HOW SOUTH AFRICAN UNIVERSITIES CAN CONTRIBUTE TO PREPARING THE FUTURE WORKFORCE FOR THE FOURTH INDUSTRIAL REVOLUTION

by

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ABSTRACT

The Fourth Industrial Revolution (Industry 4.0) is a complex phenomenon. Its transformative nature holds implications for South African universities, graduate employability and the workplace. Artificial intelligence (AI), machine learning, automation and digital technology, amongst others, have already transformed the world of work. Consequently, mismatches between graduate skills and workplace requirements have emerged which exacerbate the already high levels of unemployment in South Africa. Universities that do not adapt to the speed of innovation will become obsolete. As far as its core function, teaching and learning is concerned, a radical reconsideration of current curricula and pedagogy will be required, including the technological enhancement of teaching and learning practices. This begs the question as to how the key functions of South African universities, particularly those related to teaching and learning, should be transformed to better prepare the future workforce for the Fourth Industrial Revolution.

The aim of this study was to undertake a scoping review to explore this question in more depth, presenting possible scenarios of change to be considered. Linked to the above, the sub-objectives that informed the study related to determining the role of South African universities in preparing the future workforce. Furthermore, I attempted to review, analyse and identify key themes from the scoping review results, in order to summarise and group findings together. The exploration of the literature and published research on innovative teaching and learning practices was focused on finding ways of better preparing and equipping students with the required skills for future jobs in the Industry 4.0 workplace. The results were used for developing conceptual models as a representation of the findings deriving from the scoping review. These models could inform transformation and innovation relevant to South African universities, particularly teaching and learning, to better prepare the future workforce for the Fourth Industrial Revolution.

This is a non-empirical study that integrated the human capital theory as theoretical framework. The adoption of the interpretivist paradigm was largely aimed at exploring and making sense of the Fourth Industrial Revolution phenomenon. Within the interpretive paradigm, the study followed an exploratory qualitative approach. The primary research method for this study was a scoping review which formed the basis for the development of two conceptual models. The main focus of the scoping review was on gaining a comprehensive understanding of the Fourth Industrial Revolution and the implications thereof for South African universities, with specific reference to teaching and learning as one of the core functions of a university. A protocol with predefined search strategies and terms was used to search publishers' databases for relevant resources. Development of the

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conceptual models commenced after conducting a broad review of literature by consulting peer-reviewed journal articles, books/monographs, conference papers and other relevant resources, to identify and outline the core concepts and possible relationships in the different models.

The result of this study could point to developing better practices towards equipping students with the required skills, thus improving graduates' future success in the Industry 4.0 workplace. The conceptual models and findings provide a transformation roadmap - giving direction in preparing the future workforce and initiating a new *University 4.0.*

Key words:

Fourth Industrial Revolution; 4th Industrial Revolution; Industry 4.0; Universities; University 4.0; Higher education; Teaching and Learning; Skills; Skills 4.0

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OPSOMMING

Die Vierde Industriële Revolusie (Nywerheid 4.0) is 'n komplekse fenomeen. Die transformerende aard daarvan hou implikasies in vir Suid-Afrikaanse universiteite, studente en die werksplek. Kunsmatige intelligensie, masjienleer, outomatisering en digitale tegnologie, onder andere, het die wêreld van werk verander. Gevolglik het wanverhoudings tussen gegradueerdes se vaardighede en werkplekvereistes ontstaan, wat die reeds hoë vlakke van werkloosheid in Suid-Afrika vererger. Universiteite wat nie aanpas by die spoed van innovasie nie, sal in die toekoms nie meer relevant wees nie. Wat die universiteit se kernfunksie, onderrig en leer, betref, sal 'n radikale hersiening van huidige kurrikulums en pedagogie nodig wees, insluitende die tegnologiese verryking van onderrig- en leerpraktyke. Die vraag is dus hoe die sleutelfunksies van Suid-Afrikaanse universiteite, veral dié wat verband hou met onderrig en leer, getransformeer sal moet word om die toekomstige werksmag vir die Vierde Industriële Revolusie beter toe te rus en voor te berei.

Die doel van hierdie studie is dus om 'n omvangsbepaling te onderneem om hierdie vraag in meer diepte te ondersoek en moontlike scenario's van verandering voor te stel. Gekoppel aan bogenoemde, hou die subdoelwitte wat die studie onderskryf verband met die bepaling van die rol van Suid-Afrikaanse universiteite in die voorbereiding van die toekomstige werksmag. Addisioneel is daar gefokus op die ontleding en identifisering van sleutel-temas en -terme om die bevindings saam te vat en te groepeer. Die eksplorasie van die navorsingstudies en meer spesifiek navorsing oor innoverende onderrig- en leerpraktyke is gemik op die ontdekking van nuwe innoverende maniere om studente beter voor te berei en toe te rus met die nodige vaardighede vir toekomstige werksgeleenthede in die Industrie 4.0 werkplek. Die resultate is gebruik vir die ontwikkeling van konseptuele modelle wat as 'n skematiese voorstelling van die bevindinge wat voortspruit uit die omvangsbepaling, dien. Hierdie modelle kan transformasie en innovasie wat relevant is vir Suid-Afrikaanse universiteite, veral ten opsigte van onderrig en leer, inlig om hulle toe te rus om die toekomstige werksmag vir die Vierde Industriële Revolusie beter voor te berei.

Hierdie nie-empiriese studie het die menslike kapitaalteorie as teoretiese raamwerk gebruik. Die studie is gedoen binne 'n interpretivistiese paradigma aangesien dit hoofsaaklik daarop gerig is om die Vierde Industriële Revolusie-verskynsel te ondersoek en beter te verstaan. Binne die interpretatiewe paradigma het die studie 'n verkennende kwalitatiewe benadering gevolg. Die primêre navorsingsmetode vir hierdie studie was 'n kwalitatiewe bestek-oorsig wat die basis gevorm het vir die ontwikkeling van twee konseptuele modelle. Die hoof-fokus van die omvangsbepaling-resensie was om 'n omvattende begrip van die Vierde Industriële Revolusie en

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die implikasies daarvan vir Suid-Afrikaanse universiteite, met spesifieke verwysing na onderrig en leer, as een van die kernfunksies te ontwikkel. 'n Protokol met voorafbepaalde soekstrategieë en terme is gebruik om as riglyn te dien vir soektogte na relevante studies op uitgewersdatabasisse. Die ontwikkeling van die konseptuele modelle is gebaseer op die analise en interpretasie na 'n breë oorsig van die beskikbare navorsingstudies bestaande uit tydskrifartikels, boeke/monografieë, konferensie verrigtinge en ander relevante bronne gedoen is. Daar is gepoog om die kernbegrippe en moontlike verhoudings in die verskillende modelle te identifiseer, illustreer en te omskryf.

Die resultate en bevindinge van hierdie studie kan ‘n bydrae lewer tot die ontwikkeling en daarstelling van innoverende en verbeterde praktyke om studente met die nodige vaardighede toe te rus, en sodoende die sukses van gegradueerdes se indiensnemings mootlikhede in die toekomstige Vierde Industriële Revolusie werkplek verbeter. Die konseptuele modelle en bevindings bied 'n transformerende padkaart en kan as 'n rigtingaanwysing dien ter voorbereiding van die toekomstige werksmag en die inisiëring van 'n nuwe *Universiteit 4.0*.

Sleutelwoorde:

Vierde Industriële Revolusie; 4de Industriële Revolusie; Nywerheid 4.0; Universiteite; Universiteit 4.0; Hoër onderwys; Onderrig en leer; Vaardighede; Vaardighede 4.0

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"NEVER STOP DREAMING,
NEVER STOP BELIEVING,
NEVER GIVE UP,
NEVER STOP TRYING,
AND
NEVER STOP LEARNING".

- Roy T. Bennett

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LIST OF ABBREVIATIONS AND ACRONYMS

4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
ICT	Information Communication Technology
HE	Higher Education
MOOCs	Massive Open Online Courses
OERs	Open Educational Resources
PSD	Professional Staff Development
RQ	Research Question
S-RQ	Subsidiary Research Question
S-RQs	Subsidiary Research Questions
STEM	Science, Technology, Engineering, Mathematics
WEF	World Economic Forum

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CHAPTER 1
INTRODUCTION

Throughout history industrial revolutions demonstrated one commonality, namely, societal transformation that occurred as a result of new technological breakthroughs (Schwab, 2017). Further to this, every industrial revolution has significantly changed the substance of work, affected higher education (HE) and more specifically impacted on the preparation of the future workforce (Sakhapov & Absalyamova, 2018). The First Industrial Revolution moved work from manual to machine labour, by innovatively using water and steam power. This prompted the *en masse* rise of new occupations and mechanisation of production (Kodama, 2018). In turn, the Second Industrial Revolution was characterised by another incredible leap forward in innovation and societal urbanisation. Mass production, assembly lines[1] and electrical power caused rapid improvement of the operations of the cutting-edge enterprises, introducing electricity, design, aeroplanes, avionics, synthetic industry and mechanical engineering (Sakhapov & Absalyamova, 2018). As a result, as Sakhapov and Absalyamova (2018) explain, these innovations increased the interest in science and engineering, augmenting the demand for skilled workers in these domains. The Third Industrial Revolution ushered in electronics and computers, leading to innovative computerised processes (Kodama, 2018). Within the Third Industrial Revolution, the extension of access to HE became even more prominent resulting in considerably expanded campus diversity, in addition to the accelerated globalisation of scholarly studies through digital technologies with an increased demand for training service professionals (Sakhapov & Absalyamova, 2018).

From the advent of the Fourth Industrial Revolution (4IR) (Schwab,2016), there have been controversy and conversations around this complex phenomenon, best described as a combination of technologies “blurring the lines between man and machine” (Schwab, 2016:156). According to Martin (2018), this unclear and complex image will remain confusing as the 4IR accelerates; the only clear picture at this stage is that digital skills will become more and more important in the world of work.

[1] Assembly line is a process in manufacturing where the incomplete item proceeds between workstations until the item is completed.

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What becomes apparent with the commencement of every successive Industrial Revolution, is the need for new skills (talents) - as complexity increases, as McGowan, (2017) illustrates in Figure 1.1.

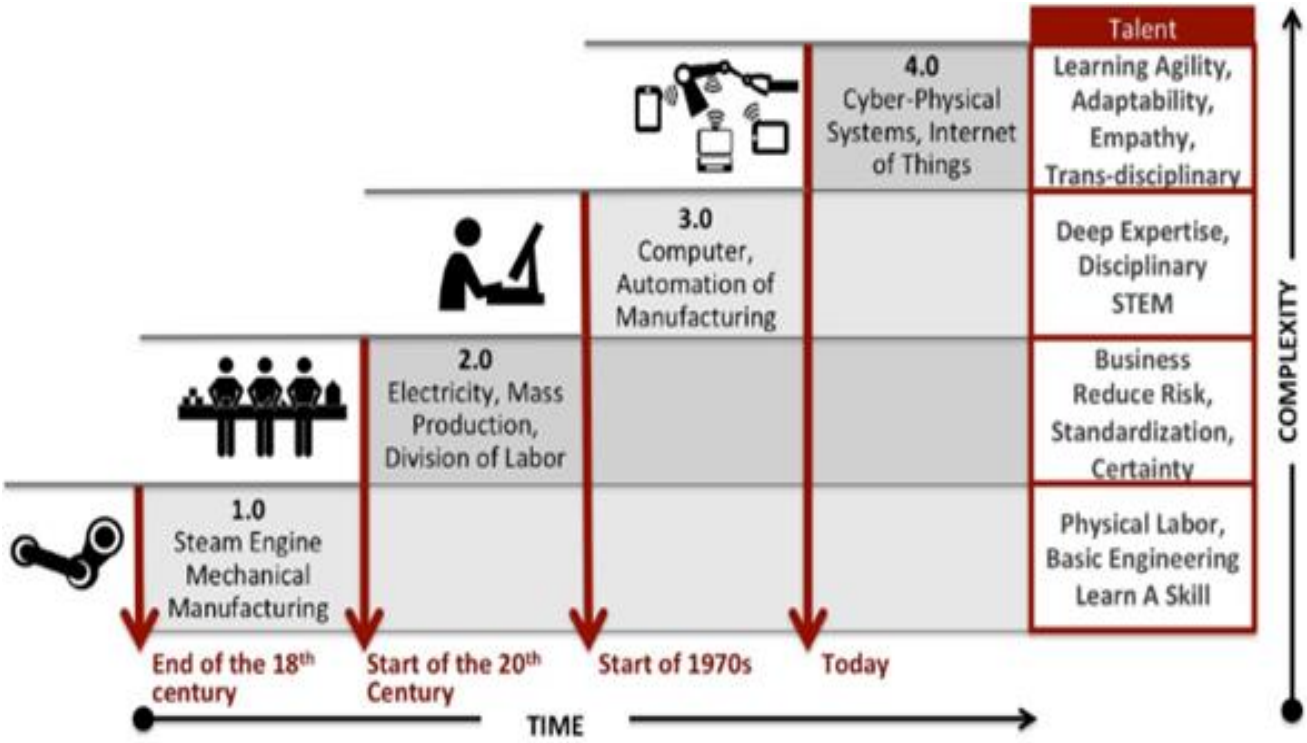

FIGURE 1.1: Learning new skills with every new industrial revolution (McGowan, 2017:2)

The 4IR has universal and transformative requirements, such as codifying and programming, implanted into artificial intelligence (AI) systems, that will supplant and reshape human work practices (Lee, Yun, Pyka, Won, Kodama, Schiuma, Park, Jeon, Park, Jung, Yan, Lee & Zhao, 2018). In the South African context, the 4IR promises to be even more challenging and complex.

1.1 BACKGROUND

South Africa is currently faced with huge challenges around unemployment, poverty and inequality, exacerbated by a slowing economy. However, there is yet another force South Africa needs to prepare for to prevent even further aggravation of social injustice (Naudé, 2017). Having been brought about by the rapid development of disruptive digital technologies as mentioned above, the 4IR, also known as Industry 4.0, is a reality. Acknowledging this force,

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South Africa's President Cyril Ramaphosa announced in early 2018, in the State of the Nation address, that a Digital Industrial Revolution Commission would be constituted to investigate the 4IR (Ramaphosa, 2018). According to Chetty (2018), an acknowledgement of the implications of digital technology and of the necessity for a broader approach in overseeing and dealing with the effect of such advancements contributes to the uncertainty of what the future holds. Deloitte (2018) posits that the shift to Industry 4.0 involves the capacity to embrace and incorporate digital technologies to innovatively improve practices and increase productivity to remain sustainable and competitive. This digital transformation process will be unavoidable, as every single business will be affected. Therefore expectations are that the 4IR will similarly have a significant effect, on the core functions and operations of universities, as well as on future graduate employability (Xing & Marwala, 2017).

In recent decades, it has been observed that digitisation, automation, robotics and AI, powered by technology, have transformed the workplace (Brynjolfsson & McAfee, 2016). Tasks previously conducted by humans have now been taken over by automatons, with high efficiency (Schwab, 2017). Over time, this phenomenon is set to evolve still further, with machine learning, AI and robotics already starting to replace white-collar jobs previously held by humans (Ford, 2015).

In addition, the 4IR has an impact on business models across industries, causing disturbances and mismatches between supply and demand in the workplace (Preble, 2017). New forms of employment and new occupations are predicted to arise, partially or entirely uprooting others (Smith & Pourdehnad, 2018). In most sectors, the skill sets needed in both old and new jobs will alter and transform how and where individuals operate and work (WEF, 2016). According to Naudé (2017:13), 90% of South African corporate executive officers have in a recent survey indicated their concern regarding the "lack of availability of key skills on their organisations' performance". To avoid a future of potential graduate redundancy, two crucial questions need to be asked by South African universities: "What work will tomorrow's professionals do, and what are we training them to become?" (Susskind & Susskind, 2015:232).

Xing and Marwala (2017) confirm that graduates now require skills that were not required a decade ago. McGowan (2016) reflects this phenomenon in yet another way by pointing out the importance of students now having to possess learning agility: "the ability to learn, adapt and apply in quick cycles" (McGowan, 2016:1). Moreover, to keep pace with the ever-changing cycle of "creative destruction" (Schumpeter, 1942), students will no longer reach what was previously

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referred to as a ‘finished’ state of ‘being educated’: “lifelong learning will become a permanent part of [their] professional lives” (Sledge & Fishman, 2014:12). According to Fortier (2016:1), the greatest challenge for HE lies in preparing students for future jobs by equipping them with knowledge, expertise and skills that will “serve them long-term”.

As the above-mentioned changes continue transforming the global scene and the workplace, the implications of the 4IR for HE need to be carefully considered. As far as universities’ core function of teaching and learning is concerned, the 4IR will require a radical reconsideration of current curricula and pedagogy, including the enhancement of teaching and learning practices with digital technology and its affordances (Penprase, 2018). As the need for technologically skilled and employable graduates will rapidly increase (Preble, 2017), Jackson (2017:933) argues that universities are not only obliged to provide students with a quality degree but are also responsible for adequately “connecting students with external practice”. In addition, Sledge and Fishman (2014) stress the importance of universities shifting their focus from student output to student outcomes and graduate success in dealing with the challenges linked to employability in the Industry 4.0 workplace.

Employability spans the intersection between universities and the workplace. Hence, employability includes the skills, qualities and attributes that enable graduates to find beneficial opportunities in the labour market, thus contributing to sustained development and growth (Stokes, 2015). In a knowledge economy, universities are directly connected to economic growth through the abilities and efficiency of graduates (Duc, 2017), on account of the particular high-level skills which graduates obtain (Preble, 2017).

Whilst universities have mostly retained a distinct academic focus where the emphasis is on student success towards graduation, this focus now needs to shift towards “a mixed model driven both by subject discipline and external context”, which includes the labour market and 4IR demands (Wilson, Lennox, Hughes & Brown, 2017:33). Moreover, the World Economic Forum (2019) predicts that the rapid progress of technology will require an unprecedented rate of change in what universities offer, as the traditional qualification and curriculum content will render subject knowledge redundant before the student’s graduation. In light of this, Preble (2017) contends that graduates, who are deficient in skills and technologically ineffectively trained, are ill-prepared for future employability, resulting in unemployment, or having to settle for low-wage occupations with minimal possibilities for upward mobility.

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Against this backdrop, researchers argue that there are many incongruities between the skills that Industry 4.0 requires, and the training that most universities currently offer (Preble, 2017; Penprase, 2018; Gleason, 2018). Similarly, the World Economic Forum (2018), emphasises that the current sought-after skills in the employment market are vastly different from those of even five years ago. Consequently, many skills mismatches arise, not only in supply and demand in the current situation, but also in terms of future skills requirements (Martin, 2018).

Mismatches between graduate skills and workplace requirements can hardly be afforded in a country with such high levels of unemployment as South Africa, with 6.7 million of the South African population being unemployed in the first quarter of 2019 (STATS SA, 2019). Of the 6.7 million unemployed individuals, 6.9% had professional qualifications as their highest level of education (STATS SA, 2019). Nearly one third of this professionally qualified but unemployed group are young people under the age of 24. Accordingly, the lack of skills and its widening effect on the wage gap in South Africa are demonstrated by what is happening in the employment market where those with digital skills earn high remuneration while those without digital skills are left behind (STATS SA, 2018). Therefore, Chetty (2018) reiterates that South African universities need to be proactive in finding innovative approaches to address concerns regarding the current digital divide. Moreover, such digital skills mismatches will exacerbate even further if universities procrastinate in responding to these digital demands, as shown in the Future of Jobs Report (WEF, 2018). This suggests that South African universities should be rethinking their programme offerings and pedagogy and not be caught unprepared for confronting an uncertain and unpredictable technologically-driven future (Gleason, 2018). A prerequisite for this to happen is an in-depth understanding of the implications of the 4IR for South African universities.

While the argument above focuses strongly on the implications for HE in terms of graduate employability, it is important to acknowledge that universities have a much broader role than simply training graduates for the workplace. Public universities, particularly, have a common good role, implying that graduates also need to be prepared to become active, critical and caring citizens within their families, communities and the broader society. For the purpose of this research project, the focus is, however, primarily on the role of the university in preparing the future workforce.

The aim of this study is therefore to explore and examine the implications of the 4IR for the key functions of South African universities, particularly those functions related to teaching and

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learning, and how they need to be transformed to better equip and prepare the future workforce. In order to achieve this aim, a scoping review was done. Scoping reviews have proven to be a useful tool to provide clarity on such a broad research topic (Boland, Cherry & Dickson, 2017).

