at present.

This paper proposes providing a constitutionally enshrined, well defined, funded, coordinating sector institution to embrace the 4IR such as TETA, Department of Higher Education and Training, SAIMI so existing and future maritime education, policies, businesses, stakeholders, research and projects flourishes. Managerial and policy implications include to enable the maritime sector to thrive further the risks above could be managed more effectively and 4IR opportunities were exploited. Until this paper few visions concerning the national, regional or global future of maritime education and research exist related to the 4IR and changing future of work or the blue economy. Many maritime universities remain separated from economic realities and many global problems. They are seldom
integrated into business, government, communities and other stakeholders. They can learn from professional associations, the specialised Ethekwini Maritime Cluster, industry connections and other partnerships.

To conclude, this paper’s overarching objective remains to improve institutional capacity, wherever necessary in a post COVID-19 era given digital, climate change, pandemic health and other disruption, needing greater workforce flexibility; place autonomy and access / connectivity or innovation. Blue economy and maritime activities across shipping, logistics, fisheries, aquaculture and coastal tourism has been affected by the pandemic, calling an urgent need for new ideas to sustain maritime businesses. Reduced profit margins, fixed cost increases, declining tourism numbers, risks of pandemic spread, eCommerce growth, border closures and pressures for online / distance learning among the need for continuous education and professional skills development; further require consideration of 4IR and emerging blue economy opportunities. Digitisation can aid in proactive maintenance, risk management; virtual learning, work, payment and operating processes; provided employees, processes and MET institutions / policies adapt. Policies and local support to private and public sector institutions remains critical. This enables Africa to survive in the forthcoming age, where the ocean and maritime sector will pay an ever increasing and vital part in our lives. This remains one we cannot afford to marginalise, ignore or be uneducated to resolve. All participants should empower the ocean / blue economy through investing in maritime education to address the challenges and problems we face as humans. Continuous professional development represents a growing demand aspect for maritime education. In a rapidly changing world, to minimise collateral damage of 'Future Shock', education and people are becoming less static; continuously needing skills, courses and experiences to adapt to thrive. Or even merely keep up and survive.

References


Performances of some unmanned Aerial and Underwater Vehicles used in Maritime Missions

Sanja Bauk

Durban University of Technology, Department of Maritime Studies, Faculty of Applied Sciences, P O Box 1334, Durban 4000

70 Steve Biko Rd, Musgrave, Berea, 4001

sanjab@dut.ac.za; bsanjaster@gmail.com

Abstract: The paper deals with key features of some unmanned aerial and underwater vehicles used for marine surveillance and reconnaissance missions. Firstly, performances of Zephyr pseudo-satellite, AR5 and the AR3 medium altitude unmanned aerial vehicles (UAVs) are discussed. Then, A18-M and A9-E autonomous underwater vehicles (AUVs) features are briefly presented. The strengths, weaknesses, opportunities and threats (SWOT) approach is applied to position appropriately these UAVs and AUVs in the context of coastal security measures and tasks. The need for further investigation in the field is also revealed. The analysed vehicles are assets within the European Commission’s COMPASS2020 project applied over European seas, but they might be deployed in other sea areas, including South African ones.

Keywords: unmanned aerial vehicles; Zephyr; AR5; AR3; autonomous underwater vehicles; A18-M; A9-E; marine missions; SWOT analysis

1. Introduction

Unmanned aerial vehicles (UAVs) and autonomous underwater vehicles (AUVs) are being increasingly used for numerous purposes in both military and civilian areas. Present applications of these systems include surveillance, reconnaissance, remote sensing, target acquisition, border and marine patrol, infrastructure monitoring, communications support, aerial imaging, industrial inspection and emergency medical support. The UAVs and AUVs have capacities of sensing and perceiving the environment, processing the sensed information, communicating, planning and decision making, as well as acting autonomously by using control algorithms and actuators (Becerra 2019:452). The UAVs and AUVs presented in this article are deployed within European Commission’s Horizon 2020 COMPASS2020 (Coordination of Maritime assets for Persistent and Systematic Surveillance) project. This goal of this project is to deploy unmanned aerial and underwater vehicles in operational
coordination with manned oceanic patrol vessels used by EU Maritime Authorities, to enhance current marine border surveillance operations, with a particular focus on the detection, monitoring and control of irregular migration and narcotics smuggling. It was conceived to assist authorities in handling the pressure put on European external borders by the vast amount of irregular border crossings observed in recent years, through improving coordinated actions supported by both manned and unmanned vehicles. Besides the challenge of irregular migrants, Europe also deals with incidents of the most disperse nature such as the long-lasting issue of narcotics trafficking (COMPASS2020). Aiming to address these two big challenges, the project proposes the development of a unified system based on open standards that will enable the combined operation of multiple unmanned assets, manned platforms currently used for marine surveillance and the future accommodation of other platforms and services with minor integration efforts (Bauk et al. 2020; Gonzalo et al. 2019).

The paper deals with the performances of the UAVs and AUVs at a high level of abstraction deployed within COMPASS2020 and it is organised as follows: Section 2 deals with UAVs: Zephyr, AR5 and AR3; Section 3 considers AUVs: A18-M and A9-E; Section 4 outlines the SWOT analysis of examined UAVs and AUVs, which can be considered as an original contribution of the paper; and Section 5 provides the conclusion and some directions for further research in the field.

2. Features of the UAVs

In this section, general features of UAVs like Zephyr, AR5 and AR3 have been given. The inspiration for selecting these particular UAVs is found in recently set up Horizon 2020 COMPASS2020 project.

2.1. The Zephyr

The Zephyr is the first unmanned aircraft capable to fly in the stratosphere, harnessing the sun’s rays and running on a combination of solar cells and high-power Lithium Sulphur batteries (solar-electric power) above the weather and conventional air traffic. According to Gonzalo et al. (2019) and Kramer (2018), it is a High Altitude Pseudo-Satellite (HAPS) capable to fly for a month at a time combining the persistence of a satellite with the flexibility of an UAV (see Figure 1). As HAPS, the Zephyr uses high-definition electro-optical and infrared cameras to produce real-time visuals in any lighting. It costs around US$5 million, while an orbital satellite costs between US$50 and US$400 million (Flight Global 2019), so it is considerably cheaper than a satellite. At the moment, Airbus possesses two types of the Zephyr, designed to accommodate a variety of payloads. The production model Zephyr S has a wingspan of 25
m and weighs less than 75 kg. It has the ability to carry, view, sense and connect payloads. Presently, the larger Zephyr T, which is under development, has a wingspan of 33 m and a Maximum Take-Off Weight (MTOW) of 140 kg (Airbus, Defence 2019).