Two conceptual models were developed as representations of the findings from the scoping review: firstly, on a macro level, a conceptual model covering the core functions of a future South African university was developed. The model indicates those functions that will be most affected by the 4IR, placing the university as a whole into a future context. Secondly, on a micro level, a conceptual model was developed of the future teaching and learning practices, focused on the preparation of graduates for the future workplace.

This study is significant in that the 4IR is a new phenomenon. Its influences on South African universities and the required skills for graduates to be prepared for the new Industry 4.0 workplace have not been exhaustively researched in South Africa.

1.2 PROBLEM STATEMENT

The 4IR differs in speed, scale, complexity, and transformative power from previous industrial revolutions (Smith & Pourdehnad, 2018). Owing to, amongst others factors, globalisation and the rapid evolving of new digital technologies, some careers are becoming obsolete and being replaced by new ones, causing the changing face of work and increased unemployment rates (Preble, 2017). According to Statistics South Africa (2019), the unemployment rate of graduates in South Africa in the young graduate age group (up to the age of 24), was 31% in the first quarter of 2019. By implication, this means that 1 in 3 young professional adults in South Africa did not obtain employment in the first quarter of 2019 (STATS SA, 2019).

In light of these statistics, South African universities, as producers of graduates with high-level skills, need to take heed of the imperative to better equip and prepare graduates for the opportunities of tomorrow and future employment in the Industry 4.0 workplace. For this to happen, transformation of higher education and in particular teaching and learning, is inevitable (Adams Becker, Brown, Dahlstrom, Davis, DePaul, Diaz & Pomerantz, 2018).

The following research questions were derived taking into consideration the need for a better understanding of the 4IR and its influence on South African universities.

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The main research question that guided the study was:

> How should the key functions of South African universities, particularly those related to teaching and learning, be transformed to better prepare the future workforce for the 4IR?

The following subsidiary questions were identified:

1) What is the role of South African universities in preparing the future workforce for the 4IR?

2) Which key themes related to the implications of the 4IR for South African universities can be identified from relevant literature?

3) What innovative teaching and learning practices to better prepare and equip students with the required skills for future jobs in the Industry 4.0 workplace can be identified from relevant literature?

4) Which conceptual models (consisting of key functions and assumed relationships between these functions/practices), can be proposed for South African universities and particularly their teaching and learning function, to better prepare the future workforce for the 4IR?

This study's findings could contribute to theory, policy and practice. The suggested changes to traditional higher education approaches, as proposed by these conceptual models, may serve as a starting point for South African universities to better prepare the future workforce for the 4IR.

1.3 RESEARCH METHOD: SCOPING REVIEW

A scoping review can be characterised as a research method to thoroughly investigate the available research on a specific topic. Scoping reviews and systematic reviews pursue similar methodological avenues where trustworthiness of results and the potential for replication remain essential. Since a scoping review allows for a broader research question than a systematic review, it was selected as a suitable research method for this study. Accordingly, this scoping review implemented the five phases[2] from Arksey and O'Malley (2005) as guideline in

[2] See elaboration on the five phases in Chapter Three.

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conducting the review. While the scoping review was valuable in identifying research gaps and summarising findings, it also proved useful in reviewing and selecting the most relevant amongst a variety of available sources on the 4IR (Boland *et al.*, 2017).

Four key search concepts were identified, which guided the retrieval of studies from the different database literature searches; these search concepts are as follows: (1) 4IR, (2) universities, (3) teaching and learning, (4) and skills. For the purpose of this scoping review, skills are regarded as inclusive of workplace employability and unemployment, because the lack of skills will result in unemployment due to the demands of the future workplace or the opposite. The scoping review aimed at attaining an overview of the range and depth of available studies, opinions and conference proceedings, to name but a few. Furthermore, the review intended to gain an understanding of the phenomenon under investigation, namely, the 4IR, its challenges and implications for HE, in order to put the exploration of this study into context, hence, finding the 'what' and 'how' answers to the research questions in order to better prepare the future workforce. The outcome was the development of conceptual models through which the relationships between the identified themes and concepts are examined and presenting a logical flow of findings in fulfilment of the aim of this non-empirical study. Providing a review of studies, themes and concepts at this stage would be premature and result in duplication, as this will be dealt with and discussed in subsequent chapters.

1.4 LIMITATIONS OF THE STUDY

Given that the scoping review was performed as part of a mini-thesis, and the review was an individual assignment, two major limitations were time constraints and the fact that no consultations were held with stakeholders to verify results and findings, as suggested by Arksey and O'Malley (2005). More limitations are deliberated on in the next chapter; challenges with specific reference to the scoping review itself are discussed in Chapter Three and limitations to the overall study are dealt with in Chapter Six.

1.5 ETHICAL CONSIDERATIONS

It is important for a researcher to consider the ethical risks that might ascend in the course of the study. Although any ethical risks for this study were considered as very low, a formal ethical clearance application was submitted and granted by Stellenbosch University (see Annexure D).

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1.6 CLARIFICATION OF KEY CONCEPTS

As the 4IR is perceived as complex, key concepts used in the frame of reference are defined below.

1.6.1 Artificial intelligence and automation

AI is a rapidly progressing technology that has a significant impact on humans' daily lives through the artificial creation of human intelligence capable of reading, thinking, planning, perceiving and manipulating natural language (Internet Society, 2017). AI influences highly skilled graduate jobs and also what it means to be employable, while automation means that humans are replaced by machines in that the jobs that were previously done by humans are now done by machines (Neufeind, O`Reilly & Ranft, 2018). AI is disrupting the workplace intensely by not only automating a large number of jobs but also altering the nature of jobs which in turn will require specific skills to execute (Corfe, 2018). However, AI is likely to create more opportunities to apply general capacities in the future, translating into multidisciplinary robotic work and more human-conscious software solutions (WEF, 2017a).

1.6.2 Big data

Big data is a term describing an extreme volume of data, both structured and unstructured information or data-sets (Carillo, 2017). In South Africa, big data is having an effect on almost every sector of the economy. In agriculture, big data is utilised to increment operational productivity. In financial services, the application may be utilised to improve deals and streamline processes. In health care, big data is connected to the discovery of cures for diseases, and enhancing the general quality of life, amongst others aspects (Pellini, Weyrauch, Malho & Carden, 2019). Big data can be defined in terms of the three 'v's: volume, variety, and velocity; however, recently, two more 'v's were added: value and veracity (Brynjolfsson & McAfee, 2016:11). As a result, technologies such as big data and analytics have increased the demand for graduates with adequate creative, engineering, analytic, or digital skills (Schwab, 2017).

1.6.3 Machine learning

Machine learning is not new and can be categorised as an AI method as it "involves algorithms that are fundamental to the viability of AI" (Smith & Pourdehnad, 2018:22). Machine learning is also a sub-field of computer science. Inferring and understanding

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new commands from data is the key strong point of machine learning. It investigates and analyses data, does the math, gains from it, and utilises it to make a prediction, depending on the situation. The machine is being prepared, or truly preparing itself, on the most proficient method to perform an assignment accurately then learning from the data and building its very own logic in providing solutions (Internet Society, 2017). In other words, machine learning permits computers to learn unaided and more quickly than any human can.

1.6.4 MOOCs

Massive open online courses or so-called MOOCs are online courses that provide open access to and unlimited participation in a variety of training courses that could include practical exercises and interactive support forums (McLaughlin, 2016). Whether gratis or simply cost effective, these courses appeal to students, mainly on account of the easy accessibility thereof. Students have the freedom of where and when to do the course and on which device (Aziz Hussin, 2018). MOOCs are also popular under the employed population as a continuous learning opportunity (Bates, 2015).

1.6.5 OERs

Open educational resources (OERs) are freely available educational resources and cover a comprehensive collection of digital content and online formats that are supportive of educating, learning and research purposes (Bates, 2015).

1.6.6 Robotics

The field of robotics is a vital sphere of influence in which the impact of the 4IR can be seen. Here there is a rapid augmentation in digital development - building machines that can explore and operate in the physical world of factories. Such robotics also relate to health care where precise operations are being performed on patients, self-driven cars, and the use of robots in warehouses, war zones, and workplaces, to name only a few uses (Brynjolfsson & McAfee, 2016).

1.6.7 Skills

In this study skills refer to those special attributes and competencies required to enhance the employability prospects of a graduate (WEF, 2016). In the new workplace, acquiring these scarce abilities or skills will have a direct impact on the actual

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employment outcome. Such skills acquisition refers not only to the ability to apply successfully for a position after graduation, but also to maintain it, and to be transferable and adaptable to other, new positions (Neufeind *et al.*, 2018). It must be taken into account that a number of elements, namely economic interference, Industry 4.0, work shortages or the end of jobs, inadequacy of skills, or the combination thereof, influence employment or technological unemployment (Brown & Keep, 2018).

In other words, skills refer to those abilities and traits that are inculcated by universities, which mirror the nature of self-awareness and knowledgeable improvement of graduates, and the pertinence they convey to the work environment (Adams Becker *et al.*, 2018). Those skills that encourage adaptability within uncertain and fluctuating conditions are regarded as the most crucial skills in the workplace (Lent, 2018).

1.7 SIGNIFICANCE OF THE STUDY

This study is significant in that the 4IR is a new and relatively unknown phenomenon. Its influences on South African universities and implications for the required skills for graduates to be prepared for the new Industry 4.0 workplace have not been researched adequately in South Africa.

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1.8 CHAPTER OUTLINE

This thesis comprises six chapters. The content of each chapter is summarised below:

Chapter One introduces the study and describes the problem. It continues by providing the overall research aim, objectives and the main research question with the subsidiary research questions, as well as the clarification of key concepts and the significance of the study.

Chapter Two presents the research design and methodology, in addition to justifying the reason for using a qualitative approach based on the findings of a scoping review. It explains the approach to analysing the collected data for the present study. It also points out the overall limitations of the study as well as the ethical considerations involved.

Chapter Three provides a detailed description of the methods used for the scoping review and the effect thereof on the final sample of studies. This chapter outlines the main themes and sub-themes that emerged from the scoping review. It also provides the principal findings and the strengths and limitations of the scoping review itself.

Chapter Four delivers an overview of the findings from the scoping review on the profile of South Africa as a country regarding the employability scope, the future workforce, the future workplace and future careers. This chapter also describes the skills needed to succeed in this new Industry 4.0 workplace, identified through the scoping review in the previous chapter.

Chapter Five outlines the conceptual approach in developing the two proposed models for this study. Furthermore, this chapter elaborates on and illustrates the relationships between the identified themes and sub-themes of the thematic analysis to explain in more detail the extracted data introduced in Chapter Three.

Chapter Six is the concluding chapter, which summarises the findings of this study. It also highlights implications within the South African context and provides recommendations for future studies.

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CHAPTER 2
RESEARCH METHODOLOGY

2.1 INTRODUCTION

This chapter discusses the theoretical background, research methodology and design that were tailored and applied for this non-empirical study. A discussion of the data collection method and the reasons for using a scoping review and conceptual modelling approach also form part of this chapter. Important matters regarding the inclusion and exclusion criteria of identified studies, as outlined in the scoping review protocol, data analysis methods and matters of reliability and trustworthiness are deliberated. The research objectives that aim to address the research questions are proposed, placing the overall research motivation of this study into context. Finally, limitations experienced throughout the duration of the study and the ethical considerations of the study conclude this chapter.

2.2 THEORETICAL FRAMEWORK

During the 4IR human beings with digital skills will become a valuable and sought-after asset when competing with robots in a dramatically and fundamentally changed world of work (Kupe, 2019). In this modern and technology-driven era, economic progress is based on the fast processing of data, the implementation of digital technologies and the development of human capital (Schwab, 2016). In the 4IR, a human being's unique abilities, expertise and knowledge will become the primary and substantial asset in remaining robot-proof (Aoun, 2017). These developments can be interpreted in various ways, depending on the theoretical framework adopted by the researcher. The two theoretical frameworks found to be most related to the 4IR and its implications for HE is human capital theory and human development theory (Tomer, 2016). These theoretical frameworks are briefly introduced below, followed by my argument for adopting human capital theory as theoretical framework for this study.

2.2.1 Human capital theory

Human capital theory [3] originated in the 1700's when Smith (1776) claimed that education forms the basis of human capital in every society, allowing and sustaining economic growth. Smith (1776) determined that the acquisition of valuable skills and knowledge by one nation's inhabitants increases individual human capital, while at the same time increasing the general

[3] First coined by Adam Smith in his book: Wealth of Nations in 1776.

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wealth of that nation. Kupe (2019) therefore argues that universities, globally and in South Africa, are expected to contribute to the advancement and development of their societies by investing in their graduates. In this regard, government, the private sector and students themselves are investing in the acquiring of human capital through, for example, a relevant university education (Alan, Altman & Roussel, 2008). This needs to be supported by teaching and learning policies that produce excellently educated, emotionally intelligent students equipped with adequate skills for the 4IR workplace (Kupe, 2019).

A standard definition could not be found to define human capital. The definition varies amongst studies. Rastogi (2000) used words meaning knowledgeable, highly skilled, driven and innovative, Maringe (2015) adds entrepreneurship and Davidsson and Honig (2003) incorporate a creative mind exploring and making new discoveries, into the mix. According to Baptiste (2001) the term *human capital* refers to understanding, mind-sets, and abilities that are mainly open to and appreciated for their economic potential. Be that as it may, these are all qualities that are most wanted and relevant in the 4IR domain. Human capital theory also has a profound impact on a variety of other disciplines ranging from education to humanities and social science, amongst others. Human capital theory is therefore seen as a comprehensive approach to analysing human affairs and recommending policies according to a particular viewpoint (Tan, 2014). Furthermore, human capital theory is perceived as the dominant paradigm on the financial side of HE, suggesting that efficient training and development are investments that can greatly contribute to graduates being more successful (Maringe, 2015). Sledge and Fishman (2014) confirm this, pointing out that students' reasons for enrolling at universities have changed as employability is now an important and decisive factor in their decision to enroll at university. Tan (2014) agrees and places HE at the core of the human capital theory approach, as it primarily seen as the source of economic growth (Tan, 2014). Human capital theory propounds that higher academic levels result in increased productivity and higher income (Tomer, 2016). However, Olaniyan and Okermakinde (2008) caution that HE is an economic benefit because it is difficult to obtain and therefore should not fail by adding little value or no skills.

The theory of human capital has been subject to consistent criticism since its inception. Tan (2014:427-428) lists the following shortcomings of human capital theory. The first shortcoming concerns the boundaries of economics as a discipline. The reality is that there is a multidisciplinary element in all subjects and in the 4IR it is desirable to eliminate such boundaries. However, the manner in which knowledge and expertise are exchanged at this multidisciplinary level should hold shared advantages for all participating disciplines. It should

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not be a top-down or economics-orientated superiority strategy, which is what economics is criticised for. The second shortcoming is integrally connected to the first; it is asserted that HE is being regulated merely as an additional section of industry. Thus, HE is no longer seen as an integrated tool for fostering independence, self-enrichment and human development, but rather as a profit-driven enterprise. Further criticisms on human capital theory relate not only to the economic domination and infiltration to try and steer other subject fields. Criticism has been levelled on how human capital theory has focused HE on company requirements and regarding HE as a financial uncertainty survival instrument.

In addition, Baptiste (2001) discloses human capital theory's experiential and theoretical shortcomings. These include, for example, the excessively one-dimensional perspective on individuals of the theory, its limited understanding of employment, the contradictory nature of its scientific proof, and the statistical barriers connected with measuring return on capital in HE, amongst others. Some critics believe that this theory was based on a limited insight into human development (Alkire and Deneulin, 2009). Tomer (2016) posits that, for the most part, human capital theory has highlighted human cognitive growth and the acquisition of knowledge and skills that allow for increased productivity and income but then has focused far too little on non-cognitive human development.

2.2.2 Human development theory

Human development theory is known for its focus on increasing the abilities of individuals and offering them the chance to develop, whether at work or in a private capacity. Human development theory extends beyond the human capital theory organisational boundaries, leading to the liberty of individuals to choose where and how they would like to work or live (Welzel, Inglehart & Klingemann, 2003). Furthermore, Alkire and Deneulin (2009) indicate that human development theory considers all areas of life - financial, social, and cultural. Hence, economic growth is perceived as merely a small segment of the overall concept of human development. Tomer (2016) elaborates that human development theory was largely influenced by Maslow's (1943) humanistic psychological view, in particular, his needs hierarchy (Maslow, cited in Tomer, 2016:4).

According to Welzel *et al.* (2003), three significant equations of revolutionary change occur in human development theory. The most important is socio-economic development which can be defined as a collection of strongly related modifications, including technological change, innovation, productivity growth, increased life expectancy, higher incomes, higher education

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levels and access to big data. The second equation, value change, correlates with the concept that conventional values of compliance subordinating human freedom to the morality of the society tend to give way to more emancipatory values that accentuate human decision. The last equation is a notable shift towards more democracy (Welzel *et al.*, 2003).

Integrating the human development and human capital approaches, as suggested by Tomer (2016), could enhance and broaden the human capital approach, as underpinned by Robeyns (2006). In an uncertain 4IR epoch, in which human beings will face complexity on a daily basis, the three-sided human development theory pyramid (Figure 2.1) could be crucial in surviving automation.

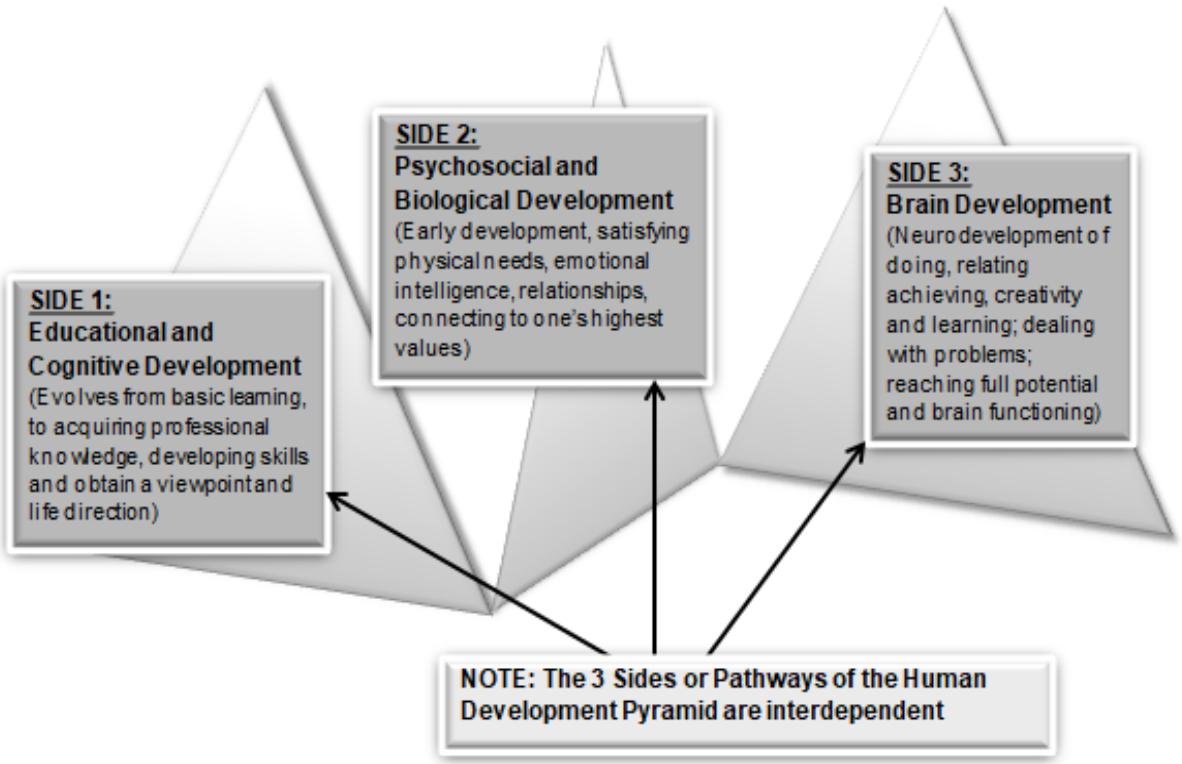

FIGURE 2.1: The three-sided human development pyramid (adapted from Tomer, 2016:6-10)

The first side of the above pyramid reflects the development of higher skills and knowledge, thus an educational path. The second side includes the development of psychological and social aspects that could lead to better and much sought-after emotional intelligence and

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enhance personality traits, a path that recalls the hierarchy of needs of Maslow. The third side involves the neurodevelopment of a person, that assists in dealing with disruptive and stressful situations (Tomer, 2016). Thus, the pyramid concept provides an important guideline for understanding how different types of human capital investment can help the individual develop in various aspects of their lives to reach their full potential.

2.2.3 Human capital theory and conceptualisation of the 4IR

Despite the limitations and criticisms of the human capital theory, this concept was nonetheless considered the most suitable as theoretical framework for this study. In the 4IR context, Tan (2014) highlights that HE needs to enhance students' abilities, adaptability, and mobility, at least in theory, which will in turn decrease technological unemployment. One of the 4IR's imperatives is to improve human capital in order to satisfy the workplace demands of expertise and ability (Diwan, 2017). Olaniyan and Okermakinde (2008) caution that the assumption that HE is contributing to the developmental needs and economic growth of every country, depends on the quality and success of their graduates. Schwab (2016) emphasises that investing in human capital, through upskilling and reskilling the current workforce, will be crucial. It will therefore also be inevitable for universities to contribute to economic growth through preparing the future workforce in order to remain sustainable (Schwab, 2016). Busteed (2019) agrees, and stresses that having already incurred substantial student debt, the future workforce expect return on their investment. This entails being prepared for and employable in the 4IR workplace, thus receiving a good income to provide for their needs and own well-being. Furthermore, the World Economic Forum White Paper (2017) advances a shared view of reform priorities in HE, employment prospects and assisting leaders in promoting human capital investment in the context of the 4IR. In the words of Marshall (1920:626), "the most valuable of all capital is that invested in human beings”.

2.3 RESEARCH METHODOLOGY

An interpretive paradigm was adopted for this study. This implies a philosophical stance that concentrates on investigating and exploring the social world to gain a better understanding of phenomena (Gray, 2014:24). The role of the researcher in the interpretivist world view is to strive purposefully to unravel the reality of the circumstances within a particular contextual environment (Babbie, 2017). Thus, in this study the adoption of the interpretivist paradigm was largely aimed at exploring and making sense of the 4IR phenomenon. Moreover, the interpretivist paradigm has enabled the researcher to pursue an understanding of the

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implications of this technologically-driven world, exploring the various perspectives, and interpreting them to make meaning thereof (Creswell, 2007:21).

Within the interpretive paradigm, the study also followed an exploratory approach. Blumberg, Cooper and Schindler (2014) explain that an exploratory research approach is valuable in situations where the phenomenon is new and complex, and limited information is available. The exploratory research approach aimed at assessing the influence of the 4IR on universities. The study also investigated the preparation of the future workforce for the 4IR and the role therein of South African universities. This has incorporated the knowledge and skills students require for improved graduate employability.

This was a non-empirical study; non-empirical research is “interpretative, often involving aspects and processes that cannot be observed directly” (Du Plooy-Cilliers, Davis & Bezuidenhout, 2014:69). In view of this, the primary research methods for this study were a scoping review and conceptual modelling. Arksey and O’Malley (2005) propose that scoping review has become a popular methodology in providing an overview of an emerging phenomenon, defining concepts and addressing broad research questions.

A scoping review can be described as:

> a type of knowledge synthesis that addresses an exploratory research question directed at mapping main ideas or concepts, research findings and gaps linked to a specified field or subject area through the systematic search, selection and synthesis of current state of knowledge (Colquhoun, Levac, O’Brien, Straus, Tricco, Perrier, Kastner & Moher, 2014:1293).

The main focus of the scoping review was on gaining a comprehensive understanding of the 4IR and the implications thereof for South African universities. Specific reference was made to teaching and learning, as one of the core functions of a university. Chapter Three provides more details regarding the scoping review approach, inclusion and exclusion criteria and how studies were screened and selected.

Development of the conceptual models commenced after conducting the review of existing studies by consulting peer-reviewed journal articles, books or monographs, conference papers, and other pertinent sources, to identify and outline the core concepts and possible interactions within the different models. The key findings deriving from the scoping review were selected and used for designing the two conceptual models.

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According to Verschuren and Doorewaard (2010), a conceptual model is perceived as an informal and simplified presentation of a real life scenario. The terms “representation” and “model” are closely related to one another; professionals see a model as an illustration or representation of a concept.

A conceptual model can be therefore be defined as:

> schematic representation of the key ideas or concepts of a research study (variables) and the presumed causal relationships between these key ideas or concepts (Doorewaard, 2010:202).

The protocol[4] for the scoping review was developed by focusing on the five phases of Arksey and O’Malley (2005) for examining existing studies. The five phases are: (1) identifying the research questions, (2) searching for relevant sources and studies within the predetermined criteria, (3) screening titles and abstracts for selection, (4) extraction and charting of the data, and (5) collating, analysing, summarising, and reporting the resulted findings (Arksey & O’Malley, 2005; Levac *et al.*, 2010). The final analysis phase in the scoping review should include “a descriptive numerical summary and a thematic analysis” (Levac *et al.*, 2010:6).

Drawing from the findings of the scoping review, as previously mentioned, a step-by-step approach to the construction of the conceptual models was followed. The first conceptual model indicates those functions of South African universities that will be most affected by the 4IR. The second, more detailed conceptual model of teaching and learning was developed, indicating foreseen changes, transformation of practices and technological advancements that would better equip and prepare the future workforce for the 4IR.

The significance of a conceptual model lies in connecting the research with the real-world phenomenon, in other words creating intangible portrayals of reality. These portrayals or representations play an important role in illustrating those concepts of reality under investigation (Doorewaard, 2010). Since a conceptual model is a (simplified) reflection of the real world, it may seem less intricate than reality itself.

The “transparency, systematic methods, and comprehensiveness of a scoping review” validate efforts to avoid or reduce bias and ensuring trustworthiness (Hanneke, Asada, Lieberman, Neubauer & Fagen, 2017:5). Trustworthiness is all about ensuring credibility, transferability,

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[4] See Annexure A for the scoping review protocol

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confirmability and dependability, which are described in more detail below. In this study the researcher adhered to the clearly specified inclusion and exclusion criteria in the scoping review protocol and performed consistently in the application thereof to ensure that the findings are credible. Additionally, transferability is demonstrated by the criteria as described in the scoping review protocol that can be applicable to other similar contexts.

The scoping review protocol prescribes a transparent and rigorous approach to better understanding of a complex phenomenon, namely, the 4IR (Boland *et al.*, 2017). The scoping review protocol was reviewed by a qualified information librarian and by the supervisor to reduce selective publication, reporting bias and ensuring confirmability. The scoping review protocol further ensures the dependability of the study in that other researchers can replicate the search results by using the same clearly defined search syntax and arriving at similar results. In addition to this, the PRISMA flow chart, in Chapter Three, reveals the search results, screening and review process that was followed. Such a process demonstrates that integrity and reliability, as principles of trustworthiness, were thoroughly taken into account throughout the investigation. This scrutiny was particularly ensured regarding the reporting of the results and findings (Collier-Reed, Ingerman & Berglund, 2009). Using Mendeley, as a reliable reference management software tool ensured a well-organised, transparent and searchable data-set of relevant studies for the scoping review.

Creswell (2007) reiterates the importance of accuracy, appropriate data selection methods, and mitigation of researcher bias, as these factors could have a direct impact on the credibility of results. The researcher therefore took precautions in using the pre-developed scoping review protocol as guideline to ensure a reliable, accurate and usable research outcome. A Python programme (discussed in Chapter Three) was written to verify and present trustworthy data extraction results.

2.4 RESEARCH AIM AND OBJECTIVES

The field and scope of the 4IR in the context of HE is very wide and complex. Currently, a large degree of uncertainty around this phenomenon exists. This applies especially to identifying the implications of the 4IR for universities, and even more so, in the South African context. The same challenge exists as far as the core function of teaching and learning is concerned. The research objectives are viewed as the perceptible actions taken in achieving the overall aim of the study (Du Plooy-Cilliers *et al.*, 2014). By embracing these actions and working with the emerging themes and concepts from the scoping review, the findings were analysed, discussed,

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and presented in the conceptual models. These models would serve as an effort to accomplish the overall aim and intentions of this study, which is providing guidelines for transformation towards a University 4.0.

In light of achieving the research aim and objectives and placing the research objectives of this study into context, the main research question and subsidiary research questions of this study are recapped and displayed in Figure 2.1:

FIGURE 2.2: Main research question and subsidiary research questions of this study

In order to gain an understanding in searching for answers to the above research questions, suitable data sources had to be obtained. Consequently, for this study as previously introduced, the scoping review was deemed fit as the research method of application for the data collection phase. The collection of the secondary data included a broad range of relevant sources, both print and online sources.

Deriving from the above-mentioned research questions and main aim of this study, the following research objectives were formulated in such a way as to address these particular questions.

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TABLE 2.1: Research objectives, methods and data sources

MAIN RESEARCH QUESTION	**MAIN RESEARCH AIM**
RQ	To conduct a scoping review and to explore and examine how the implications of the 4IR will influence the key functions of South African universities, with specific reference to teaching and learning, in the preparation of the future workforce for the Industry 4.0 workplace
Method	Non-empirical: Scoping Review
Data sources	Secondary data: Books, journal articles, conference proceedings, publications, reports and grey literature
SUBSIDIARY RESEARCH QUESTIONS	**SUBSIDIARY RESEARCH OBJECTIVES**
S-RQ1	To determine the role of South African universities in preparing the future workforce for the Fourth Industrial Revolution
Method	Non-empirical: Scoping Review
Data sources	Secondary data: Books, journal articles, conference proceedings, publications, reports and grey literature
S-RQ2	To review, analyse and identify key themes from the results, in order to summarise and group findings together
Method	Non-empirical: Scoping Review
Data sources	Themes and concepts from the results of the scoping review
S-RQ3	To explore the literature and published research on innovative teaching and learning practices to better prepare and equip students with the required skills for future jobs in the Industry 4.0 workplace
Method	Non-empirical: Scoping Review
Data sources	Secondary data: Books, journal articles, conference proceedings, publications, reports and grey literature
S-RQ4	To develop conceptual models as a representation of the findings deriving from the scoping review, that will facilitate transformation and innovation relevant to South African universities and particularly teaching and learning to better prepare the future workforce for the Fourth Industrial Revolution
Method	Non-empirical: Scoping Review
Data sources	Themes and concepts from the findings and results of the scoping review

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The results of this study could be valuable to graduates, South African universities and Industry 4.0 employers. The study could encourage the developing of better practices towards equipping students with the required skills, thus improving graduates' future success in the Industry 4.0 workplace.

2.5 DATA ANALYSIS METHODS

As the data analysis methods are discussed more broadly under the scoping review in Chapter Three, only a brief summary is provided here. Thematic analysis was used to identify, group and cluster the emergent themes and sub-themes from the scoping review in an attempt to answer the research questions of the study. These emerging themes also served as guidelines in the construction of the conceptual models.

Thematic analysis was used based on its permission for flexibility in the data analysis process. This method also offers a guided construct of the organisation and grouping of themes that support the synthesising and interpretation of the phenomenon under investigation (Braun & Clarke, 2006).

Braun and Clarke's (2006) six steps guided the thematic analysis process and were utilised for completing the data analysis of this study. The most important advantages of the six phases in thematic analysis conveyed by Braun and Clarke (2006) are that they provide a clear and functional basis for applying thematic analysis and helping to unravel a complex and uncertain topic. Braun and Clarke's (2006) six steps are illustrated in Figure 2.3.

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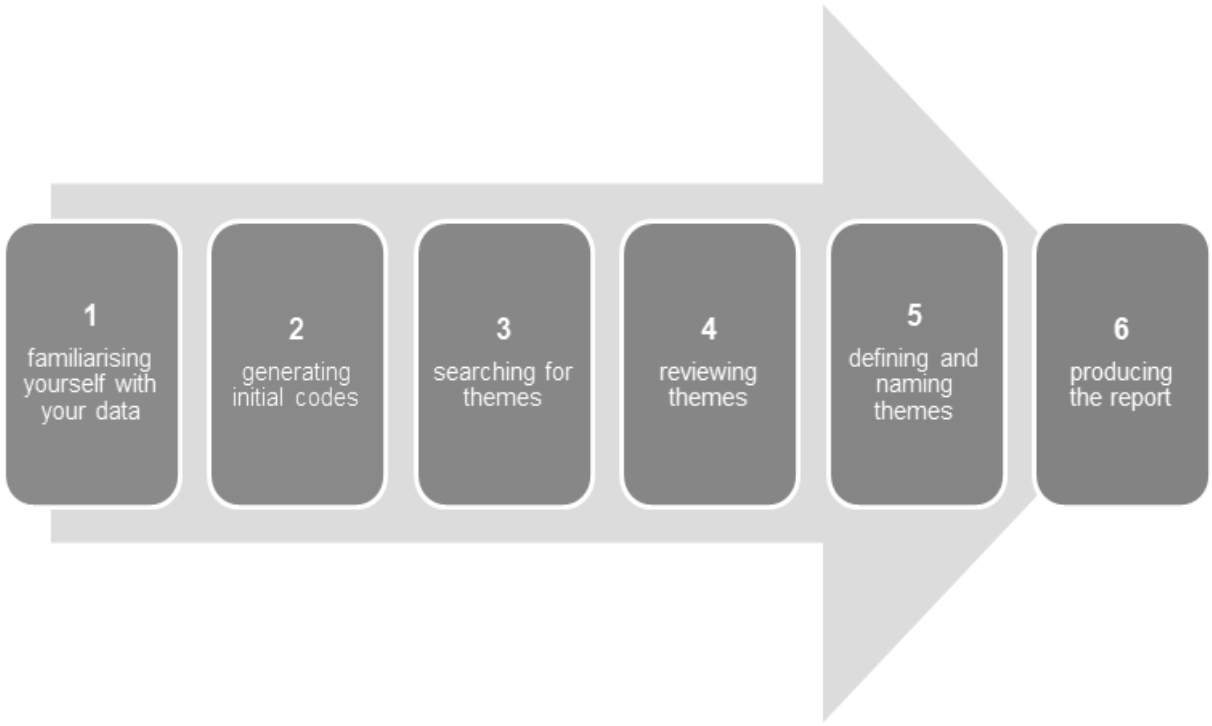

FIGURE 2.3: Six step guide to thematic analysis (adapted from Braun & Clarke, 2006)

2.6 LIMITATIONS OF THE STUDY

This study has encountered two types of limitations, with the first type that was predominantly related to the scoping review. These limitations have arisen in the scoping review process, more specifically the screening and selection of studies. The language delimiter of studies only published in English could supposedly exclude important studies piloted in other languages. Other limitations that should be noted from this scoping review are that, despite various attempts, this scoping review may not have identified all studies relevant to the 4IR and South African universities in the published and grey literature scope. These limitations or challenges will be discussed more broadly in Chapter Three. To sum up, there is the possibility of excluding some relevant studies, owing to database limitations, oversight or language restriction. There is also the possibility that the inclusion criteria did not capture all aspects of the main concepts.

The second was more general limitations which had to do with the difficulties experienced in capturing all key concepts and findings that emerged from the scoping review when constructing the conceptual models. Also, there were time constraints in managing to complete the research

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within the predicted timeframe. In the end, considering the broad range of a scoping review, the review still produced a usable outcome.

Lastly, a limitation with no degree of control due to the contemporaneity of the 4IR was that potentially useful information and new implications arose spontaneously during the course of the study. Although a follow-up search was conducted to include newly published studies, addressing this type of limitation to keep the research up to date by the time of completion, is unfortunately not possible. It must be borne in mind that the 4IR is a new concept. Hence, the time span of the scoping study may prove limiting.

2.7 ETHICAL CONSIDERATIONS

The scoping review was conducted by obtaining data through database searches, hand selection from publicly available literature, and conference proceedings, amongst others, which do not contain any personal information that is not already available in the public domain. Therefore, this study was considered very low risk.

However, ethical clearance for the study was applied for and granted by Stellenbosch University (refer to Annexure D), as there remains a weighty obligation on the researcher to produce a reliable outcome that fully supports and adheres to the Ethical Code of the University of Stellenbosch.

2.8 SUMMARY

This chapter provided a brief overview of the research methodology and design used in the current study. Furthermore, this chapter also restated the research question and subsidiary research questions that steered this study, followed by providing the motivation, goal and objectives of the study.

Additionally, a summary of the scoping review and data analysis methods for this non-empirical study were provided. A more detailed description will be provided in the next chapter. This chapter touched upon thematic analysis and the developing of conceptual models as approaches in analysing and explaining the data. This will allow rich discussions to be held on the phenomenon under research, delivering an illustrated path towards transformation.

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Also discussed in this chapter were the study's reliability and the attempt to avoid bias by the researcher. Furthermore, limitations experienced in conducting the study were highlighted, as well as the ethical considerations that were considered and applied.

The next chapter describes the scoping review method applied to this non-empirical study.

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CHAPTER 3
SCOPING REVIEW

3.1 INTRODUCTION

Scoping reviews intend to collate research on a particular topic and explore the underpinnings of a research area, while identifying and clarifying the main concepts, sources of evidence, theories and gaps in the current body of knowledge (Arksey & O'Malley, 2005). The purpose of scoping reviews in general is to outline and include all available studies related to the topic under investigation, without any limitations on the type of resourced information (Boland *et al.*, 2017). The scoping review differs from the systematic review in that it is not a linear process. It allows going back-and-forth between initial findings and varying insights (Levac *et al.*, 2010). It also allows adjustments to search strategies and syntax to retrieve more refined and related results (Arksey & O'Malley, 2005). Further to this, scoping reviews have been shown to explain the main perceptions and terminology in a manner that enables exploration and the unravelling of a new, uncertain, controversial phenomenon (Arksey & O'Malley, 2005). Therefore, the scoping review was seen as a suitable method for this study since the topic under research is the 4IR which is perceived as an uncertain, multifaceted, novel and much debated phenomenon.

Traditionally, scoping reviews do not provide an evaluation or assessment of the quality of retrieved studies, but rather, a summary or an overview of existing knowledge that in future may form part of an ongoing, more systematic review (Arksey & O'Malley, 2005; Boland *et al.*, 2017; Daudt, van Mossel & Scott, 2013).

For this study, a scoping review was deemed appropriate to provide an overview of research without evaluating the quality of the selected studies, thus not excluding grey literature[5] or unpublished research.

[5] Sources in the public domain, for example, web sources, blogs, and broadcasts.

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3.2 METHOD

The method for conducting this scoping review has been adopted from Arksey and O'Malley (2005:22). The process consists of the following five phases, which is discussed in more detail in this chapter:

1. Formulating the research and sub-research questions to be addressed
2. Identifying sources that are relevant to the research questions
3. Evaluating and selecting sources to be included in the review
4. Charting the information and data within the included sources
5. Organising, summarising, and reporting extracted results of the review

In Phase One, the primary research question driving the scoping review was determined as, *How should the key functions of South African universities, particularly those related to teaching and learning, be transformed to better prepare the future workforce for the 4IR?* This research question led to subsidiary questions to determine the role of South African universities in the 4IR and the challenges they will face in fulfilling this role. It also led to identifying influences of the 4IR on main functions of South African universities, in particular, teaching and learning. In this way, meaningful discoveries could be made, and the identified concepts could be mapped in usable conceptual models. The planning of the review and the developing of a scoping review protocol form an essential part of Phase One.

3.2.1 Planning the review

In contrast to an exhaustive literature review, scoping reviews tend to utilise a more rigorous approach of obtaining studies on a research topic or phenomenon of interest. The following steps guided the planning of the search strategy in developing the scoping review protocol (Boland *et al.*, 2017: 64):

Firstly, considering the extensiveness of the search is vital. The 4IR and its influence on universities are still new and unpredictable. Therefore, through the scoping review search process, most 4IR relevant and available studies were included.

Secondly, the different types of studies required consideration. Scoping reviews allow for including diverse types of studies, such as grey literature and unpublished studies (Hariharasudan & Kot, 2018).

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Thirdly, identifying databases to be utilised for performing searches was essential. In relation to this study, more than one bibliographic database was identified, the aim being to explore and examine the implications of the 4IR for universities in their fullest consequences. Therefore, an extensive search across a number of selected bibliographic databases was necessary and a wide range of studies as opposed to a limited number of in-depth studies were included.