**Figure 1.** Zephyr launching.

The Airbus’ Zephyr S was first launched on 11 July 2018 in Yuma, Arizona, USA. Previously, it was transported from Farnborough, UK because it had a small ground infrastructure. It was a historical take-off, when after eight hours Zephyr reached the stratosphere. Its lower altitude was 18 km, and the highest 23 km. This was, at the time, the longest flight without refueling, lasting 25 days, 23 hours and 57 minutes (Airbus Defence 2019). Unfortunately, on 15 March 2019, the Zephyr aircraft crashed near its launch site in Wyndham, Western Australia (UKDJ 2019). This was caused by severe adverse weather. Luckily, it happened in an extremely remote location and caused no injuries or property damage. Work on the Zephyr improvements is continuing and there is expectation that the Zephyr’s mechanical launcher will be tested in 2020.

The Zephyr was conceptually integrated in the proposed COMPASS2020 architecture as a valuable asset for future concepts of operation. Due to its potential of acting as a high-altitude platform capable of performing early detections and providing the respective warnings to the system, it is considered to bring added value to the solution, by providing persistent surveillance and the first detection of potential events of interest. The goal of the project is to develop the solution in such a way that it will be possible and simple to integrate the Zephyr (both physically and in terms of data processing) within the overall system, once this platform has reached a development maturity that allows it to be operationally deployed (Bauk et al. 2019).
2.2. The AR5 Life Ray Evolution

The AR5 Life Ray Evolution is a medium-endurance and medium-altitude fixed wing UAV (see Figure 2). It is designed for wide area land and maritime surveillance, pollution monitoring, fisheries inspection and communication relay (Bold Business 2017). The AR5 has advanced on board capacities in terms of data processing. It can simultaneously process Electro-Optical/Infra-Red (EO/IR), radar and AIS data (FLIR 2019).

**Figure 2. AR5 EVO.**

![AR5 EVO](image)

Source: Tekever (2018)

The AR5 Life Ray Evolution is sub-tactical UAV dealing with 180 kg MTOW. It allows high speed beyond line of sight (BLoS) satellite communications (SATCOM). It also provides high precision video, imagery and sensor data in real time. Its features include a flexible architecture, supporting multiple types of payloads anddatalinks. Moreover, this platform complies with the highest production standards as the first European-wide UAV-based maritime surveillance system, which is International Traffic in Arms Regulations (ITAR) free (Digital Insider 2019). As an UAV that requires a runway for take-off and landing, its automatic take-off and landing capabilities, as well as the fact that it can use short and unpaved airstrips, are great advantages. The AR5 EVO has a cruise speed of 100 km/hr and a standard endurance of approximately 16 hours. The available payload capacity is up to 50 kg, wingspan 7.3 m and length 4.0 m. It is equipped with a three axis multi-sensor gyro-stabilised gimbal, capable of supporting the integration of multiple types of payloads. This includes AIS transceiver, multiple EO/IR sensors, Emergency Position Indicating Radio Beacon (EPIRB) and radar (Tekever 2018; Naval Technology 2019).

Within COMPASS2020, the AR5 EVO UAV plays an important role as a middle layer platform, which is able to provide wide maritime area surveillance, complementing the operational gap between the wider coverage but lower resolution capabilities of the Zephyr, and the lower altitude and more localised situation monitoring provided by the AR3 Net Ray (Bauk et al. 2019; Bauk et al. 2020).
2.3. *The AR3 Net Ray*

The AR3 Net Ray is a ship-borne UAV designed to carry out several types of maritime and land-based missions (see Figure 3). These missions include intelligence, surveillance, target acquisition and reconnaissance (ISTAR) actions, pollution monitoring, infrastructure surveillance and communication support operations. This UAV is capable of delivering an endurance up to 10 hours, which makes it an ideal solution to carry out both maritime and land-based missions. The payload capacity is 4 kg and it includes: multiple options for EO/IR sensors, near-infrared to long-wave infrared (LWIR) sensors, laser illuminators, communication relay systems, AIS transceivers and EPIRB. It provides real-time collection, processing and transmission of high-definition video. Its communication range is up to 80 km within radio Line of Sight (LoS), cruise speed is 85 km/hr, MTOW is 23 kg, launch is conveyed via catapult, recovery via parachute and airbags (for land-based operations) or using a net system (for maritime-based ship-borne operations). The AR3 dimensions are 3.5 m of wingspan and a length of 1.7 m (Tekever 2018).

![Figure 3. The AR3 Net Ray taking-off.](image)

*Source: Tekever (2018)*

The AR3 Net Ray UAV will be included in the COMPASS2020 surveillance ecosystem as an organic asset of the oceanic patrol vessels operated by the maritime authorities. This UAV will be operated (launched, piloted and recovered) from the vessel to provide the tactical teams with enhanced real-time information to help decision making. The AR3 will cover a surveillance level below the AR5, providing a more localised monitoring of events and situations of interest (Bauk et al. 2019; Bauk et al. 2020).
3. Features of the AUVs

This section briefly presents crucial features of AUVs like A18-M and A9-E. The inspiration for selecting these particular UAVs is like in the previous case of UAVs found within Horizon 2020 COMPASS2020 project.

3.1. The A18-M AUV

The A18-M is the military configuration of ECA Group A18 AUVs family (see Figure 4). Its applications for the defense and security sector encompass: (i) Rapid Environment Assessment (REA); (ii) Intelligence, Surveillance and Reconnaissance (ISR); (iii) organic underwater mine warfare: mine countermeasures mission module for large multipurpose vessel and mission module for oceanic mine warfare; and (iv) conventional underwater mine warfare: detection and classification. The system can be delivered with a Launch and Recovery System (LARS) allowing automatic underwater recovery. Data post processing can be made with Triton imaging applications. It performs autonomous missions up to 300 m depth, and is easily transportable by plane for overseas missions. Due to its large endurance, very high area coverage rate (2 km²/hr) and payload capacity, it is able to host high performance payloads according to the mission’s requirements as Synthetic Aperture Sonar (SAS), Conductivity, Temperature and Depth (CTD) sonde, video, forward-looking sonar (FLS), multi-beam echo sounder, and others (Naval Technology 2019). For navigation, it uses Inertial Navigation System (INS), Doppler Velocity Log (DVL), Military Global Navigation Satellite System (GNSS) and Global Positioning System (GPS) periodically, after resurfacing. It can communicate via Wi-Fi, Ethernet, Iridium and / or acoustic wireless communication channel. Its average speed is 3-5 knots (while the maximum is 6 knots). It withstands harsh environmental conditions and offers a greater stability when encountering heavy turbulence from waves. The high degree of stability enables this AUV to capture high-resolution images. The information obtained by the platform is processed to the command centre (ECA Group n.d.; Bauk et al. 2020).
3.2. The A9-E AUV