Fourthly, key concepts had to be identified and described together with search terms relating to the research topic and research questions; also, a search strategy or search syntax for these bibliographic databases had to be designed. The majority of bibliographic databases have more advanced search options, which allow search terms to be added to more than one box or field. These were combined with Boolean operators, namely, 'AND' – combining concepts or terms to narrow the search strategy, 'OR' – broadening the search by finding all studies containing any of the concepts captured, 'NOT'- excluding concepts to narrow the search strategy by not including the concept entered after 'NOT'.

Lastly, all above-mentioned and collected information had to be incorporated into the development of a scoping review protocol. A detailed, written scoping review protocol was required, to be utilised post hoc as guideline for starting the initial searching process.

3.2.2 Designing the scoping review protocol

The scoping review protocol for this study includes a list of key concepts and combination of terms, search strategies and strings that are applicable to the 4IR and HE context. The overall scoping protocol not only contains the identification of search terms and the selection of databases, but also the inclusion and exclusion criteria, data extraction description and methods of charting extracted data.

After completion, the scoping review protocol was submitted for feedback. The supervisor, departmental committee and the faculty information specialist advised on the scoping review protocol. The feedback received was incorporated and used to revise the scoping review protocol. The finalised scoping review protocol was used as a guideline for searches, as for this study a thoroughly planned search strategy was vital. The scoping review protocol[6] was also used throughout the reviewing and screening process of the selected studies.

[6] See Annexure A for the scoping review protocol.

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3.2.3 Scoping searches

Phase Two requires the researcher to identify, in a planned, systematic and well-documented manner, the literature that is of relevance to the research question. In this phase of the scoping review, the main objective was to establish what is known about the 4IR and its implications for South African universities, in particular for teaching and learning. It seemed apposite to identify and select a broad spectrum of studies and expert opinions related to the 4IR in the HE context that would contribute to finding answers to the research questions.

The purpose of this first level of perusal was to accrue an adequate body of available research highlighting the implications of the 4IR for universities. Thus, establishing an overview is a critical initial step, before embracing a progressively more advanced search attempt, especially when the phenomenon under scrutiny is considered new and complex in nature (Daudt *et al.*, 2013). The perusing procedure grants the researcher the opportunity of describing the degree, range and nature of the phenomenon, which is valuable in deciding on vital enquiries that could be answered based on the retrieved research information (Boland *et al.*, 2017).

The initial search for potentially related studies was conducted in November 2018, on the following main electronic databases: EBSCO- (Eric, Education Source, Africa Wide, Academic search premier), Emerald, Google Scholar, IEEE; ProQuest, ResearchGate, Sabinet - SA E-publications, Scopus - Elsevier (Science Direct), Springer and Taylor & Francis.

The descriptions of these databases with indicating platforms are presented in the following table.

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TABLE 3.1: Bibliographic databases, descriptions and platforms

DATABASE	DESCRIPTION	PLATFORM / INTERFACE
EBSCO	EBSCO's databases offer a variety of scholarly sources, by using one simplified platform to search across several high-quality databases, for example, ERIC, Education Source, Africa-Wide and Academic Search Premier.	EBSCO Host https://www.ebscohost.com
Emerald	Emerald is a multidisciplinary global publisher hosting a comprehensive collection of peer-reviewed academic sources.	Emerald Insight https://www.emeraldinsight.com/
Google Scholar	Google Scholar is controversial in the sense that it is perceived by some as a search engine and by others as a bibliographic online database. Google Scholar retrieves scholarly sources across an array of disciplines and formats from the Internet.	Google Scholar https://scholar.google.com/
IEEE Xplore	IEEE Xplore is a research database providing access to an array of sources linked to more technical fields in the engineering and computer science domains.	IEEE Xplore Digital Library https://ieeexplore.ieee.org
ProQuest Databases	ProQuest provides a central database to an ample and diverse collection of multidisciplinary and multimedia academic sources.	ProQuest Central https://www.proquest.com/
ResearchGate	ResearchGate is a social networking site for researchers and scientists with its own internal database of scholarly articles and knowledge sharing and collaboration platforms.	ResearchGate https://www.researchgate.net/
Sabinet	Sabinet exclusively contains South African Journals, previously known as SA ePublications collection, which makes it the most wide-ranging African electronic content searchable collection.	WorldShare Metadata Service https://www.sabinet.co.za
ScienceDirect	ScienceDirect published by Elsevier is a database for scientific, medical and technical research and provides access to journals, open access journals and books.	ScienceDirect https://www.sciencedirect.com/

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Scopus	Scopus from Elsevier is one of the largest scholarly peer-reviewed literature, citation and abstract databases, comprising of: scientific journals, conference proceedings and books.	Scopus https://www.scopus.com/ https://www.elsevier.com/research-platforms
SpringerLink	SpringerLink is a combined database for a variety of full-text academic sources published by Springer.	SpringerLink https://link.springer.com/
Taylor & Francis Journals	The Taylor & Francis Group provide access to all full-text academic sources published by Taylor & Francis and Routledge.	Taylor & Francis Online https://tandfonline.com/

3.2.3.1 Search strategy

The databases in Table 3.1 were selected on the grounds that they are multidisciplinary and provide comprehensive coverage of the global research output and available research studies. The search strategy contained no restriction on the type of study, country of origin or on the sector (e.g. academic, policy, government, etc.). The search was delimited to include only studies that were published in the English language within the timeframe between the years 2014-2018.

The above-mentioned timeframe was decided on in part because of the current nature of the research topic, and more importantly, to improve the probability of completing the scoping review by keeping it within a manageable scope. To identify relevant studies on the prior mentioned databases, a combination of the four key search concepts as set out in the scoping review protocol was used. Choosing the correct search terms is crucial for retrieving relevant studies.

What became apparent - proving the complexity of the phenomenon - was that three main search terms were used interchangeably to retrieve information about the phenomenon. According to Google Trends, a website by Google that analyses all the search queries pursued in Google Search, across continents and all languages, the most used search term worldwide to retrieve information about the 4IR, in the category ‘jobs and education’, over the last five years was ‘Industry 4.0’, as illustrated in the Figure 3.1 below:

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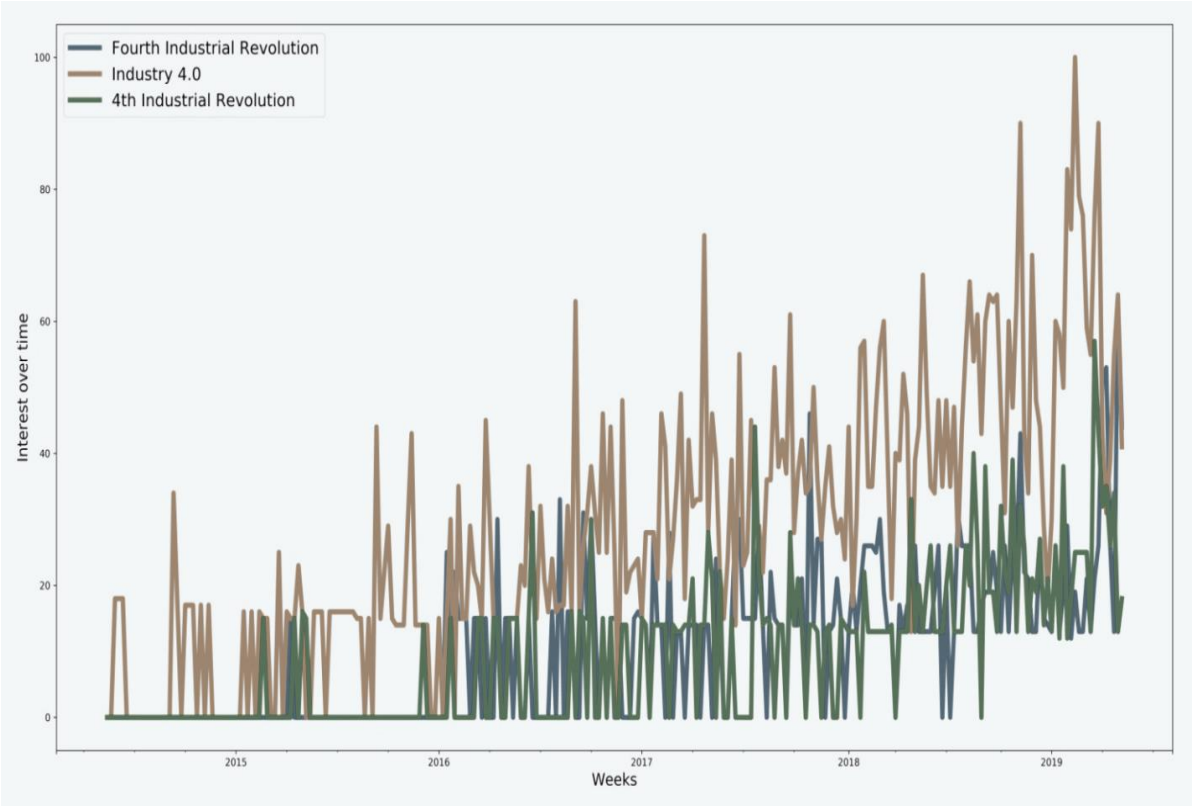

FIGURE 3.1: Google trends worldwide last 5 years web search

Google Trends' results on the line graph of "interest over time" convey that term's popularity over a defined time range. Google Trends results are based on a term's complete search numbers, relative to Google's amount of searches.

In comparison to the worldwide web search results, the term ‘Industry 4.0 was the least used in South Africa, with ‘Fourth Industrial Revolution’ and ‘4th Industrial Revolution’ as the more popular choices.

The next figure illustrates the comparison between search terms used in South Africa over the last five years in the category ‘jobs and education”.

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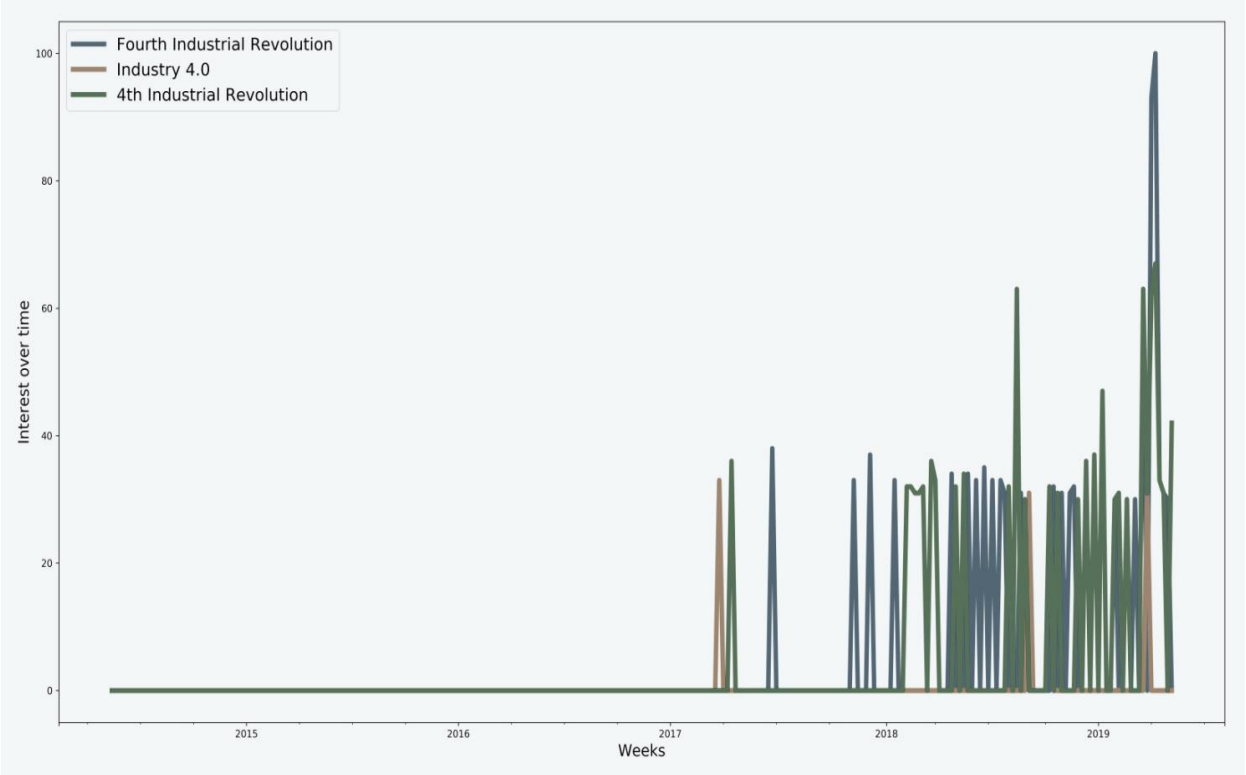

FIGURE 3.2: Google trends South Africa last 5 years web search

Therefore, the decision was made to include all three search terms in the search strategy combined with the operator 'OR'. The search syntax was put together, taking this into consideration as well as the nuances of the different selected electronic bibliographic databases. Consequently, specific combinations of these concepts, namely: ('Fourth Industrial Revolution' OR '4th Industrial revolution' OR 'Industry 4.0') AND ('universit*' - *includes university and universities* OR 'higher education' OR 'higher education institution*'- *includes institution and institutions* OR 'tertiary education') AND ('teaching and learning' OR 'teaching' OR 'learning') AND ('skill*' – *includes: skill, skills and skillset*), were used. Such terms were also combined with broader emerging terms, as outlined in the scoping review protocol. These were combined to the latter search string with the Boolean operator AND, for example, one of the following: 'disrupt*' - *including: disrupt, disruption(s) and disruptive*, 'innovati*' - *including: innovation and innovative*, 'student*' - *including: student and students*, 'curricul*'- *including: curriculum, curricula, curricular*, 'technolog*' - *including: technology, technological and technologies* and 'employ*' - *including employment and employability,* was used.

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Using these key concepts with a combination of the broader search terms generated a substantial number of results, which was considered necessary to ensure that all possible related studies had been retrieved in the results. This process yielded 486 results, which were saved as the initial sample.

The initial sample was examined more closely and too many duplicates were observed, namely, the same titles were discovered on different database platforms. There were also too many irrelevant search results. Also, the search result and scope had to be scaled down to achieve a more manageable outcome. In close conjunction with an information specialist, it was decided to refine the initial search strategy by focusing on the key concepts for search terms only and to eliminate the broader terms, the inclusion of which resulted in generating the bulk of unrelated studies.

A modified Boolean search was constructed by creating a search syntax or statement with only the four key concept operators and focusing on South African content by using AND ‘South Africa*’ - *includes South African* to narrow the search down even further.

A second search was conducted within the initial sample and on the same databases in January 2019, based on the conceptualisation of combined search terms as illustrated in Figure 3.3.

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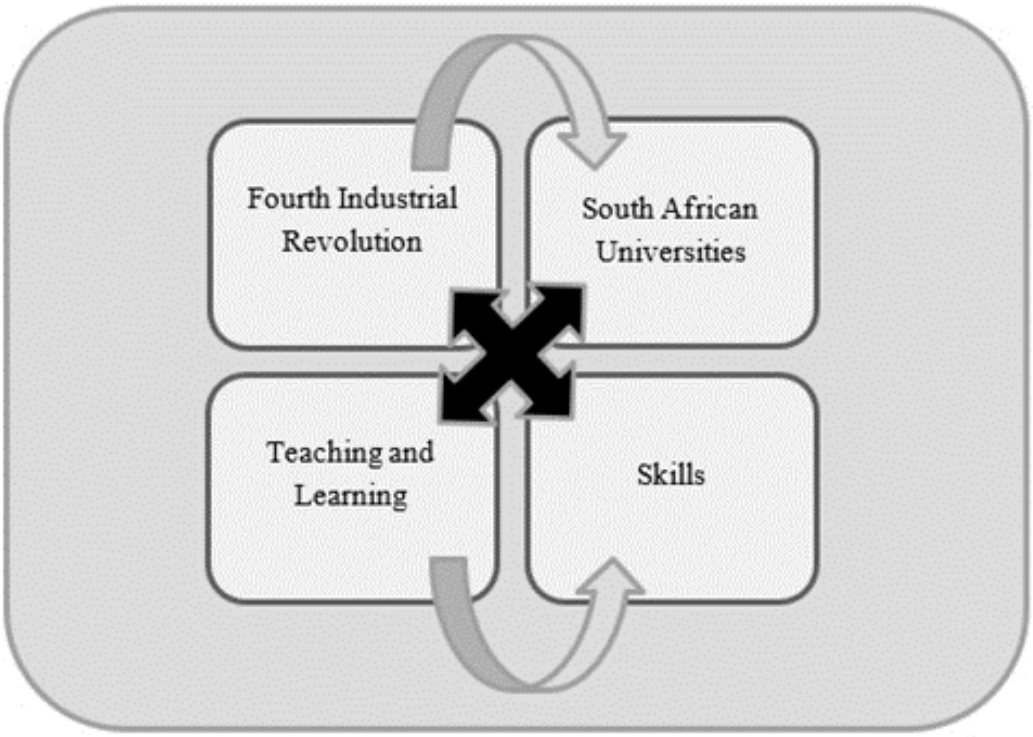

FIGURE 3.3: Conceptualisation of combined search terms

Consequently, the refined search syntax delivered a more practicable result, with the total number of retrieved and identified studies at 225. An additional 29 studies were added by manually searching the web, internet and other sources, bringing the total number of studies to 254. These studies were downloaded and imported, with the abstracts, keywords and references, into Mendeley, a reference management software platform, for further reviewing and screening.

3.2.3.2 Inclusion and exclusion criteria

It is essential to define a clear set of inclusion and exclusion criteria, as these are used as a guideline to judge the relevance and appropriateness of the identified studies and consequently lead to finding answers to the identified research questions (Boland *et al.*, 2017:81).

The inclusion and exclusion criteria for this study were carefully considered to clarify the complexity and uncertainty of the topic under research (Levac *et al.*, 2010). These criteria are

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also outlined in the scoping review protocol, which was used as a guideline, against which to judge the studies, throughout the screening process.

The inclusion and exclusion criteria that were documented are listed below:

Inclusion criteria:

- Publication years 2014-2018 (only last five years owing to the current nature of the topic)
- English language
- Focus on universities and HE within the 4IR context and containing at least two of the key search terms in the titles, abstracts, or author keywords
- Focus on teaching and learning practices within the 4IR context and containing at least two of the key search terms in the titles, abstracts, or keywords
- Grey literature containing at least two of the key search terms in the titles, abstracts, or keywords

Exclusion criteria:

- Not related to universities or HE
- Not related to the 4IR
- Languages other than English
- Duplicate record

It must be stressed that it is vital to determine the above criteria before the onset of the scoping review and the screening process of identified studies (Daudt *et al.*, 2013).

3.2.4 Screening titles and abstracts

Phase Three involved the screening and selection of the identified studies and the applying of inclusion and exclusion criteria. The starting point for the first screening was to identify duplicate records by using Mendeley's 'check for duplicates' tool. Some 27 duplicate studies were merged and removed, resulting in a remainder of 224 studies. Further duplicates were removed, as and when they were found later in the process. After the de-duplication process, a rapid screening process was done by using the sort and search functions in Mendeley: (1) citation information was downloaded and updated; (2) studies had to be published between 2014-2018; and (3) the English language had to be the medium. Another six studies were removed, the reasons being that either the study was not in the English language, the citation was not recognised by Mendeley and could not be updated automatically, or the study fell outside the above-mentioned parameters.

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After the rapid screening process in the first round, the remainder of the inclusion and exclusion criteria as outlined in the scoping review protocol were applied. This part of the first screening process was also done in Mendeley by using the 'find / search' and 'filter by author keywords' functions to eliminate those studies that did not contain at least two key search terms. As a result, of the first review round, only 221 studies were selected to undergo a second screening review. Arksey and O'Malley (2005) recommend this two-stage review strategy of not imposing a strict screening process with applied relevancy criteria in the first round, in order to become acquainted with a broader view of existing knowledge on a research topic. In the case of this study, after becoming familiar with the available evidence in the first review, it was apparent that research over the last three years has grown more concerned with the implications that the 4IR holds for universities than the vague mentioning thereof during the initial years.

However, to ensure that collected studies had been screened objectively, the need arose to adjust and add to the above-mentioned criteria. The additional relatedness criteria evolved as the first review and screening process developed and progressed. It is essential that in the second review and screening round, the criteria for relatedness be applied more strictly. Therefore, in order to determine to what extent, the identified studies in fact met the relatedness criteria, the researcher screened the titles and read the abstract, headings and keywords of each of the 221 remaining studies. After an article received a rating, in accordance with the explained criteria, each article was also 'tagged' in Mendeley with the indicator acronym of relatedness, as described in Table 3.2 below.

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TABLE 3.2: Inclusion and exclusion criteria explained

	CRITERIA (with indicator acronym in brackets)	**CRITERIA EXPLANATION**
INCLUSION	Partially Related **(PR)**	The study research focus falls within the 4IR and HE context but without detailed descriptions
	Closely Related **(CR)**	The study research focus is mainly on HE within the 4IR context **CR1**: The study research deals with the fourth industrial revolution and HE in the South African context **CR2**: The study research focus is in the HE context with specific reference to teaching and learning **CR3:** The study research focus is in the HE context with specific reference to the employability of students and the role of universities
EXCLUSION	No Full text **(NF)**	The study contains no full text, or no access available to be evaluated
	Not Related **(NR)**	The study deals with 4IR issues but out of the scope of this study
	Loosely Related **(LR)**	The study research focus deals with the 4IR implications in general and universities are only mentioned as a concern without HE being the main focus

Whilst the screening process was a very time-consuming process, it was at the same time a very productive process for getting a synopsis of the available research. Of the 221 studies, 104 studies were, after scrutiny, considered to be not related or loosely related, which resulted in the exclusion of a large number of studies despite their initial inclusion. Another nine studies were excluded following the unsuccessful retrieval of an available full-text.

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Consequently, only 108 studies remained with a rating of partially or closely related. Of the 79 studies that were considered as closely related, 15 randomly selected studies were screened further (Pham, Rajić, Greig, Sargeant, Papadopoulos & McEwen, 2014). The reference lists of each selected study were hand searched to detect studies not yet captured. Citation chaining, also known as ‘snowballing’, is the process of investigating one study’s reference list to find other related studies (Boland *et al.*, 2017:72). This was done to ensure as far as possible an inclusive process. The process is twofold - backward searching involves reference checking to include studies that might have been missed, and forward searching which focuses on the citation results of key authors or commonly cited journals (Boland *et al.*, 2017; Hariharasudan & Kot, 2018). An additional 20 studies were identified, bringing the total number of primary studies included in this scoping review to 128.

A follow-up search was conducted in April 2019 to identify any recent studies published after the last search. The decision to add 2019 studies and to revisit the initial period was based on the recentness of the 4IR. Some 16 more studies from 2019 were included, resulting in a total number of 144 studies for this scoping review.

Figure 3.4 explains this process diagrammatically.

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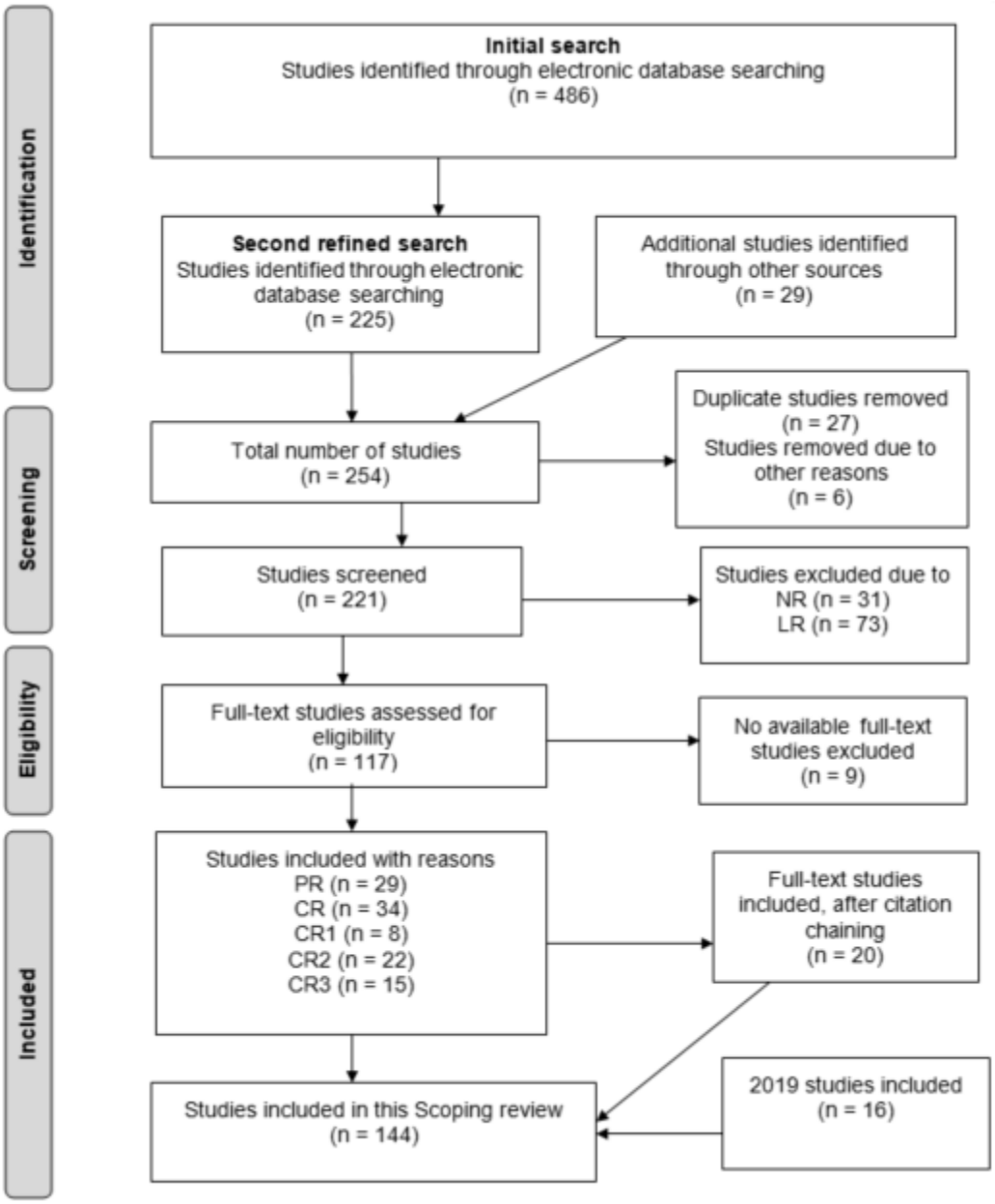

FIGURE 3.4: PRISMA flow chart showing scoping review results (Moher *et al.,* 2009)

The PRISMA flow chart provides an outline of the progression of data through the various phases of the scoping review , mapping out the number of studies with decisions taken to arrive at the final number of studies included (Moher, Liberati, Tetzlaff & Altman, 2009).

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3.3 DATA EXTRACTION REPORTING

The aim of Phase Four in the scoping review is the extracting and charting of the data that seems related to the purpose of this study (Arksey & O'Malley, 2005; Levac *et al.*, 2010). The process of extracting and charting the data assists in identifying concepts and the logical assessing of the findings, both "descriptively and analytically", to get a better understanding of the findings, as presented in the tables and charts below (Boland *et al.*, 2017:94).

3.3.1 Databases

Searches were conducted for the scoping review on the bibliographic databases displayed in the pie chart of Figure 3.5 below.

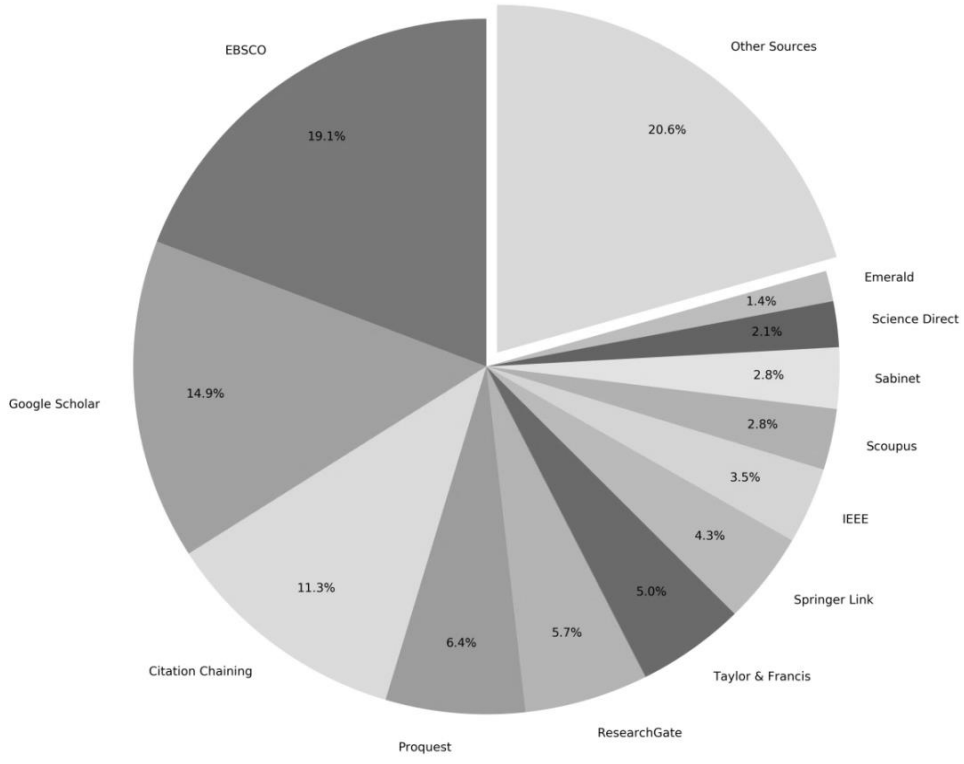

FIGURE 3.5: Bibliographic databases utilised for this study according to percentages of sources

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The number of sources produced by each bibliographic database varied, with the majority of studies retrieved from EBSCO host and Google Scholar that also proved to be the most popular choices by most researchers. The scoping review, which permits the inclusion of grey literature and other sources, was essential for gathering a large portion of studies or sources, as captured in the pie chart above, which would not have been the case with a systematic review that focused on quality peer-reviewed studies only. Citation chaining also played a vital role in finding studies identified by authors that have done research in this field already.

3.3.2 Country of origin

The chart below indicates the country of origin of the author or authors of each study and not the country in which the study was published.

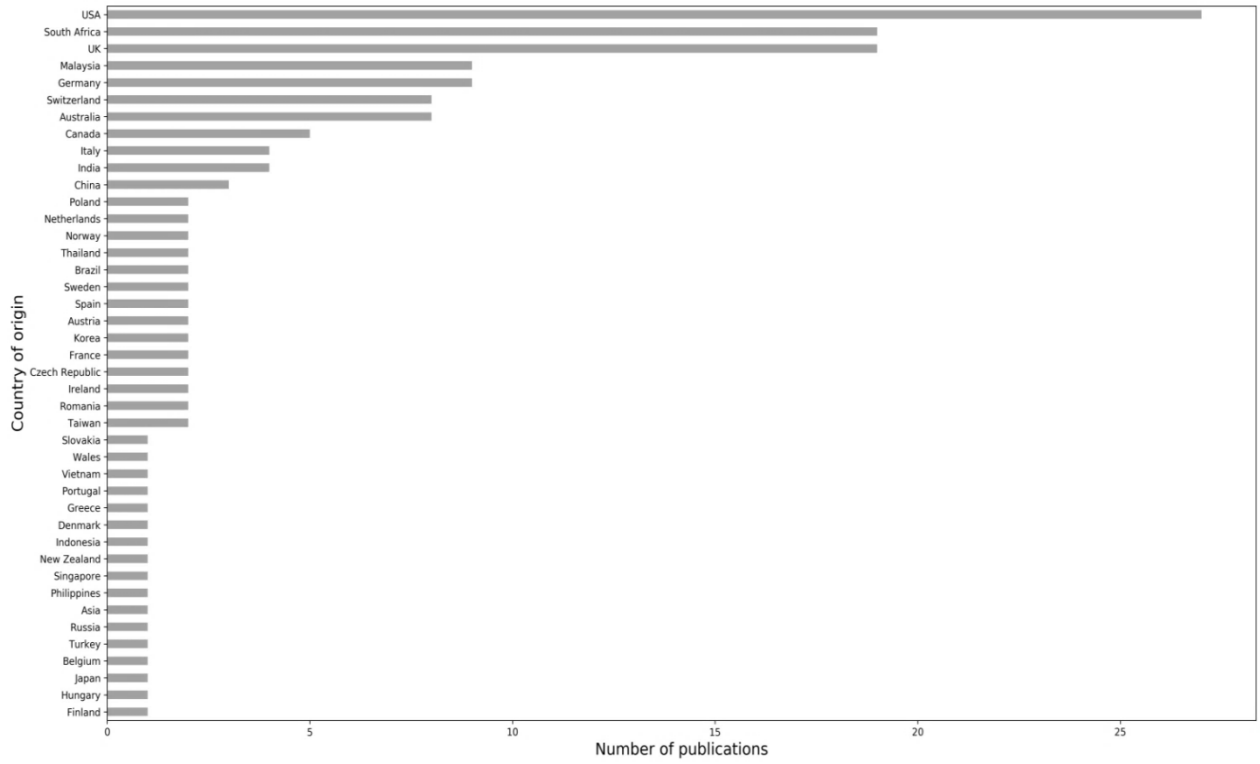

FIGURE 3.6: Country of origin of contributing authors

The United States came out strongly with most studies by authors originating from this country. The United Kingdom and South Africa came jointly second. The reason for South Africa lying second is that the search was narrowed down to the South African context and content,

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therefore influencing the results. Malaysia, Germany, Switzerland, Australia and Canada have also contributed greatly in the field of addressing implications the 4IR holds for universities.

3.3.3 Year of publication

The growing interest in researching the 4IR is illustrated in the graphic representation of Figure 3.7 below, indicating the growth in the number of studies that were published over the last five years.

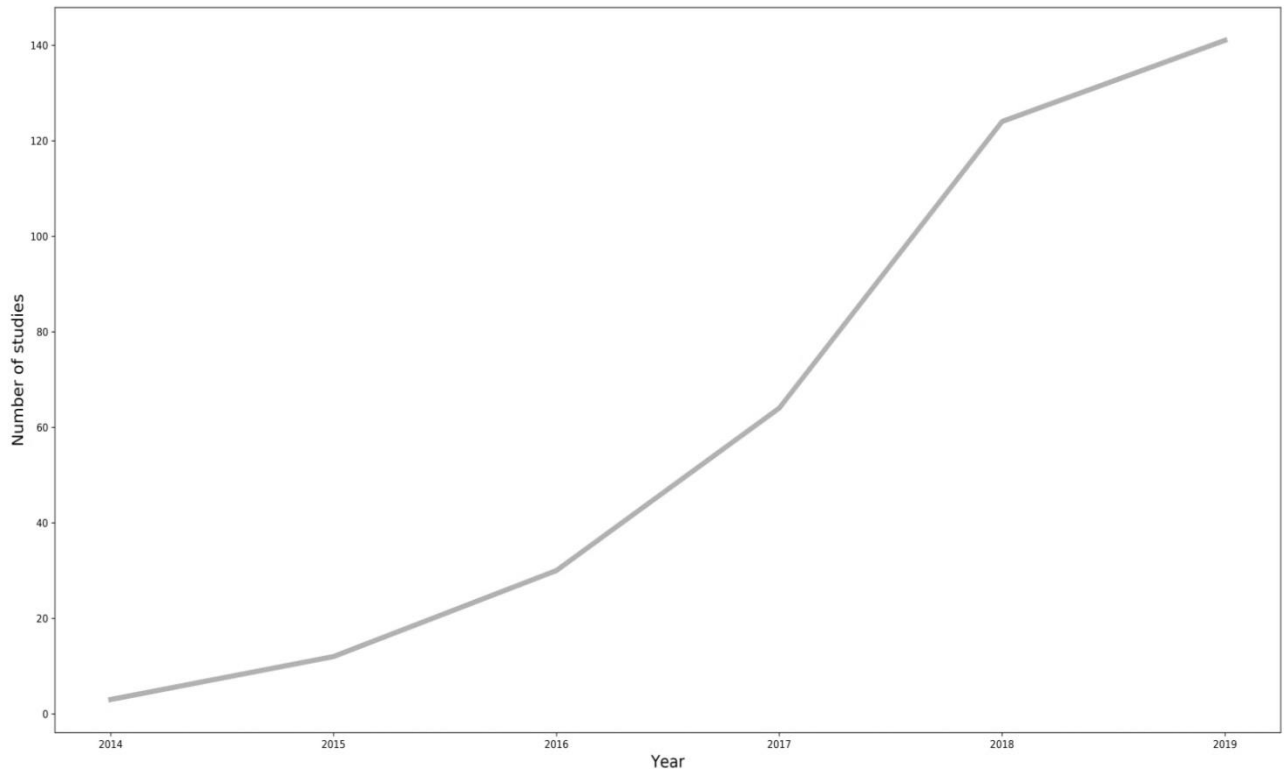

FIGURE 3.7: Number of studies that were released per year

What became apparent is that the 4IR interest elevated slowly in 2015, showing an incline since 2016 and increasing more markedly towards 2017 with peaking results from 2018 up to 2019, especially in the field of higher education and the implications and challenges of the 4IR. This proves that the 4IR significantly gained interest in the last year to date, becoming more and more important as a topic of discussion and the phenomenon under investigation.

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3.3.4 Type of study included in the scoping review

The intention with this scoping review was to scrutinise different types of studies in the controversial field of the 4IR, by conveying or mapping what is known about important concepts from a variety of sources, such as study outcomes, grey or unpublished sources, and expert viewpoints, as exhibited in Figure 3.8 below.

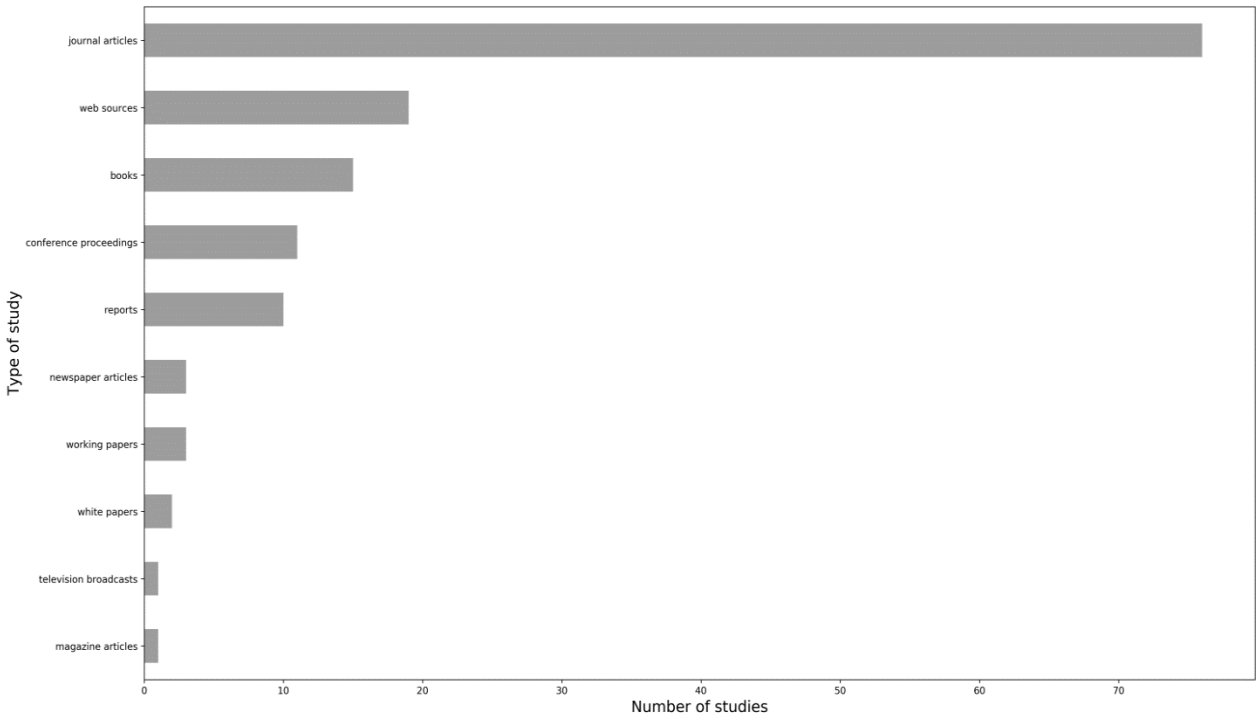

FIGURE 3.8: Type of study included in the scoping review

The type of study that was most prominent in this scoping review was journal articles, making up the majority of included studies. This was followed by web sources (which include web pages, blogs and webinars), created to stimulate conversations around the topic. Books or chapters in books dealing with the 4IR in all its facets have also been published recently. The number of conference proceedings shows that the topic has been debated at conferences with speakers trying to make sense of this phenomenon and its implications. Other sources included are reports, working papers, white papers and also newspaper articles indicating the newsworthiness nature of the topic. In addition, the scoping review includes information of a more popular nature in the form of magazine articles speculating about the issues of the 4IR.