The A9-E AUV is the configuration of ECA Group for environmental monitoring (see Figure 5). In addition to the seabed image acquisition, the A9-E AUV can record bathymetric data as well as environmental information such as water turbidity, conductivity, temperature, fluorescence, dissolved oxygen and/or pH. Mission planning and monitoring are done through user friendly software which allows operator to follow the vehicle at any time during its mission. This underwater drone has been designed to meet STANAG 1364 requirement; as such, its acoustic and magnetic signatures are minimised in order not to trigger any underwater mines when doing the mine warfare survey. As part of early trials for the SWARM project, ECA Group’s A9-E fitted with the interferometer side-looking sonar demonstrated ability to conduct surveys in a shallow water of 13-20 m depth. It uses a phase differencing bathymetric sonar that increases area coverage by close to 200% over conventional multi-beam echo sounders in shallow water (ECA Group n.d.). For navigation, it uses INS, DVL, GPS and for communication purposes radio (UHF), Wi-Fi, Ethernet and the acoustic wireless communications. Its payload consists of, but it is not limited to: Interferometer Side Scan (ISS) sonar, video, CTD, and environmental sensors (turbidity, pH, fluorescent Dissolved Organic Matter (fDOM) / waste water discharge).
Within the COMPASS2020 project plans, the AUVs are to be deployed from the offshore patrol vessel into a strategic location that is coincident to the traffickers’ typical routes. The AUVs are programmed to follow circular trajectories in the area of interest, navigating underwater at low depth in order to remain undetected from the smugglers and at the same time staying closely enough to the surface in order to optimise the possibility of detecting the target. The AUVs carry sets of hydrophones that enable detecting speed boats and localise dumped cargo (cases or bags with narcotics). After detection of the target, the AUVs can communicate to the Zephyr, which is used as a communication relay in the system (COMPASS2020).

4. SWOT analysis

This section deals with some basic positive and negative factors connected with previously introduced UAVs and AUVs. These factors are summarised through a SWOT analysis (see Table 1). In accordance with SWOT principles, strengths, weaknesses, threats and opportunities of the considered UAVs and AUVs are highlighted. Current solutions for analysed UAVs and AUVs are in development and/or testing phases. Therefore, it was not possible to conduct surveys due to their strengths, weaknesses, threats and opportunities among potential end users such as European coastal or maritime authorities. Developers and researchers involved in the project have developed their own internal documentation, which is treated as intellectual property within the project. Therefore, the following SWOT analysis is based mostly on secondary literature resources that include Alop (2019), Chavaillaz et al. (2016), Andrews (2016) and Sahoo et al. (2019) and some scarce information upon the results of the field experiments recently discovered within the project. However, the references used are sound and provide quality of conducted study. Through further investigation, the examined features of UAVs and AUVs can be assessed within the specific context, which might be different from the analysed one – European coastal areas monitoring and...
combat against narcotic smugglers by the maritime authorities. Apart from this, at the current stage of the research in the field, the following SWOT is at high level of abstraction and only partly anchored to the afore mentioned project and its specific setting.

Table 1. SWOT analysis of the UAVs and AUV.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>UAVs</th>
<th>AUVs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UAVs</strong></td>
<td>- Lightness.</td>
<td>- Capacity to support high risk activities.</td>
</tr>
<tr>
<td></td>
<td>- Manual launching or reduced logistics footprint.</td>
<td>- Capacity to reach areas inaccessible for humans.</td>
</tr>
<tr>
<td></td>
<td>- Low energy consumption.</td>
<td>- Capacity to explore unexplored marine habitats.</td>
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<tr>
<td></td>
<td>- Lower acquisition price in comparison to satellites.</td>
<td>- Capacity to monitor and repair underwater constructions, pipelines and cables.</td>
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<tr>
<td></td>
<td>- Better quality of information in comparison with satellites.</td>
<td>- High level of autonomous navigation, collecting data and coming back to the sea surface vessel.</td>
</tr>
<tr>
<td></td>
<td>- Lower operational costs in comparison with manned aircrafts used for the same mission profiles.</td>
<td>- Silence operation and consequently not disturbing the environment and being imperceptible to potential foes.</td>
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<td></td>
<td>- Ability to fly for more hours continuously in comparison to manned aircrafts, as there is no need for aircraft downtime for pilot rendition.</td>
<td>- Being tight and waterproof.</td>
</tr>
<tr>
<td></td>
<td>- High seeing, sensing and communication capacities.</td>
<td>- Having shape that mimics sea creatures (fishes, crabs, turtles, beetles and snakes).</td>
</tr>
<tr>
<td></td>
<td>- Capacity of both LoS and BLoS operations.</td>
<td>- High appropriateness of kinetic and dynamic properties for underwater environment.</td>
</tr>
<tr>
<td></td>
<td>- Large coverage and durability of flight without recharging.</td>
<td>- Capacity of delivering with a Launch and Recovery System (LARS).</td>
</tr>
<tr>
<td></td>
<td>- High level of automation.</td>
<td>- Navigation with combination of Inertial Navigation System (INS), Doppler Velocity Log (DVL), military global navigation satellite system (GNSS) and</td>
</tr>
<tr>
<td></td>
<td>- Possibility to be safely integrated with commercial aviation.</td>
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</tr>
<tr>
<td></td>
<td>- Capacity to support high risk activities.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Capacity to reach areas inaccessible for humans.</td>
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</table>
Global Positioning System (GPS)
periodically.
- Possessing advanced sensors such as Synthetic Aperture Sonar (SAS), video, forward looking sonar (FLS) and multi-beam echo sounder.
- Communications via acoustic, radio and optical (light and laser) waves.

<table>
<thead>
<tr>
<th>Weaknesses</th>
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<tbody>
<tr>
<td><strong>UAVs</strong></td>
<td></td>
</tr>
<tr>
<td>Complexity of the UAVs makes them more vulnerable.</td>
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<tr>
<td>Requirements for highly skilled personnel for designing, creating, operating-controlling, maintaining and upgrading the UAVs.</td>
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<tr>
<td>Lack of law regulations at a wider scale.</td>
<td></td>
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<tr>
<td>Lack of management and operational knowledge at different levels of the UAVs operation.</td>
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</tr>
<tr>
<td>Lack of common communication capacities between the UAVs and other vehicles within integrated traffic and transportation system.</td>
<td></td>
</tr>
<tr>
<td>The link between the UAVs and ground control stations.</td>
<td></td>
</tr>
<tr>
<td>Maneuvering and obstacles’ avoidance algorithms and features are under development.</td>
<td></td>
</tr>
<tr>
<td>Computer vision is also still until development.</td>
<td></td>
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<tr>
<td><strong>AUVs</strong></td>
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<tr>
<td>Better adaptive control using neuro-fuzzy techniques is needed.</td>
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<tr>
<td>More accurate localising using improved INS non-linear Kalman filters, cooperative localisation (swarm intelligence), artificial intelligence vision and object detection, odometry, are to be developed.</td>
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<tr>
<td>Underwater wireless communications are to be improved, particularly at the longer distances.</td>
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<tr>
<td>High-density battery power supply is necessary.</td>
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<tr>
<td>Energy harvesting methods are to be improved.</td>
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### Opportunities

<table>
<thead>
<tr>
<th>UAVs</th>
<th>AUVs</th>
</tr>
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<tbody>
<tr>
<td>- Increasing safety and security at sea and in general.</td>
<td>- Increasing safety and security at sea and in general.</td>
</tr>
<tr>
<td>- Reduction of traffic congestion in areas with high density traffic.</td>
<td>- Approaching up to now inapproachable corners of seabed.</td>
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<tr>
<td>- Approaching up to now inapproachable areas.</td>
<td>- Approaching areas of high risk for humans.</td>
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<tr>
<td>- Approaching areas of high risk for humans.</td>
<td>- Gathering more information on distance areas, aquatic flora and fauna, constructions.</td>
</tr>
<tr>
<td>- Gathering more information on distance areas, entities, constructions.</td>
<td>- Lower ecological footprint.</td>
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<tr>
<td>- Lower ecological footprint.</td>
<td>- Developing 3D path planning with obstacle avoidance.</td>
</tr>
<tr>
<td>- Developing 3D path planning with obstacle avoidance.</td>
<td>- Developing potentials of autonomous systems.</td>
</tr>
<tr>
<td>- Developing potentials of autonomous systems.</td>
<td>- Further development of artificial super-complex AUV systems.</td>
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<td>- Further development of artificial super-complex UAV systems.</td>
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### Threats

<table>
<thead>
<tr>
<th>UAVs</th>
<th>AUVs</th>
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<tr>
<td>- Collapse of the UAVs due to severe weather conditions / harsh environments.</td>
<td>- Losing human control over the crafts.</td>
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<tr>
<td>- Negative effects of external factors as natural forces and cosmic impacts.</td>
<td>- Unsafe Launch and Recovery System (LARS).</td>
</tr>
<tr>
<td>- Losing human control over the crafts.</td>
<td>- Internal disturbances and faults in the systems as super-complex ones.</td>
</tr>
<tr>
<td>- Unsafe landing and recovering.</td>
<td>- Over-reliance on technology, AUVs in the analysed context.</td>
</tr>
<tr>
<td>- Internal disturbances and faults in the systems as super-complex ones.</td>
<td>- Unauthorised malicious intrusion into the system (hacking).</td>
</tr>
<tr>
<td>- Over-reliance on technology, i.e., UAVs in the analysed context.</td>
<td>- Scarcity of the cost-benefit analysis.</td>
</tr>
<tr>
<td>- Unauthorised malicious intrusion into the system (hacking).</td>
<td>- High investment risks.</td>
</tr>
<tr>
<td></td>
<td>- The lack of readiness of entrepreneurs to support further development of AUVs.</td>
</tr>
</tbody>
</table>
- Scarcity of the cost-benefit analysis.
- High investment risks.
- The lack of readiness of entrepreneurs to support further development of UAVs.
- Uncertain revenue of investments.
- Users’ reluctance to accept high risk investments in the UAVs innovations.
- Questionable innovation acceptance success.

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5. Conclusion

This paper has reviewed the UAVs and AUVs within the context of the COMPASS2020 project. The paper also described the Zephyr, the AR5 and the AR3 UAVs and A18-M and A9-E AUVs through pointing out their key features. Based on the findings from secondary literature resources and experiences from the project up to now, some strengths, weaknesses, opportunities and threats of the considered UAVs and AUVs have also been identified and highlighted.

The future research in this area should provide a deeper insight of compatibility of the UAV and AUV systems with the existing and well established manned and unmanned crafts used for the same or similar purposes. Common communication schemes and algorithms among (un)manned, aerial, sea surface and underwater craft are currently under further development.

There is a strong argument in favour of increasing initiatives for testing, validating and integrating unmanned systems within current surveillance infrastructures (both land and maritime based), as these assets can assist current surveillance and monitoring capabilities of authorities in a cost-effective way. However, the so-called blind-belief in technology, including the analysed UAVs and AUVs, should be critically reviewed. The willingness of various involved parties to develop, implement and adopt such advanced systems should be investigated with the aim to provide their innovation implementation success in military, civil, industry and other errands.

Such advanced systems can be used as subjects of further research work and base for applying for research funds not only in developed, but also in developing countries as South Africa. The scope of the analysed craft can be broadened beyond patrolling and combat missions in European seas. For instance, the South African Operation Pakhisa Programme

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inspired by blue economy can enrich its scope by investigating possibilities of optimal deploying the UAVs and AUVs within the national context, in accordance with the actual needs and preferences in maritime.

6. Acknowledgment

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References


The Fourth Industrial Revolution, Rural Industrialisation and Development: Successes for Youth in the Creative Economy of South Africa

Narissa Ramdhani
Vaal University of Technology, Private Bag X021, Vanderbijlpark 1911
Andries Potgieter Blvd, Vanderbijlpark, 1900
narissar@vut.ac.za