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Then the scoping review also includes a television broadcast of the South Africa president's State of the Nation address, taking the 4IR seriously and calling on South Africa to be prepared.

3.3.5 Author keyword count

In researching a fairly new phenomenon, the author keywords play a prominent role in establishing novel terms in the field under research. Therefore, the number of occurrences of the relevant keywords of the authors included scoping review studies were counted. A calculation of the rate of recurrence and prominence was generated in the word cloud below.

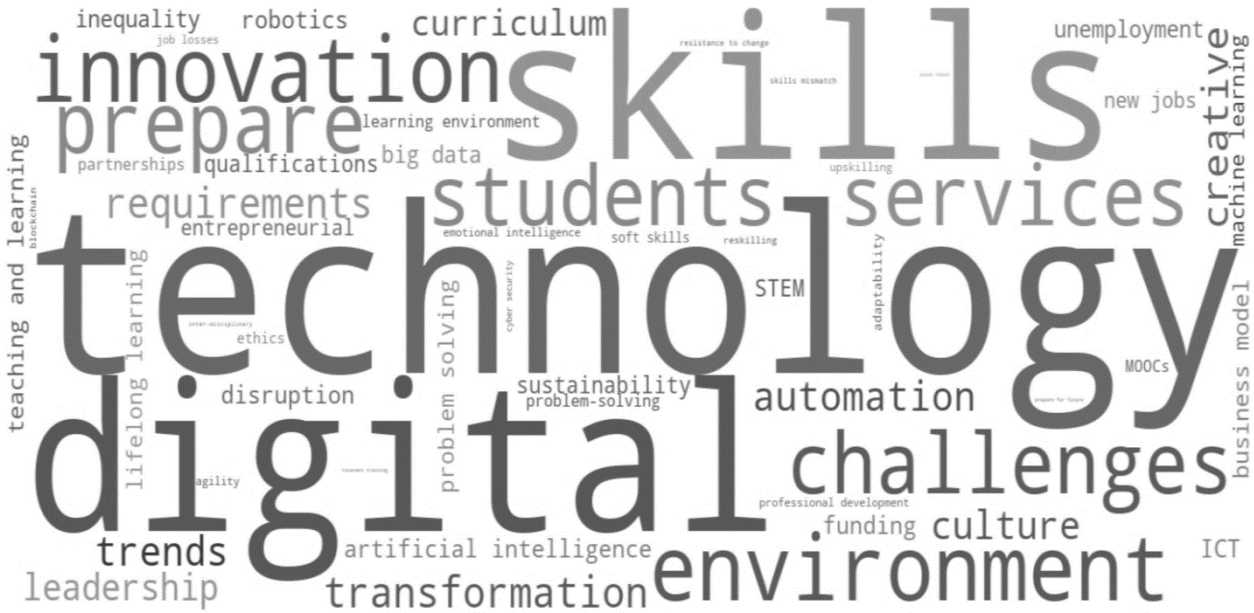

FIGURE 3.9: Prominent author keywords in scoping review studies

From the word cloud above, it became apparent from the studies included in the scoping review that the day-to-day jargon involving conversations around the 4IR includes words such as 'technology', 'transformation', 'challenges', 'innovation' and 'digital'. The words 'prepare' and 'skills', amongst others were also prominent.

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3.3.6 Summary of data extraction results

Data from each of the 144 sources included in this study were documented such as: bibliographic databases and other sources used for the retrieval of relevant sources, authors' country of origin, study distribution by year or publishing period, type of study included in the scoping review and the most prominent author key words used.

These results from the data extraction were presented in charts and graphs above that indicated the following: 11 databases were utilised for the retrieval of sources with the largest representation from EbscoHost and Google Scholar. Citation chaining or reference scanning also played an indispensable role in the retrieval of valuable sources. Overall the retrieved sources about the 4IR were piloted in 42 countries, with the United States most well-represented. What is more, the United States, as a country, has conducted ground-breaking research on the 4IR and its implications for universities and the workplace since the day Schwab announced the dawn of the 4IR. Furthermore, most sources became publically available in 2018 with the oldest sources in this scoping review that became available during 2014, while the latest sources included were from 2019.

The type of source most frequently represented in this study was journal articles, particularly owing to numerous journal articles being published over the last three years, followed by web sources, print and electronic books. Also, many conferences have been held to stimulate the debate around the 4IR and its implications for universities, the workplace and the future workforce. In recent years, several newspaper articles, web pages and blogs have seen the light inspired by experts, futurists and researchers affiliated to universities, all tasked with making sense of the 4IR. In addition, a list of recurring author keywords and terms used to depict or describe the multifaceted 4IR has been collected. Prominent terminology was displayed in a word cloud, showing technology, digital and skills amongst others as words used by authors aimed at depicting and describing the 4IR. Even though, these data extraction results need further analysis they already corroborate that the 4IR is a new and complex phenomenon that has gained momentum as a distinct research area, particularly in the last two years.

3.4 DATA ANALYSIS

The data analysis represents the techniques or methods that the researcher utilised for the qualitative content analysis to facilitate the interpretation process (Levac *et al.*, 2010). During Phase Five, the data was summarised through thematic analysis.

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3.4.1 Thematic analysis process

Braun and Clarke (2006:87) outline a six-step process that was used as basis for the thematic analysis of this study.

The first step as described by Braun and Clarke (2006) refers to the process of reading and re-reading selected studies, to familiarise oneself with the data by filtering the data. The extracted data results were therefore used to extract the meaningful key words, patterns and topics found in the dataset.

Step two was to generate initial themes. These initial themes were identified through the occurrence and prevalence of concepts and phrases in the various studies (Maguire & Delahunt, 2017). This was a very basic step in further organising the data results, developing themes and systematically reducing the data relevant to each of these initial broader themes.

Step three involved searching for broader themes and sub-themes. The thematic analysis process assists with combining research findings for a better understanding of a complex phenomenon and identifying evolving trends under each theme (Bearman & Dawson, 2013). In other words, breaking down the data further into sub-themes helps to unravel findings and connect discoveries made from the data directly to the research questions under review (Levac *et al.*, 2010; Boland *et al.*, 2017).

In step four all the themes were reviewed. These themes were modified going back and forth, subdivided and grouped under broader themes, focusing on relatedness and significance to the research questions (Braun & Clarke, 2006). Accordingly, broader themes and sub-themes were organised in such a manner as to provide a meaningful explanation and description of their significance within the data-set of included studies. The occurrences of these themes[7] in the included studies were counted to calculate the percentage of studies that investigated and discussed the various themes, showing the importance thereof.

Step five involved the final refinement of the themes. The last refinement of themes is important to distinguish the “essence” of what the themes mean, and to determine their interaction and whether the sub-themes are basically “themes-within-a-theme” (Braun & Clarke, 2006:22). Maguire and Delahunt (2017) reiterate the importance of the final refinement to ensure that

[7] See Annexure B: Themes and Occurrence in Number of Studies

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themes are embedded in the overarching theme to simplify the mapping of concepts that link to the research questions and to determine the interaction between these themes.

The final step six concluded as explained above, with themes that state something noteworthy or intriguing about the data and that can be linked to the research questions of this study. According to Braun and Clarke (2006), there are no rules regarding what is considered a theme. This rather depends on the noteworthiness of such a theme. In the final report[8], the identified sub-themes across the data set of studies were clustered under the overarching theme and broader themes that relate directly to the specific research questions as indicated in the report.

The thematic assessment was helpful in summarising the main concepts and themes from the scoping review data extracted results. It forced the researcher to adopt a step by step strategy to data processing, contributing to provide a descriptive and structured outcome. The observations and themes from the thematic analysis report may be seen as the canvas for painting the real-time 4IR picture for South African universities and connecting the dots to develop the conceptual models thus addressing part of the main RQ and S-RQ4 of this study.

3.5 STRENGTHS AND CHALLENGES OF THIS SCOPING REVIEW

The methods used in this scoping review were guided by the scoping review protocol, which was applied objectively and transparently. Using Mendeley, the reference manager software, ensured that all studies and citations were considered, interpreted and managed properly. Contributing to the strength of this scoping review was using the citation chaining or snowballing method that resulted in adding relevant studies that would not have been retrieved exclusively with the search strategy. Furthermore, conducting a follow-up search accounted for more recent studies to be added. Particularly in view of the current nature of the research topic, the follow-up search definitely improved the topicality of this scoping review.

This scoping review was not without challenges. A major challenge to this study was having to stay objective from a single-researcher and single-reviewer perspective. When annotating and screening 144 studies to identify themes and sub-themes for thematic analysis, different reviewers may have reached different results owing to focusing on different themes from different viewpoints. Therefore, to mitigate the latter challenge as far as possible, the ‘author keyword’ function in Mendeley was utilised. To verify the keyword counts from Mendeley, a

[8] See Annexure C: Report of Themes Clustered According to Research Questions

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statistician wrote a small program in Python, by, that extracted the principal themes from each source and counted occurrences of the themes found and mentioned the most frequently. Despite small discrepancies, the results of the Mendeley and Python methods were almost similar. Hence, it is sensible to infer that different reviewers could have arrived at similar themes and sub-themes relevant to the research topic. It is also worth noting that while concentrating on the most frequently mentioned themes, themes that were less mentioned but also important may have been overlooked.

From a completeness point of view, the scoping review would have been more comprehensive if it had been conducted by a team of reviewers. Despite this, this review has filled a vital gap in the current body of knowledge by broadly scoping the available studies focusing on the 4IR and universities and more particularly teaching and learning in preparing the future workforce.

Considering that the 4IR is still a new concept, the scarcity of studies on the implications thereof in the context of South African universities together with the manageability for a single reviewer, made it impossible to include a broader selection of studies. This scoping review could serve as a strong and useful foundation for a follow-up, more systematic review. Taking everything into account, regardless of the revealed and discussed challenges, this scoping review has brought to the fore the most current topics under discussion in dealing with the 4IR and the implications it holds for South African universities now and in the future.

3.6 SUMMARY

The intent of this study was to determine what information and research has been revealed about the 4IR and the implications thereof for South African universities in the preparation of the future workforce, using a scoping review approach. The scoping review method was very useful in retrieving relevant sources on the 4IR. With this scoping review, a wide-ranging synopsis of available sources from the period 2014 to 2019 was created. The scoping review method also had tremendous potential in its capacity to examine and explore these available sources on this specified research phenomenon. Furthermore, through this review, the need for a comprehensive evaluation of the existing state of studies and available research on the 4IR and the implications for HE has been addressed. As this review was not intended to define the efficacy of any specific intervention or source, it rather used a broad lens perspective to collate all relevant research results on a limited and new study field. This method was valuable in identifying research gaps and priorities or main concerns regarding the 4IR.

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The data extraction results revealed underlying explanations of the evolvement of the 4IR and the casual links between the data organisation, bringing together an overview of a variety of sources in the scoping review. Using thematic analysis to capture important concepts helped to cluster themes for further consideration and making sense of the 4IR. This data analysis phase was crucial in mitigating speculations and limiting the assumption approach around the uncertainties of the phenomenon, establishing clear direction in addressing the implications of the 4IR and how universities should respond to remain relevant.

Keeping in mind the main research question and the aim of the study (see Figure 2.1 and Table 2.1), which require insight into and an understanding of the future South African workforce and workplace requirements, the next chapter (Chapter Four) extracts from the scoping review perspectives on the employment situation of South Africa as a country, as well as the future workforce and workplace requirements. This serves as a backdrop for Chapter Five, which focuses more specifically on gaining a better understanding of what is expected from South African universities.

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CHAPTER 4
THE FUTURE WORKFORCE

4.1 INTRODUCTION

It is crucial for South African universities to understand the dynamics and requirements of the new 4IR work milieu. Therefore, Chapter Four begins by providing a brief synopsis of South Africa's current employment landscape and preparedness for the 4IR. The chapter also sketches the background, as was gathered from the scoping review, regarding the employment prospects and future opportunities for the workforce in South Africa. In other words, what will this new, unpredictable and disruptive technology-driven workplace be like, which the future workforce will enter over these next years? This chapter further attempts to address the second part of the main RQ (*to better prepare the future workforce for the 4IR).* Having established the need, demands and requirements of the future workplace as well as prospects for future careers, a better understanding of how universities should transform their key functions to best equip their students for prosperous and meaningful future employment in these much speculated-upon workplaces can be formed. This, it is dealt with in Chapter Five, in order to answer the first part of the main RQ.

4.2 SOUTH AFRICA AS A COUNTRY

The scoping review reveals that the 4IR offers valuable and significant opportunities to drive economic and social growth, reinventing the position of South Africa on a worldwide level (Ayentimi & Burgess, 2018). Naudé (2017) cautions that the 4IR brings about both pressures and prospects for South Africa. While lingering on the brink of the 4IR, South Africa has several choices - to follow suit and grab the opportunities, or to be distracted by the threats; to prepare for the future together as a nation, or to allow the 4IR to pass us by (Balkaran, 2016).

To form a better understanding of what the burdens and benefits of the 4IR could be, good research is vital. The NEDLAC[9] 2019 report provides a range of classifiers, including exaggeration, misconception, denial, fear of change and lack of vision, amongst others, that co-create the 4IR's anticipated influence. In South Africa, especially, where inequality, joblessness and penury place additional layers of complexity on the 4IR challenges, these feelings and opinions have been sometimes exacerbated (Roux, Viljoen & Samson, 2019). Chetty (2018)

[9] National Economic Development and Labour Council (South Africa)

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reiterates that the world's reliance on technology has pervaded society as a whole, affecting all industries of the economy. In a nation of high inequality, such as South Africa, this effect further perpetuates disparity (Chetty, 2018). However, Butler-Adam (2018) postulates that as the world economy moves towards the extensive implementation of AI alternatives, demand will increase for workers with the abilities necessary to execute, manage and operate alongside the latest technology. Therefore these technological breakthroughs are changing the boundaries between the duties performed by humans and those performed by machines and algorithms: significant transformations are taking place on worldwide employment markets (WEF, 2018). South Africa as a country is no exception; such transformation has already occurred in the current workplace.

A closer look must be taken at recent research by WEF[10] (2018) on technology adoption in the South African business market, in which industry indicated that their business was either “likely” or “very likely” to have adopted the specified technology (Figure 4.1) as part of their innovation plan by 2022 (WEF, 2018:96).

[10] World Economic Forum

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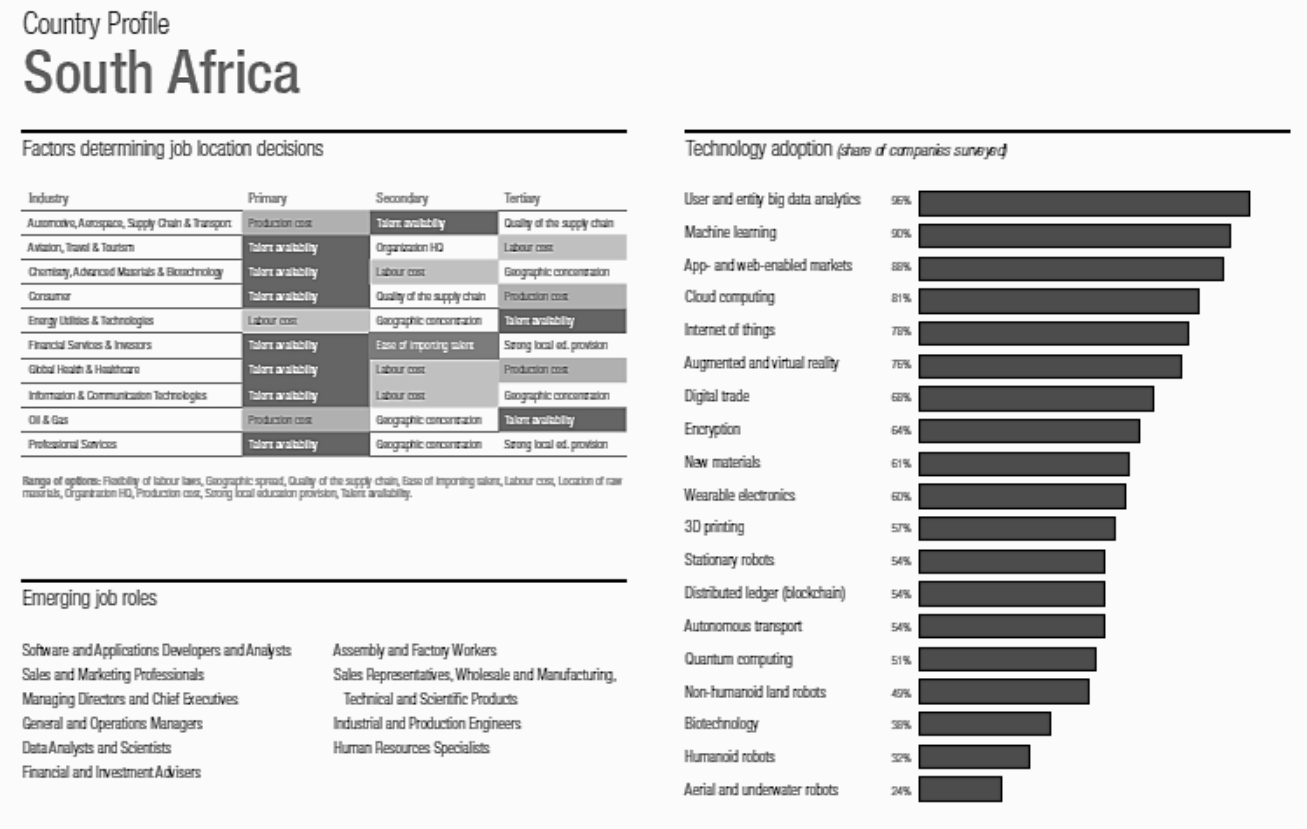

FIGURE 4.1: Country profile: South Africa (WEF, 2018:96)

In the Figure 4.1 from the WEF (2018), the first section: Factors that determine job location choices for businesses operating in South Africa, offers an overview of the variables determining worldwide job-location choices. In the second section: Technology adoption, the bar graph reflects the proportion of survey participants from businesses in South Africa who indicated that their business would most probably adopt or has already adopted the specified technology as part of their sustainability strategic plan by 2022. The third section: Emerging job roles, gives a list of employment positions expected to rise in demand across South Africa over the period 2018–2022 (WEF, 2018:37).

What becomes clear in this picture is that technology is not waiting for anyone, nor is the 4IR, in all its multifaceted technological glory. The speed and scope of implementation of technology drives industry development, the creation of new jobs and the need to increase current employment, provided that industry can fully harness the skills of a committed and versatile workforce equipped with abilities to explore these new job possibilities (Roux *et al.*, 2019).

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Chetty (2018) argues that the 4IR has already caused mass unemployment in South Africa. Talent and skills shortages have already led to work redundancies, skill disruptions, and huge work dislocations (Ayentimi & Burgess, 2018).

Unless the South African government, together with industry and universities, is prepared to keep up with the 4IR's ever-changing surroundings, it will leave its workforce behind (Chetty, 2018). Moreover, if the country proceeds on its present route, the economy and its citizens may suffer significantly (Roux *et al.*, 2019). In future, if South Africa fails to put a positive spin on 4IR possibilities, this will lead to the infamous *blame game* as to who should have done what to prepare its workforce, yet did not (Balkaran, 2016:17).

Pragmatically, Hattingh (2018) proposes that government, businesses and universities need to take hands and adopt skills policies to guarantee preparing and equipping the future workforce to be productive and successful in the new workplace environment. In view of this, it will be essential for policymakers to ensure that ethical legislation is in place. Policies must be transparent in approach, empowering the workforce to succeed in the 4IR modified workplace (Corfe, 2018).