Abstract: This is the ‘Age of Change’ or the Age of the Fourth Industrial Revolution and includes the advance of Internet and digital technologies; economic challenges and globalisation trends; broader environmental sustainability and social equity concerns. These shifts represent opportunities globally, continentally and nationally; thus they are driving new forms of business innovation which can be used as a vehicle for rural modernisation and development which impact on youth populations. However, this age is also of relevant concern in the face of globally driven economic changes. Undeniably, the world is getting younger as one in every four people is below the age of 25 and South Africa, like many other countries on the continent, faces record levels of youth unemployment and limited capacities. This assumption therefore remains in conflict with the need for new digital capabilities and innovation. Given the current situation, innovative solutions are desperately needed to reverse this devastating trend especially in the rural nodes of the country. The implementation of the creative economy as a solution in the rural communities has undoubtedly been a topic of increasing interest to researchers and policy makers. For rural communities, especially the youth, many challenges are presented by socio-economic circumstances, isolation and disinterest by Government. These challenges can be mitigated by the creative economy in supporting innovation and economic regeneration while preparing rural youth for the Fourth Industrial Revolution. This paper, which grows out of fieldwork undertaken in these nodes to explore the effectiveness of innovative practices such as the implementation of creative economies, will suggest that this sector is sustainable. It can start out small, use local resources and indigenous knowledge while demonstrating the potential for massive commercialisation. Starting with the developmental challenges while also pronouncing on solutions drawn from global experiences as possible resolutions for the country’s rural dilemma, this paper will also interrogate the value of technology for poverty alleviation, sustainability and rural industrialisation. This is considered vital as the Fourth Industrial Revolution represents new methods through which technology can become embedded within societies and rural communities. The paper will then examine the value of the five-phased plan and highlight its implementation process and successes and will conclude with directions...
and cautions for policy makers in South Africa. To support the hypothesis, the choice of methodology for the research presented few challenges because the researcher chose an implementing partner already working in the field in the seven provinces in South Africa. A qualitative and quantitative approach was used as a component of the field project on the value of the creative economy in the regeneration of rural nodes of the country. Data was drawn through the use of images, reports, testimonies (structured and unstructured), focus groups and visual analysis – all which corroborated and enhanced conclusions reached in the field and project reports of project directors and trainers. More importantly, this methodology did prove effective in providing the answers to the questions raised.

**Keywords:** commercialisation; creative economy; creative industries; development; employment; fourth industrial revolution; globalisation; Ifa Lethu Foundation; income generation; innovation; poverty; rural diversification; rural industrialisation; unemployment; World Economic Forum; youth

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**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
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<tbody>
<tr>
<td>4IR</td>
<td>Fourth Industrial Revolution</td>
</tr>
<tr>
<td>GEM</td>
<td>Global Entrepreneurship Monitor</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>ICT</td>
<td>Information Communication Technology</td>
</tr>
<tr>
<td>ILF</td>
<td>Ifa Lethu Foundation</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>UNCTAD</td>
<td>United Nations Conference on Trade and Development</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>WEF</td>
<td>World Economic Forum</td>
</tr>
</tbody>
</table>
1. Introduction

“We stand at the brink of a technological revolution that will fundamentally alter the way we live, work and relate to one another. In its scale, scope and complexity, the transformation will be unlike anything humankind has experienced before. We do not yet know how it will unfold, but one thing is clear, the response to it must be integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academia and civil society” (Scwab, 2016).

This is the Age of Change or the Age of the Fourth Industrial Revolution (4IR) and includes the advance of internet and digital technologies; economic challenges; globalisation trends; broader environmental sustainability and social equity concerns. These shifts represent both challenges and opportunities globally, continentally and nationally; hence, they are driving new forms of business innovation which can be used as a vehicle for rural modernisation and development which are impactful on youth populations. Undeniably, the world is getting younger as one in every four people is below the age of 25 (Khokhar, 2017). South Africa, like many other countries on the continent and globally, faces record levels of youth unemployment. This assumption therefore remains in conflict with the need for new digital capabilities and innovation. Given the current situation, there is desperate need for innovative solutions to reverse this devastating trend, more especially in the rural nodes of the country. This paper, which grows out of fieldwork undertaken in these nodes to explore the effectiveness of innovative practices such as the promotion of creative economies for rural regeneration, will highlight the challenges and the impact of trends and issues related to the Age of Change and their impact on the youth. It will further interrogate global perspectives and experiences in relation to creative economies and the 4IR, while exploring solutions for the rural communities.

2. The creative economy

Although its value is recognised at policy levels, the term creative economy does appear ambiguous; it is not widely understood and often remains low on the list of funding priorities. Therefore, it is vital to furnish an explanation, especially in relation to work in South Africa. According to the United Nations (UN) Creative Economy Report 2013, the creative economy “is not a single highway, but a multitude of different local trajectories found in cities and regions in developing countries” (United Nations Development Programme 2013: 25). It really represents a new paradigm, within which lies a development component and one that creates the connection between economy, culture and the creativity. While today it represents a rapidly growing sector of the global economy, and has attracted the attention of global policy makers,
for South Africa, it is characterised by the possibilities of income generation, employment, rural development and industrialisation and export especially since the creative industries form the nucleus of this model. Moreover, it transforms the areas in which communities reside and wish to be employed, as these individuals suffer from a lack of material resources for relocation to far more lucrative areas. Burdened by poverty, social dilemmas and rampant unemployment, the creative economy therefore breathes new life to their creativity and prospects for successful and sustainable endeavours. In effect, it provides the opportunity to grow economic status of youth and of their localities through non-formal learning and occupational activities.

3. Methodology

The objectives of the field research were twofold: to investigate whether the creative economy is the appropriate organ that could be impactful for youth unemployment and economic growth and secondly whether it could be successfully harnessed for rural industrialisation and modernisation while generating innovation and preparing creative youth for the 4IR, and in so doing, alleviating poverty. To support the hypothesis, the choice of methodology for the research presented few challenges when choosing an implementing partner already working in the field in seven provinces in South Africa. A qualitative and quantitative approach was used as a component of the field project on the value of the creative economy in the regeneration of rural nodes of the country. More importantly, this methodology did prove effective in providing the answers to the questions raised.

The words of Klaus Schwab, the Executive Chairman of the World Economic Forum, highlighted at the beginning of this introduction, emphasise the starting point for work on the youth and the creative economy. However, as his words present a warning on how business should be undertaken in the future, this set the tone for the research questions and conclusions. Further, in May 2017, the World Economic Forum (WEF) on Africa convened in Durban. In his opening address at the conference, the former President Jacob Zuma called on global leaders to prepare for the 4IR and asserted “The World is changing. We are entering the 4IR. The question that faces the leaders of the world, politically and economically, is how do we meet this new challenge” (World Economic Forum, 2017). This issue of the 4IR remained a much discussed topic during deliberations with Former President Zuma and many speakers focusing on the need to equip youth with new skills to face the new digital age. In other words, each speaker at the Forum provided their perspectives on how to give life to 4IR while empowering the youth in Africa. Nonetheless, all arguments reached consensus on the need to invest in the youth of their respective countries. Discussions evolved around how technology could mean more employment and poverty alleviation. During the course of the
research, although there was belief that the Zuma trajectory was correct, there was a vague optimism about whether African governments could create the necessary environments to address the challenges of the digital age while preparing youth for this revolution. Members of the audience from many African countries appeared sceptical about the views and promises of speakers representing the different governments. These views and discussions justified the research path in preparing South African rural youth for the digital age and their contribution to poverty alleviation.

There is already a large and growing body of literature on the 4IR and the creative economy, especially in relation to the South African case. Unlike many research works on this area, the researcher paid close attention to the many global reports and the various country experiments in conjunction with the data generated by fieldwork and methodology, making the work more intimate and timeous. These include the UN Creative Economy Report 2013 Special Edition, the UN United Nations Conference on Trade and Development (UNCTAD) Report on ‘Creative Economy Report 2008: ‘The Challenge of Assessing the Creative Economy: Towards Informed Policy Making’, the Report of the Expert Group of the European Commission: ‘Developing the creative and innovative potential of young people through non-formal learning in ways that are relevant to employability’, and the Human Development Report 2004: ‘Cultural Liberty in Today’s Diverse World’, published for the United Nations Development Programme (UNDP). Given the suspicions of rural communities to outsiders asking questions and offering solutions, the issue of intimacy played a key role ensuring cooperation and trust. Added to this was the confidence the researcher built in her work and subsequently in her ability to win over local leaders such as headmen, councillors, local indunas, local mayors and other community leaders. Such confidence resulted from the efforts of almost eight years of work by the implementing agency in these areas of the country. Literature was also drawn from the many reports of the United Nations, government publications and reports, case studies from countries such as Australia, Malaysia, India and Scotland and studies from the European Commission (Anwar-McHenry, 2013). Evidence was drawn through the use of images, reports, testimonies (semi-structured and unstructured), focus groups and visual analysis—all which corroborated and enhanced conclusions reached in the field and project reports of project directors and trainers. The fieldwork was conducted following seven provinces. These areas / villages were identified by local authorities and the implementing partner as being in need of urgent intervention to assist with social and economic challenges which affected youth.
Aside from experience in working with the rural communities, the researcher experienced challenges further burdened by continental and country-borne statistics (Department of Rural Development, 2019). On the continent, the following situation prevailed:

- Over the next 35 years, 2 billion babies will be born.
- By 2050, 40% of the world’s youth will live in Africa.
- In 2017/2018, 100 million youth were out of school, out of a global population of 263 million youth.

The South African situation fared no better with the following alarming statistics (2016/7 figures):

- 60% of unemployed youth below 35 have never worked.
- 34.7% of the population is rural.
- 43% of rural population comprises women.
- The youth constitute 37% of the country’s population, translating into 19.1 million (Stats South Africa, 2019).

In view of the above, it became important to situate these figures within the framework of the research. Without doubt, failure to do would most certainly create the potential for catastrophic repercussions for the continent’s youth.

In order to strengthen the findings and choice of methodology, it was clear that the researcher needed to develop strong partnerships across South Africa, those that included communities, academia, government, and NGOs. For this project, the partners included the South African Ministries of Arts and Culture, Trade and Industry, Tourism and Foreign Affairs, the National Arts Council, Brand South Africa, the British Broadcasting Corporation, TATA India and the Governments of Chile, the United Kingdom and Australia. Perhaps even more
critical to the objectives was the choice of an implementing agency. Aside from the financing and other agencies, the implementing agency had a role to play in turning into concrete results the objectives we highlighted in our strategic plan.

The Ifa Lethu Foundation (ILF) of South Africa was identified as the most suitable implementing partner as it began preparing rural youth in the creative sectors for the Digital Revolution since 2010. Ifa Lethu is an NPO which was born in 2005. Meaning Our Heritage in Xhosa, Ifa Lethu has a national footprint and manages South Africa’s largest creative entrepreneurial and rural development effort devoted to empowerment of youth and women in the rural areas of the country (Ifa Lethu Foundation, 2016). This is undertaken with a view to up-skill youth and women in preparation for future leadership roles in their communities and in the country. This allows Ifa Lethu to align its work to the United Nation’s Sustainable Development Goals, South Africa’s National Development Plan, Mzansi’s Golden Economy, The National Youth Development Policy 2020, the Commonwealth Youth Charter and the Green Economy. More importantly, the Foundation enjoyed impeccable credentials in seven of South Africa’s nine provinces.

Knowing the terrain in these seven provinces, the ILF provided a focused and tangible solution for the fieldwork while creating the necessary documents for our funding agencies and for the oral testimonies in fragile contexts as well as providing the assessments on risks and feasibility. This was purposeful in deciding the geographies in which to intervene while assisting with the support for the theoretical and policy aspects of the project.

Through its work over the last three years, the Foundation has successfully assisted 2 300 poverty-stricken youth and women, delivering on benefits such as income generation through an economic model that has resulted in job creation, human rights education, and social empowerment. During this time, 800 successful youth businesses have been incubated to support their impoverished families. Many include young people heading households affected by HIV. For the Foundation, the creative economy was considered as the most feasible option for its development work in the rural nodes of the country. Much of the Foundation’s sterling work has been accomplished through many noteworthy public-private partnerships that have addressed many of the country’s most pressing youth problems. Therefore, the Foundation enjoys a successful track record in providing alternative developmental solutions to poverty alleviation and income generation in the extremely underdeveloped areas of South Africa. It also enjoys impeccable credentials in countries like the United Kingdom, United States of America (USA), India, Chile, Australia, and France.
4. The solution

In South Africa, it is commonly known that one of the most important development challenges facing the country South Africa is that of rural poverty. Some of the main causes of rural poverty include low productivity, lack of off-farm employment opportunities, rampant unemployment, increasing rural-urban migration as well as a lack of productive assets and problems of inaccessibility. Evidence unearthed from a study of such environments in India, Malaysia, Scotland, the Nordic countries and South America have demonstrated that rural non-agricultural activities, such as those of the creative industries (art and craft), provide a significant number of productive jobs and thus relieve the problems of rural unemployment and out migration (Florida, 2002). These studies have also shown that this sector is sustainable because it tends to start out small, uses local resources and is based on indigenous knowledge. It has also demonstrated the potential for massive commercialisation.

In the work in the various provinces, the researcher drew extensively from the above studies while acknowledging research conclusions that conventional forms of development were not delivering widely or quickly enough to cater adequately for the needs of the poor especially the youth. Thus, the researcher turned to the alternative concept of development for work with the creative industries. This alternative approach of development provided a vehicle to increase the capabilities of poor creative practitioners to enable them to gain access to resources, use services and information, innovate and to explore new conditions and resources. This strategy became the basis of the implementing partners’ self-reliance and income generation programmes throughout South Africa with the ultimate goal of poverty alleviation through creative and social entrepreneurship.