4.3 THE FUTURE WORKPLACE

The 4IR, with its much elaborated-on technologies and innovations, portrays significant alterations and complications for nearly all types of employment, but also for transforming the workplace (Plumanns, Sommer, Schuster, Richert & Jeschke, 2016). Balkaran (2016) warns that these 4IR technologies sneak into the workplace and affect the surroundings in ways that most struggle to understand until it is metaphorically knocking on the office door. Therefore, the need is for South African universities to understand what the new workplace would look like in order to be able to prepare the future workforce to fill their place as employees.

The increasing modernisation of the workplace provides the strong probability that contracts for permanent jobs may, in certain cases, give way to less binding agreements on the "gig-economy workplace" (Roux *et al.*, 2019: 109). As workplaces modify, so does the graduate for whatever is required to be work-prepared. Therefore, the future of employment will be completely different, mainly driven by the "machine economy, where robotics and machine learning take over repetitive and programmable" employee duties and employee roles are being enhanced by AI (Ernst & Young, 2018b:7). Tvenge and Martinsen (2018) predict future workplaces to have less or no need for employee interaction, with augmented automation,

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tracking and regulated automated systems. Employees will therefore only monitor operations and contribute to repairs, upgrades and inventions for new or current systems (Tvenge & Martinsen, 2018).

Corfe (2018:6) lists a variety of future advantages for employees within this new technologically driven workplace:

- Returning to actual wage increases. Using 4IR technological innovations offers important possibilities to enhance rates of workforce productivity.
- Time-off - more free time, in working only a four-day week. Through task automation and greater productivity rates, the use of 4IR developments can allow the company to generate more services and products while also working fewer hours than at present.
- Tedium's end - work becomes more fulfilling. 4IR has the ability to make the hours spent working more pleasant and less controlled by repetitive duties, along with increasing revenue and free time.
- Promoting family and social life and diminishing wage gaps. 4IR can assist in guaranteeing that personal lifestyles flourish by enabling employees to work fewer and more flexible hours – permitting employees more family time.
- A healthier and safer workplace- There are important prospects for using robotics and linked systems to make the workplace safer. Robots can perform relatively dangerous manual duties, such as transporting and lifting heavy items. The use of linked computers in such workplace settings can assist in safeguarding employees to take adequate rest breaks from computer monitors to prevent eyestrain and forgo working long hours.

On the one hand, the use of robots at the workplace holds some advantages for employees, as seen above. On the other hand, the increasing use of various types of technology to perform job operations and exchange data can lead to a decrease in employee interactions within the workplace, with potential adverse effects in terms of non-formal learning, workplace engagement, encouragement and overall well-being (Ghislieri, Molino & Cortese, 2018).

Brown and Keep (2018) argue that the future workplace will be dominated by three diverse perspectives: skill shortages, job shortages and job cessation.

All three perspectives recognise disruptive technological change in the workplace, even though there is dispute over its effect on employment levels and quality of employment. All three views recognise the need for digital abilities, while also concentrating on social skills. These abilities

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are seen as significant because, in the rapidly changing workplace environments, the workforce will need to be creative, adaptable, and innovative.

Finally, all three perspectives see a potential position for HE in the preparation of the workforce. However, those who subscribe to a skills scarcity perspective believe that a large percentage of workers will need high-level abilities to remain ahead of the robots' march, while the other two perspectives highlight restricted possibilities for high-skills employment that enable autonomy and creativity (Brown & Keep, 2018:39).

Along these lines, Johannessen (2018) reflects the future workplace in yet another way by speculating that it will not necessarily be a set geographic place, but that it could be dispersed across geographical locations, and split structurally. Corfe (2018) postulates that the dawn of deep change is about to take place in the world of work. Executed properly, the 4IR could enhance work life dramatically. However, executed improperly the 4IR brings with it significant difficulties for the Industry 4.0 workplace, workforce, policymakers, and South African universities (Corfe, 2018).

According to Media (2019), smart robots and intelligent 4IR wearable devices are just the start of the effects of the potential innovations to be found in these high-tech and automated workplaces (Media, 2019). This new evolving workplace setting will be emphasising its shift towards automation and building on robotics and big data, as illustrated in Figure 4.2.

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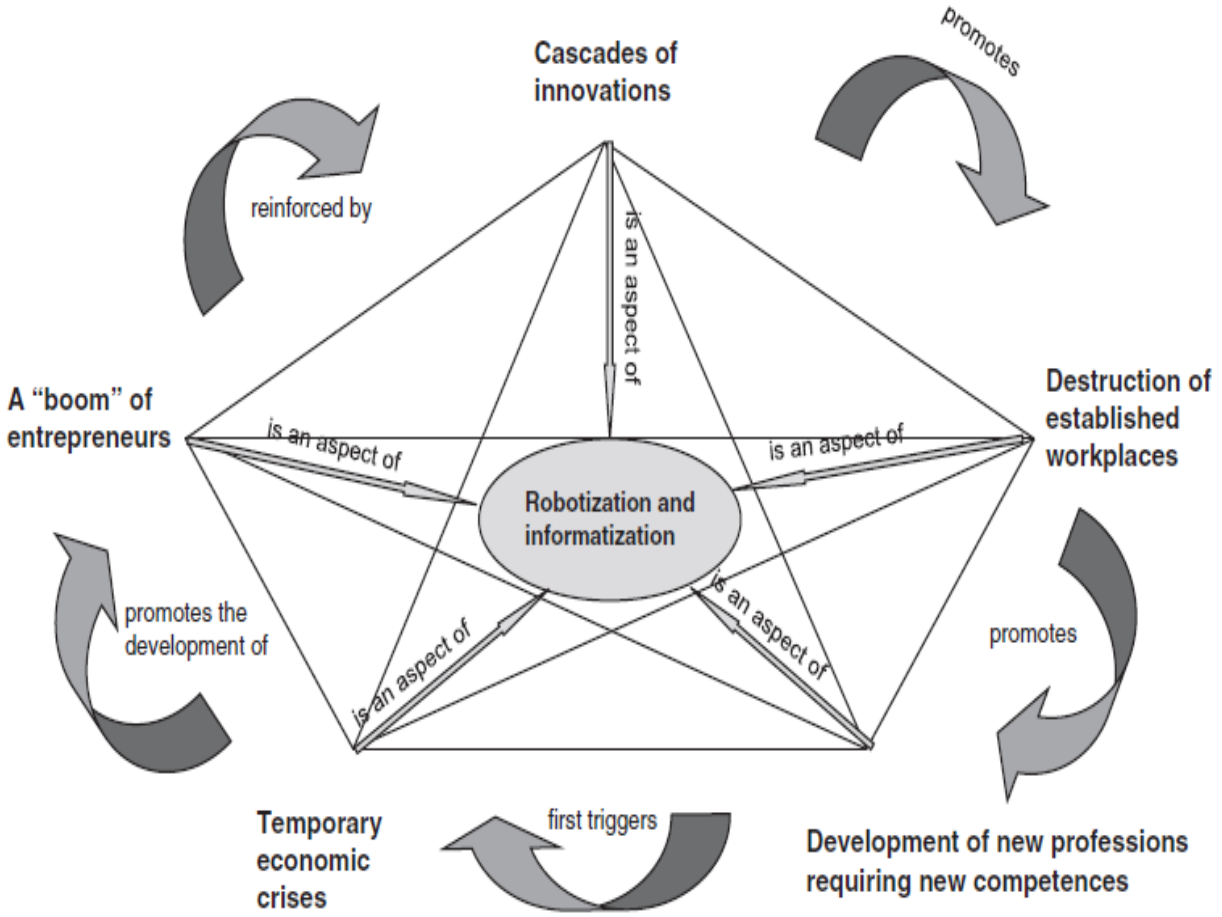

FIGURE 4.2: Future workplace impacted by robots and big data (Johannessen, 2018:9)

Figure 4.2 shows the simulation of inventions and trends, namely, the transformation of existing workplaces, the creation of new jobs and careers, the need for new skills and the emergence of entrepreneurs, all driven by robots and big data (Johannessen, 2018).

Apart from the physical appearance of the future workplace, the demographical outlook of its workers is also expected to be vastly different. In South Africa, research has shown that almost fifty percent of its population is under the age of thirty. This demographic feature will have an enormous impact on South Africa's future workplace (Phillips, Seedat & Van der Westhuizen, 2018), as illustrated in the graph in Figure 4.3.

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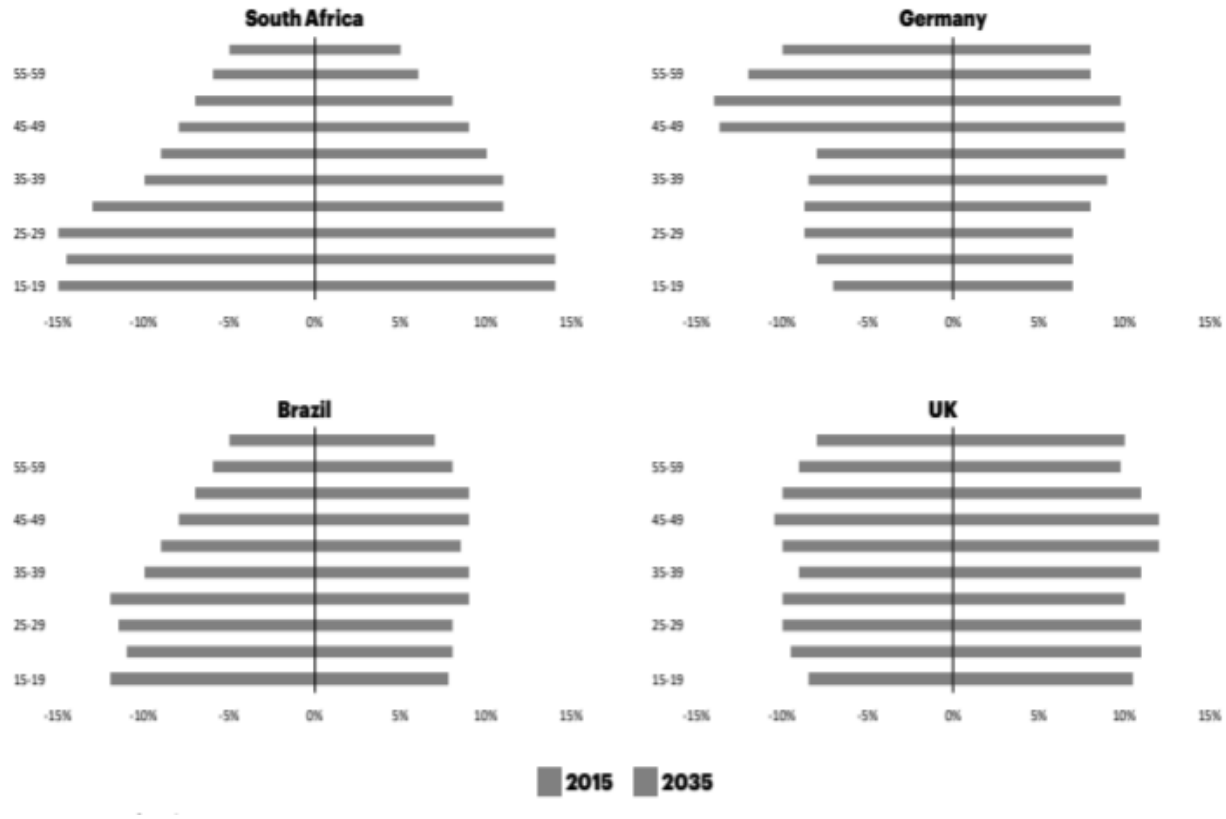

FIGURE 4.3: Demographics of South Africa, Germany, Brazil and the UK, 2015 and 2035
(cited in Phillips, Seedat & Van der Westhuizen, 2018:6)

Recent research shows that 35% of all employment in South Africa (approximately 5.7 million occupations), is in danger of complete automation at the moment. Further work losses in South Africa could have a crippling impact on an already struggling economy, increasing unemployment, particularly amongst young people (Phillips, Seedat & Van der Westhuizen, 2018:2). That said, South Africa's youthful population, compared to other countries creates the possibility of investing in population capital gain. Such population gain is likely to be fully utilised only in cases of adequate skills growth and an increasing feeling of autonomy. Thus, such growth creates an opportunity for HE to empower today's students for the future.

Therefore, South African universities have a crucial role in preparing the future workforce with the adequate skills and knowledge demanded by this high-tech future workplace to fill the gaps and work alongside the robots. In other words, South Africa's universities must find efficient and innovative ways to *robot-proof* the future workforce for future careers.

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However, Balkaran (2016) argues that with robots continuing to radically change workplaces, the HE system has demonstrated an inconsistency with the challenge of preparing the future workforce to become valuable assets in progressing forward. In making the shift from the training space to practice, academia may find it difficult to relate theoretical understanding and knowledge to practice (Leibowitz, Bozalek, Garraway, Herman, Jawitz, Muhuro, Ndebele, Quinn, Van Schalkwyk, Vorster & Winberg, 2017). In this respect, it is essential for South African universities to be acquainted with the future workplace, its potential and requirements.

4.4 FUTURE CAREERS

Challenges of future careers are one of the variables influencing the role of South African universities to rethink their mission and remain viable. There are several 4IR forces, including workplace, industry, and economic forces that either discourage current career options or encourage new future career options (Abeid, Rahman & Dahlan, 2018). These careers of the future are those that computers and robots are unable to do, relying on creativity, human interaction, agility, compassion, inventiveness and cooperation (Brown-Martin, 2017). Baxter (2017) agrees that workers will increasingly focus on those tasks that computers cannot perform, resulting in more complex and difficult employment. Interaction between employee and machine demands high-tech skills (Baxter, 2017). Therefore, the first task for South African universities would be to develop in students those high-tech abilities needed for the future workplace and employment (Beliz, Basco & de Azevedo, 2019). According to Brown-Martin (2017), the future workplace will need mathematicians, engineers, statisticians, scientists and designers to predict, develop and fabricate alternatives to the most urgent challenges facing humankind, while learning how to live and work side by side with machines.

Brynjolfsson and McAfee (2016) postulate that technology has often demolished careers and as often generated new careers. Hence, with the onset of the 4IR and with new technologies in place, new careers are emerging and new skills are required, in line with the new workplace. Such new emerging careers are in the fields of “Cyber Security, Data Science, IoT[11], Intelligent Systems, and Cloud Computing” (Media, 2019:1). Careers based on STEM, digital technology and media have become the cornerstone of highly qualified and highly-paid careerists (WEF, 2017b). According to Gleason (2018) there are many current careers that will be outmoded and automated, as the outcome of innovations in technology facilitated by improvements in big data and machine learning.

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[11] Internet of Things.

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It would seem that there still is great uncertainty about the effect of automation on employment and whether industry can generate enough new employment opportunities and future careers to make up for the losses (Beliz *et al.*, 2019). Nonetheless, even those careers that are likely to stay useful are experiencing a significant change in the abilities needed to conduct them (WEF, 2017b).

There are many game changers here that South African universities should take note of in planning ahead. AI and automation have already displaced and disrupted skilled jobs; skills portfolios have become more vital for employability than university degrees; the composition of the workplace has changed to more freelancers than full-time workers (Ernst & Young, 2018a). Doepker (2019) proclaims that millions of skilled jobs around the world are predicted to be displaced through automation. In fact the future career scene is predicted to gain “133 million” new evolving careers worldwide and to be exact, “75 million” current careers are forecast to decline or disappear within the next few years (WEF, 2018:8).

In Figure 4.4, the top 10 emergent future careers and top 10 diminishing careers are displayed.

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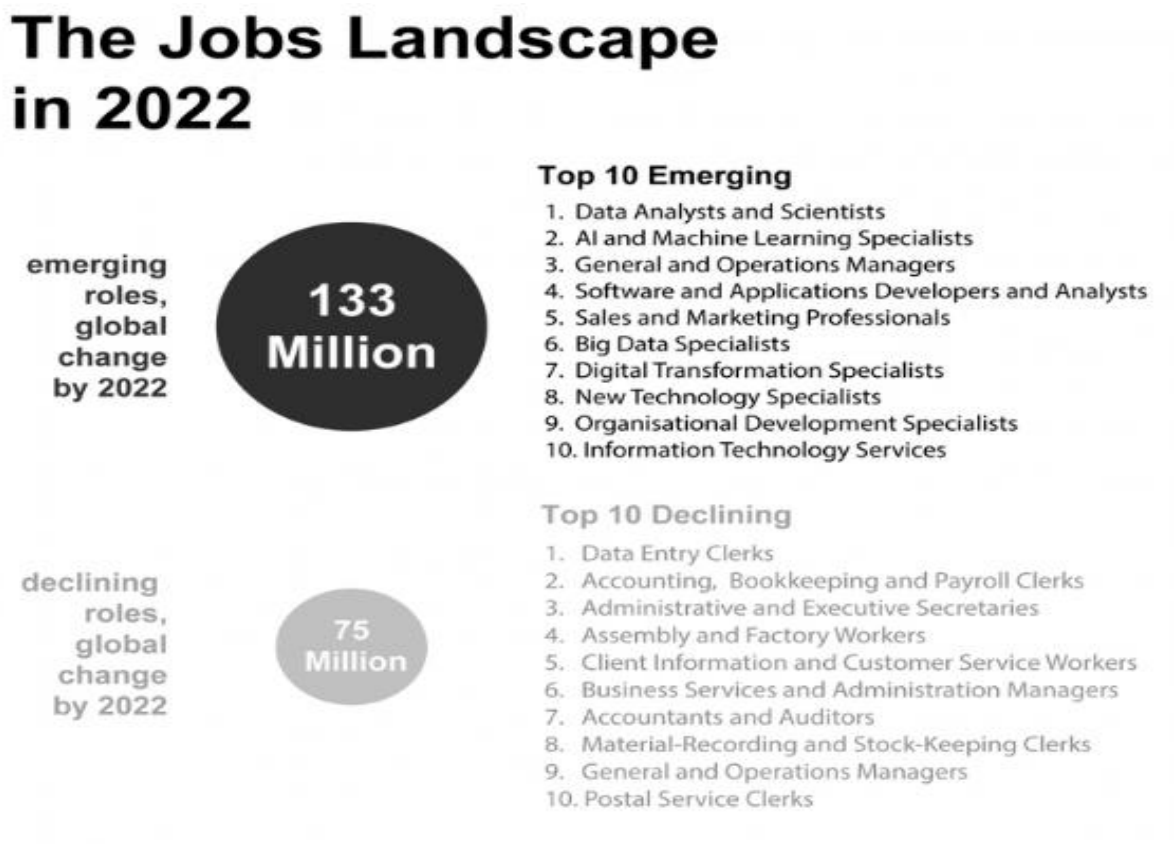

FIGURE 4.4: Top 10 future careers (WEF, 2018:9)

Doepker (2019) reiterates that, in most instances in which jobs have been automated; those who have lost their jobs lack the required skills or qualifications to fill the new emerging jobs. Avogaro (2019) warns that as a result, the less skilled and educated workforce appears to be destined to be restricted to the region of routine and poorly paid employment. Hovering over them will be the threat of being replaced by robots capable of doing the work in a less costly manner. However, in today's ‘create new jobs and automate old jobs’ setting, it is apparent that this same setting leads to a high percentage of employment being lost, while at the same time a shortage of skilled employees remains (Baxter, 2017).

Therefore Busteed (2019) argues that those students with foresight will enter their career path sooner and study while already employed, which would assist in bridging the career-preparedness gap encountered by many of today’s graduates. Nevertheless, the development of abilities is not just about universities transferring skills but is also about nurturing a culture of lifelong learning, hands-on training, and entrepreneurial attitude (Beliz *et al.*, 2019). The

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emergence of completely new careers is likely to grow more prevalent, given the rate of reform. Therefore lifelong learning will become a continuous component of the future way of working (Sledge & Fishman, 2014). This lifelong learning security net appears sensible in preparing for when strategies are being based on imagining what-if future career scenarios.

Many less knowledgeable students, going by the mantra - pursue your calling - may be unwilling to consider the probability that their much-valued career choice may be susceptible to automation by the time of applying for employment (Lent, 2018). Future career planning has become an intangible blind alley, rather than, for most students, a path to a better future.

How can HE prepare the future workforce for new careers that will only materialise in the future or be constantly altered by technological innovation? Will self-employment become the norm with the growing automation scope? (Peters, 2017).