Clearly, there was a need for rural diversification. After studies of the economic and social challenges that plagued these rural nodes, the conclusion was that two areas could be identified as solutions for rural economic diversification-tourism and the creative industries (Waitt and Gibson 2009). Global statistics provided a good starting point enabling the researcher to determine that she was on the right path in focusing on the role of the creative economy in overcoming poverty alleviation. The dynamism of the sector was revealed as early as 2005 when it was revealed that global exports in the creative items reached $424.4 billion and this figure represented 3.4% of total global grade. Even in the more developed countries, the creative sector is viewed as the solution to growing the economy, generating employment and encouraging social cohesion, with lucrative jobs being offered especially to youth. In the same year, it was recorded that the economic yield from the creative industries amounted to
€654 million, growing far more rapidly than the economy of the European Union. Employment figures related to this growth put the results at €5.6 million (Creative Economy Report, 2008). Another noteworthy finding was that even many developing countries in Asia (Malaysia, Indonesia, India, China) have begun developing policies to heighten the value of the creative industries (Isa, 2011). While this was happening, it was also found that there were still many obstacles in these countries which prevented them from leveraging the creative economies for development accomplishments. This resulted from policy inadequacies and global prejudices.

Statistics provided by international literature such as European Affairs, Unicamp and the UK/India Business Council indicated the following in 2015:

Table 2. GDP contribution of each country.

<table>
<thead>
<tr>
<th>Country</th>
<th>Contribution to GDP (%)</th>
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<tbody>
<tr>
<td>Norway</td>
<td>3.2</td>
</tr>
<tr>
<td>Great Britain</td>
<td>3.6</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2.9</td>
</tr>
<tr>
<td>Brazil</td>
<td>6.7</td>
</tr>
<tr>
<td>France</td>
<td>3.4</td>
</tr>
<tr>
<td>Chile</td>
<td>2.9</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.18</td>
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The effect on employment was also significant. In Asia, the Indian cinematographic industry alone employed more than 4 million people and represented approximately US$3.3 million. Regarding France, Norway and Great Britain, a comparison with the figures for the agro-food industry revealed that the results of the cultural sector were undoubtedly higher. Thus, in most countries, the cultural sector greatly contributes to their economic growth, especially since their growth indices are greater than Gross Domestic Product (GDP) growth rates. It is therefore clearly apparent that this sector may constitute an engine of growth if the United States and other players establish institutional, legal and economic environments favourable to its development.

The Department of Trade and Industry (Creative Cluster) in 2015 published the figures outlined below. The analysis of the value of the creative economy to South Africa exposed the following:

- The cultural sector is a key economic driver in the country’s tourism industry.
• South Africa's creative sector alone contributes about R2-billion or 0.14% to South Africa's GDP annually.
• Sector provides jobs and income for approximately 38 000 people through an estimated 7 000 small enterprises.

However, this was certainly not enough; the expectation was the research findings would demonstrate that more could be done; that the creative sector could also be used as a catalyst for rural economic development and for fostering expanded participation in the economy, especially by women and youth as it had done in other countries. Furthermore, as the art of designing and producing cultural products is handed down from generation to generation, members of communities have an opportunity to work together and impart knowledge and social values to each other, especially the youth. This contributes to social cohesion and instills the culture of respect, discipline and *Ubuntu*. Therefore, there is continuous belief that cultural heritage represents both an economic activity and a cultural practice. Moreover, tourists are often attracted to a particular area because of its cultural and heritage significance and there is extensive recognition of the value of tourism for development. Although this presents a very positive scenario for the creative industries in SA, there is a serious development problem. South Africa, like many countries of the African continent, is not leveraging its creative economies to enhance development achievements. According to the Global Entrepreneurship Monitor (GEM), when it comes to entrepreneurial activity, South Africa performs poorly in comparison to other emerging economies. While the South African government remains committed to supporting small enterprises as one of the drivers of levels of economic growth needed to make an impact on poverty and unemployment in the country, it is still unable to successfully support such initiatives. This is evident from their failure to nurture creative skills, to leverage their creative reserves and to grow the competitiveness of South Africa’s creative sectors which can be purposeful in the promotion and protection of the country’s rich cultural diversity. Global societies are being redesigned and restructured to accommodate radical cultural, economic and technological changes. Therefore, technology and its advances can pave the way for the creative economy to function successfully in the areas in which we implemented our project. As such, the uniqueness of this research can be discerned from its emphasis on technology for poverty alleviation, sustainability, and rural industrialisation.

Aside from global influences and experiences, this has been guided by global politicians who have started to acknowledge the relation between technology and poverty alleviation. For example, Former President Barack Obama, who turned out to be USA’s most techno-savvy President, as far back as 2009, when he occupied the White House for the first time, bemoaned...
the fact that the country was 30 years behind and still in the Dark Ages. The President went further in his quest to market technology by linking it to poverty alleviation in the world. For him, the advent of 4IR had a great reach in tackling global challenges of which poverty alleviation stands tall. He argued that in the growing demand for new innovations in technology lay a part of the solution to poverty (The White House, 2017). For example, technology not only made information easier, it also created infrastructure and development in developing nations, it helped discover and get access to alternative resources, and along with all this, helped create many jobs while stimulating the economy.

The researcher has also been privileged to have engaged in many conversations with Michelle Bachelet, Former President of Chile, and was intrigued by her emphasis on how technology could alleviate poverty. These conversations occurred during her visit to Durban, South Africa, in September 2015. As a South African Diplomat to Chile, the researcher had access to the then President. Evidently, the Chilean Government had almost doubled their investment in technology. Bachelet indicated that she hoped that through such actions, Chile could rise out of poverty by the end of the decade. There are various programmes in Chile that support innovation and development of technology from organisations that give grants to entrepreneurs, to organisations that support travel abroad to Silicone Valley in the USA and Bangalore in India, to learn how these hubs of technology work. Given the researcher’s work in Chile, the support for innovation and creativity in Chile provided much encouragement.

5. Preparations for the Fourth Industrial Revolution: ICT for the rural creative economy

From the fieldwork, research and interviews with the youth, youth organisations and local councillors, it emerged that there were multiple challenges in this area. Notably, the interviews were undertaken with the youth, youth organisations, councillors and chiefs. These included Michael Seleke, Chief Hosi Ngove of Ngove Village, Geoffry Masemola, John Anthony among others. These interviews are in possession of the Project Director. The challenges noted include the following:

- The existence of minimal knowledge or interest in Information and Communications Technology (ICT).
- Problems and priorities faced by communities.
- Community disinterest in commercialisation.

Thus, it was crucial that the ILF, through its work, introduced ICT to the creative sector so that the gap in the digital divide could be narrowed especially for small and medium industries and communities in our rural areas. It also strengthened the link between digital technology,
business growth, localised production and massive commercialisation. The researcher was exposed to the term *technology justice* (Rooksby and Lucas, 2007). This was an interesting phrase as it was used to argue that such technology should be geared towards assisting humanity rather than focusing on satisfying the wealthy who could well afford such technology. It was contended that such technology should be made accessible to those living in poverty so that they could benefit from electricity, technology that ensured clean water, technology that improved technological yield and preparations for natural disasters and technology for non-agricultural activities of those who lived in rural nodes. Technology Justice was key in the crafting and implementation of the ICT Programmes for the rural creative economy. Through mobile applications, training, creative digital partnerships, ecommerce and web developments, the researcher provided an enabling environment for participants in all provinces where such programmes were implemented. The end results were encouraging as such an environment made access to information and resources possible and resulted in innovative business solutions for communities.

Taking note of Schwab’s remarks outlined at the beginning of this paper, and drawing on the case studies of global experiences, the field research and global study visits and interviews, the researcher was poised to launch innovation and rural industrialisation projects in preparation for the 4IR. A development model, which involved five phases was therefore implemented to patch the gaps in a technology intensive manner.

<table>
<thead>
<tr>
<th>Phases</th>
<th>Description</th>
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<tr>
<td>Phase 1: Product Development</td>
<td>For the training in, and development of export-ready, superior products, undertaken by product experts in the country.</td>
</tr>
<tr>
<td>Phase 2: Entrepreneurship</td>
<td>Business and financial training undertaken by the School of Entrepreneurship at the University of Pretoria to allow creative practitioners to transform their skills into successful business enterprises by being trained in finance, banking, the development of business plans and other related skills.</td>
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<tr>
<td>Phase 3: Business Incubation and Mentoring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Undertaken by the University of Pretoria to enhance business and product development practices. This phase assisted in eliminating challenges experienced in the initial stages of business growth.</td>
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Phase 4: Marketing and Distribution  
In partnership with the University of Pretoria, the retail sectors and the Duty-Free Store at OR Tambo International Airport, this phase was designed to allow consultation with the retail sector on the design of products required. This phase ensured that such retailers provided the markets for the products.

Phase 5: e-Commerce  
This phase was critical in introducing and strengthening the IT skills necessary for eCommerce. It included the training in and use of drone technology in partnership with Microsoft South Africa for the purpose of aligning the creative economy to the needs of the 4IR and export development in partnership with the Department of Trade and Industry.

These phases of the field facilitated the development of a holistic solution to the complexities confronting the researcher in the work related to the successful implementation of technology for the creative economy which in turn proved impactful for youth employment and enterprise development. Other benefits of the programme included the following:

- Infrastructure development/technology innovation which provided the edge needed for the youth entrepreneurs.
- Access to practical technology/finance.
- Partnerships/advocacy.
- e-Commerce/digital banking/block-chain technology.
- Mapped and traceable supply chain.
- Knowledge transfer and learning/low-cost powerful smartphones.
- Data protection.
- Development of the creative Cloud to provide creatives with access to all information collected by retailers, traders and agents.

While these aspects enabled the use of the creative economy to assist rural industrialisation while preparing the youth and women for the digital revolution, it was preceded by strategy geared towards ensuring that this sector understood the effects of the 4IR and emergent disruptive technologies.

The following figures bear testimony to our successes in fulfilling the research and project objectives.
Table 4. The national figures per area of development.

<table>
<thead>
<tr>
<th>Areas</th>
<th>Figures (National)</th>
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<tbody>
<tr>
<td>Entrepreneurship training programme</td>
<td>2 800</td>
</tr>
<tr>
<td>Employment created</td>
<td>1 720</td>
</tr>
<tr>
<td>Young business incubated</td>
<td>800</td>
</tr>
<tr>
<td>Ambassadors created</td>
<td>60</td>
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</tbody>
</table>

6. A future direction

Given the findings, it was evident that the creative economy was impactful in promoting a nurturing environment for economic development and skills growth of youth in the rural and deeply isolated nodes of South Africa. This also meant that the work remained fundamental in urging policy makers to support both the creative industries and creative economies as a platform for rural industrialisation. Such a cardinal role also enabled the researcher to set the direction for policy makers and government by highlighting the following:

- It is vital to bring new sectors such as the creative economies into the mainstream economy with 4IR.
- There is a need for strong inter-provincial policies and programmes that are effectively crafted and implemented.
- The optimisation of technology transfer is non-negotiable.
- Efforts should be devoted to the development of innovative economies which can be productive and flexible to changes such as 4IR.
- Mechanisms should be implemented to prevent sub-standard imports and sub-standard export products.
- Bureaucratic obstacles and regulatory delays should be removed to achieve an investor-friendly environment to attract the right innovation partners.
- Digital production should be promoted to allow for more flexible and adaptable supply chains.
- New and innovative groups of entrepreneurs such as youth and women should be developed and empowered.
- Collaboration between provinces, government, academia, science and technology councils, business and labour should be encouraged.
- More incentives, such as skills transfers, funding and internships through partnerships with industry, Universities of Technology and T-Vet Colleges, should be offered.
7. Conclusion

From the literature reviewed, there has been much interest globally and on the part of policy makers in how the creative economy, through the creative industries, can be promoted, nurtured and sustained. Moreover, the case studies of the seven areas / villages helped solve the initial problem being investigated and demonstrated that the creative economy represented a solid platform for addressing development challenges which include rural industrialisation and modernisation, while providing an enabling structure for the 4IR and for developing human capital. With an investment of R1 million in a community, a projected return, based on initial business incubation, the spawning of other businesses and export initiatives, is estimated at R24 million over six years. The technological edge furnished through the mobile applications, creative digital partnerships, e-Commerce, social media and web development have further strengthened our conclusion on the value and innovation carried by the creative economy while fulfilling the demands of the digital age and of a competitive global economy. When young people are willing to venture into a creative economy during a sluggish economy, it can lead to success stories.

As the world enters an age where billions of people are connected by mobile devices and have access to limitless knowledge, certain critical demands take centre stage. These include a rethinking of education, training and workforce development and how these impact on those we are grooming to become future global players – the youth. Through skills, development programmes and research, there is a move towards empowering the youth for future leadership roles and for being more active players in the first economy of the country.

References