The intention of HE should be to prepare students not only to be capable of working in one sector, but also to provide students with expertise about practices in varying sectors, thus equipping them with multidisciplinary knowledge (Eberhard, Podio, Pérez, Radovica, Avotina, Peiseniece, Caamaño, Gonzales & Solé-Pla, 2017). The career path to success will lie in HE's capacity to prepare the future talent with the use of innovative practices. HE must also combine relevant workplace abilities and interdisciplinary knowledge to effectively manage these ever-evolving future career conditions (Beliz *et al.*, 2019).

However, this challenge is not easy, especially in the era of spotting technological predictions at times when the lines between now and the digital future become blurred. A stable career life belongs to the past. A career in the future will lose its security validity. Stability and devotion to one workplace is not a consideration; the reluctance to move on is regarded as a failure (Janíková & Kowaliková, 2017). For South African universities to prepare the future workforce for these new careers, it is important to know which skills should be nurtured, and what this future workforce would look like.

4.5 THE FUTURE WORKFORCE

The future workforce needs new abilities for new careers not yet considered or in existence: this will be the most efficient way to succeed in the future workplace (Balkaran, 2016). The global workplace will differ considerably from the workplace that is known and understood today. Hence, understanding the significant changes in the workplace is pivotal; South African

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universities and HE leaders must start developing skills policies in ensuring that their skill preparation and other approaches are in a position to withstand the next decades' disruption.

Against the 4IR backdrop, which skills are perceived as most important to equip the future workforce? According to Cotterill (2015), the developing of four categories of skills is found to be imperative, namely, intellectual, social and coping abilities, and adequate academic and discipline knowledge. Cotterill (2015) further explains that intellectual abilities include problem-solving skills like critical and creative thinking, to cope with undefined issues. Interpersonal abilities relate to social, cooperation, communications and leading skills. Versatility and digital skills reside under coping abilities for an uncertain future. The future workforce likewise needs to create self-monitoring abilities, such as time administration, self-discipline, setting goals, efficient life and work balance, and constant learning abilities (Cotterill, 2015:407). McLaughlin (2016) agrees that future abilities depend on innovation and creativity. McLaughlin (2016) reiterates that, in order for the future workforce to succeed, HE needs efficient skills transfer methods that will drive the promotion of marketable abilities in the future workplace (McLaughlin, 2016).

In addition to the already mentioned skills, Hariharasudan and Kot (2018) postulate that intercultural knowledge, advanced technological literacy and real-life skills will become more and more important in the future workplace. Butler-Adam (2018) shares a similar viewpoint, noting that as the world economy progresses towards the extensive implementation of AI alternatives, rivalry and demand will increase for a workforce with the scarce abilities necessary to execute, handle, and operate alongside the latest technological enhancements. Moreover, knowing about new technological developments is not sufficient: using them correctly and meaningfully is crucial (Eberhard *et al.*, 2017). It is therefore essential for any young individual who wishes to remain credible in an entirely automated workplace to develop such skills (Butler-Adam, 2018).

However, what does this future workforce look like? According to PWC (2018:14), the future workforce will be characterised by specialisation which will be extremely valued and like-mindedness, as the future workforce will gravitate towards one another, aided by technology, spurred by innovation and striving to nurture the most sought-after abilities, to mandate the largest package of rewards.

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Sheldon and Abidoye (2018) have envisioned the future workforce as a cohort with a creative and active entrepreneurial mind-set. Also, they will possess social and emotional intelligence qualities. Machines can be developed to fake human understanding, though real emotive feelings can never be feigned. Morality and taking ethical decisions will also be crucial to the total package of this cohort. This is the essence of being human, and something that robots in the foreseeable future will not be able to mimic. Deftness also forms part of the tools of the future workforce. Robots are becoming progressively more agile and real; still it is dubious that they can ever fully replicate the human being's aptitude and deftness (Sheldon & Abidoye, 2018: 223-224).

Johannessen (2018) predicts that the future workforce, or rather knowledge workers, will arise as the core resource of the 4IR. In other words, in the 4IR graduates with only undergraduate qualifications will become somewhat less desirable as opposed to graduates who have a post graduate qualification (Ford, 2015). Such graduates will become the new industrial and project workers, where PhD graduates will be known as the “knowledge geeks”, split into two categories. One category will be those with T-shaped abilities[12], implying both depth and breadth of understanding, as implied by the letter T. The second category of PhD graduates will be the autonomous specialists in the 4IR (Johannessen, 2018:10).

The four “knowledge worker” categories as described by Johannessen (2018:11) are displayed in Figure 4.5, also indicating the specific skills assigned to each category, together with the level of qualification.

[12] Linear and technological skills.

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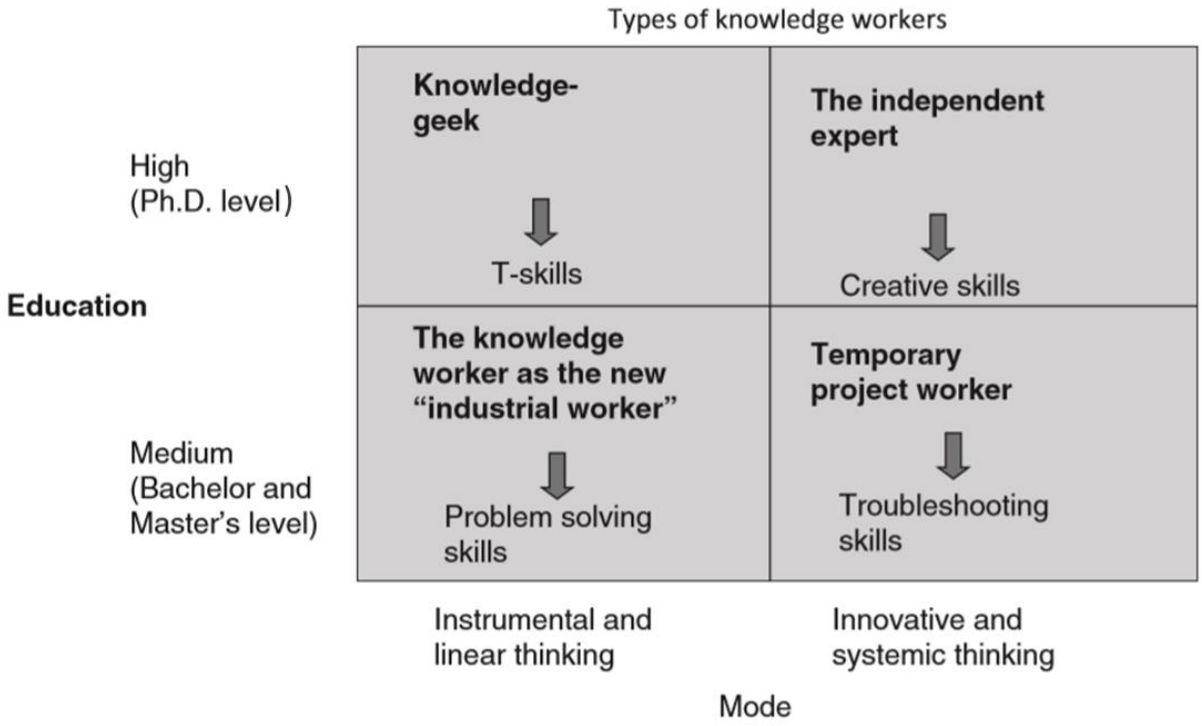

FIGURE 4.5: A typology of knowledge workers in the 4IR (Johannessen, 2018:11)

Against this background, an approximated idea can be formulated which will set the future workforce apart from machines or robots; in other words, the characteristics as described above make them human, and therefore unique. However, what was overly emphasised by most studies was that the future workforce would need specific skills to thrive in this robotic world of work skills that will equip them to work with and alongside these 4IR technologies.

According to Daniels (2017), for the future workforce to contend with the rapid modifications and variations in a worldwide industry 4.0 and act properly in response, they need the ability to reflect, reason, and apply new views and ideas. However, Huba and Kozak (2016) feel that the only way they can knock on the automated workplace door is with a good-theory-practice equilibrium, professional behaviour, interdisciplinary team cohesion, experience, and excellent communication abilities. Vestberg (2018) begs to differ, implying that the valued STEM abilities will be obligatory in satisfying the requirements of the technological workplace and safeguarding employability. Brown and Keep (2018) agree, postulating that the 4IR is an era of high-level and advanced skills, comprising coding, analytical, mathematical and statistical capabilities (Carillo, 2017).

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Nevertheless, there is still much uncertainty and differences amongst studies as to what are regarded as the most needed and demanded skills for successful employment in the 4IR workplace. Skills are constantly changing or fading out and being replaced by new, much more needed skills, in the same way as technologies are rapidly being updated. Therefore, Schwab (2016) emphasises the two skills or concepts that will be of cast-iron certainty as the ability to engage with lifelong learning and the ability for constantly reskilling and upskilling, adapting to the ever changing workplace. Auon (2017) arrives at a similar conclusion and notes that besides humanics[13], which have a dual form (new mythologies and mental or intellectual abilities of high order), lifelong learning will play an equally important role in the future. AI, robots and automation will become complicatedly entangled with both the private and career life of the automated existence of the future workforce.

However, in the 4IR, it is important to have a comparative indication of what kind of person the future workforce would need to best fit into the Industry 4.0 workplace. Also needed is to know the skill-set or skills profile that would best prepare students for this new venture into an automated workplace, called employment. The only consistency across nearly all skills predictions in the studies are the uncertainties of which skills are most required concerning the technological future, in adapting to the speedy transformation of the future workplace and skills shifts with the arising new jobs. According to Ratcheva and Leopold (2018), by 2022 there will be a noticeable shift in the abilities necessary to perform many jobs. The worldwide average abilities outlook - the percentage of key abilities necessary to perform the very same work as currently - is projected to be about fifty-eight percent. This implies that in the time leading up to 2022, employees will see a median shift of forty two percent in necessary and required workplace abilities (Ratcheva & Leopold, 2018:3). The next figure gives an indication of skills that are increasing in pre-eminence involving “analytical thinking” and “active learning” along with abilities like those of technological programming and design, illustrating the increasing demand for different types of competence and proficiency skills in technology (Ratcheva & Leopold, 2018:4).

[13] Humanics: Study of humanity or human subject matter.

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FIGURE 4.6: 2022 Skills outlook (Ratcheva & Leopold, 2018:4)

The Future of Jobs Report 2018 indicated that the key for positive, proactive management of such skills trends, as displayed in Figure 4.6, will be a comprehensive approach to workforce preparation, upskilling and reskilling.

4.6 SUMMARY

It has always been an imprecise art to foresee and predict the future. Whatever the future skills mixture requires, what is known from the scoping review studies is that students need to be prepared for whatever this 4IR future holds. Given the notional rate of transformation manifested by the 4IR, and the present speed of associated technological development driving such transformations, universities face the challenge of reacting to a multitude of forces for

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innovation, new possibilities and new problems (Wilson *et al.*, 2017). Huang and Kan (2018) suggest that it is important to contemplate the questions: what kind of individuals does the workplace of the future really need? In addition, how should the transformations in HE equip students with future core skills and competencies? Although daunting times are said to lie ahead, by highlighting new strategies to apply to the new workplace, future careers and skills needed by the future workforce, this chapter may guide the way forward in outlining the transformation process that South African universities require.

The starting point for the next chapter would therefore be to use this chapter's observations about the future workforce as a guideline to map the findings and concepts that flowed from the thematic analysis in Chapter Three. The development of conceptual models in the next chapter will be an attempt to address S-RQ4 and shed some light on this era of uncertainty.

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CHAPTER 5
THE TRANSFORMATION OF UNIVERSITIES AND TEACHING AND LEARNING: CONCEPTUAL MODELS

5.1 INTRODUCTION

The scoping review was a valuable method of identifying emerging concepts deriving from an array of studies. The functional next step, as explained by Arksey and O'Malley (2005), was to map these concepts into models as a representation of what is known about the 4IR. The need to develop conceptual models that will support the transformation of South African universities in the 4IR and more so, teaching and learning, is rooted in addressing the issues regarding the skills mismatch and graduate unemployment, mentioned previously. Therefore, the aim of this chapter is to answer the first part of the main RQ: *How should the key functions of South African universities, particularly those related to teaching and learning, be transformed?* This is done by incorporating the key concepts and findings, from the scoping review, in Chapter Three, into a foundation on which to facilitate transformation and by using the observations from Chapter Four as backdrop.

Such concepts and findings should stimulate the transformation of processes in South African universities that could contribute to preparing and assisting the future workforce in dealing with the complexity of finding employment in the Industry 4.0 workplace. More importantly, the clarification of the relationships between the concepts, including the suggested consideration of collaborations and partnerships, could lead to the establishment of sustainability for the future University 4.0.

5.2 THE CONCEPTUAL MODELS

The thematic analysis process of the scoping review identified concepts and themes from the data set. A conceptual canvas began to emerge after determining the broader themes and sub-themes, which were grouped into meaningful interpretations of the overall findings. This seemed the best way of explaining the key findings from the studies, that will enable the understanding of practices and services with reference to transforming and technologically enhancing the status quo of HE. Therefore, the objective of this chapter is to conceptualise some of the implications of the 4IR for South African universities.

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In addition, this chapter also specifically addresses the S-RQ4:

> Which conceptual models (consisting of key functions and assumed relationships between these functions / practices), derived from the scoping review, can be proposed for South African universities and particularly teaching and learning, to better prepare the future workforce for the 4IR?

Two new conceptual models are proposed to consolidate the variety of findings and concepts identified from studies included in the scoping review.

5.2.1 The macro conceptual model

The first conceptual model is constructed on a macro level to promote institutional change. This paves the way for the university of today to prepare and lead the workforce of tomorrow into a brighter future. In constructing the macro conceptual model, all of the scoping review findings have been synthesised to create a holistic view of a model for future universities, integrating all the findings, themes or concepts that surfaced from the scoping review process.

5.2.1.1 Discussion of findings underpinning the macro conceptual model

The scoping review identified technology as a crucial concept that must be implemented and utilised, for example, AI, big data, block chain, machine learning and robotics, amongst others, will become increasingly important over the next few years (Schwab, 2016; Adams Becker *et al.*, 2018; Lee *et al.*, 2018). The integration and use of these technologies for improving the efficiency of current practices form part of the most prominent factor in the 4IR, namely digital transformation.

a) Digital transformation:

Digital transformation was perceived by some studies as the fulcrum around which the entire 4IR phenomenon is turning (Eberhard *et al.*, 2017; Vey *et al.*, 2017; Abeid *et al.*, 2018). The reason for the importance of digital transformation lies in the creative and innovative manner in which digital technologies can be applied to enhance outmoded practices (Kodama, 2018). This enhancement and support of traditional practices with new digital innovative and creative practices can be seen as digital transformation from the old to the new (Adams Becker *et al.*, 2018). Pereira and Romero (2017) agree that digital transformation in universities plays a significant part in the enhancement of existing practices. However, these authors warn that the improvements inspired by digital transformation and increasing interconnectivity will bring about

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various challenges for universities, as their environment, practices, operations and services will be altered considerably (Pereira & Romero, 2017).

Many of the challenges related to the implications of the 4IR will occur under the rubic of digital transformation, which will mostly occur in the context of the core business of a university, to better meet the requirements of students by leveraging technology, knowledge and information to ensure successful student outcomes (Adams Becker *et al.*, 2018; Aziz Hussin, 2018).

Pollitzer (2019) raises another issue, namely that it is crucial to establish new business models capable of generating value from digital transformation and data operations and mitigating the effects of unskilled staff when it comes to utilising these new technologies (Pollitzer, 2019). Shahroom and Hussin (2018) arrive at similar conclusions, but add that university leaders are obliged to be astute when strategising innovative approaches which address the challenges of digital transformation. Therefore, execution of transformation in a responsible manner, together with the adoption of a code of ethics, are crucial elements in dealing with the digital transformation process for every university (Nordin & Norman, 2018; Shahroom & Hussin, 2018).

With reference to the above context, Solis (2019), provides a new, updated 2019 description of the term *digital transformation*:

> Digital transformation is the changing pursuit of innovative and flexible business and operational models — driven by emerging technologies, practices, applications, and skills — to generate new value and opportunities for students, staff, and stakeholders (Solis, 2019:1).

However, digital transformation presents a multitude of challenges for universities and thus necessitates the following of certain stages of change for successful execution, as proposed by Vey *et al.*(2017). Solis (2017) agrees, highligting six important but separate stages that should be followed or used as guidelines in the digital transformation process. These six stages attempt to avoid unnecessary pittfalls and safeguard effective implementation.

The six stages recognised by Solis (2017) are elaborated on in Figure 5.1:

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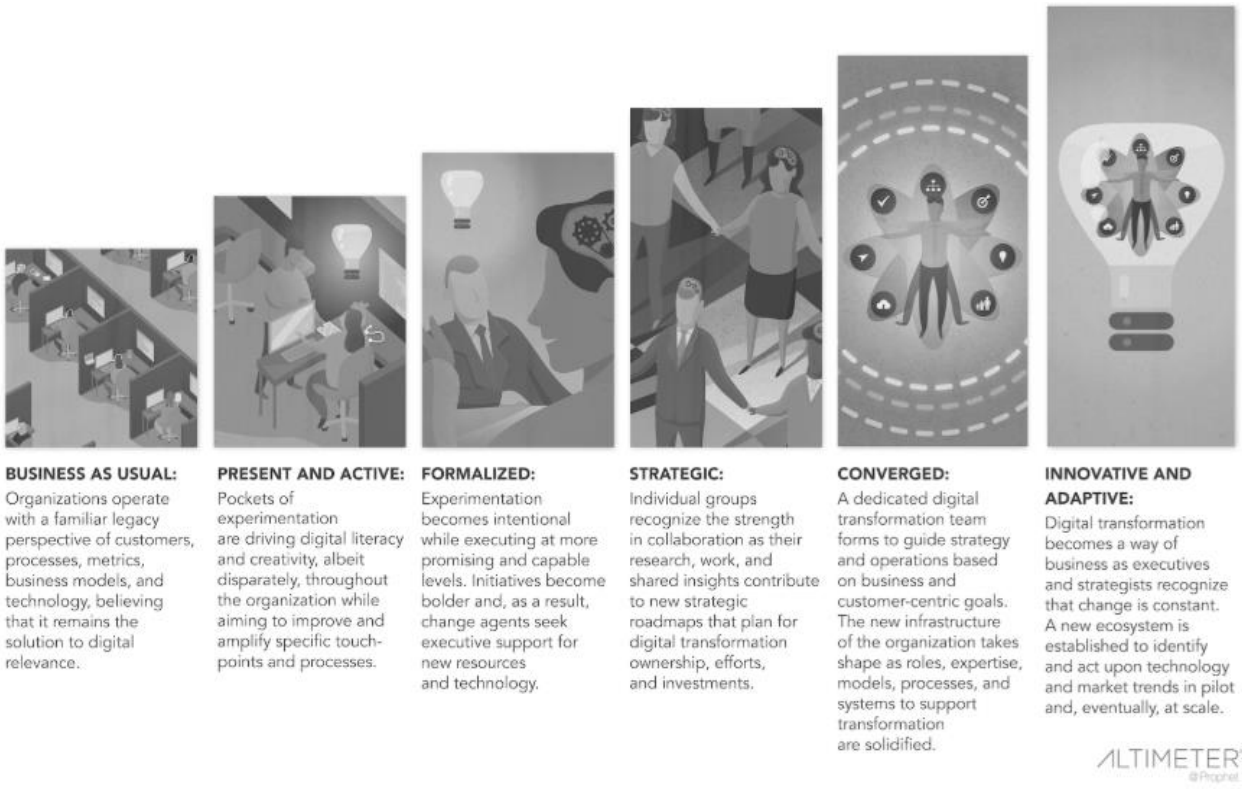

FIGURE 5.1: The six stages of digital transformation (Solis, 2017:1)

Collectively, these stages make provision for purposeful and advantageous digital transformation, so guarding against Digital Darwinism[14]. Darwin (1859) is well known for the expression that it is neither the strongest, nor the smartest that will survive, but those most adaptable to change (Darwin, 1859). Solis (2019) adopted the term Digital Darwinism to describe the rapid evolution of technology that is faster than any university can adapt to. For universities facing the prospect of Digital Darwinism, the most difficult aspect is to assess what needs to be changed first.

South African universities should therefore create new strategies for these rapidly evolving technologies in a spirit of collaboration and from an open-minded perspective, to ensure that there are more winners and fewer losers in the digital transformation process (Neufeind *et al.*, 2018).

[14] The term 'Digital Darwinism' is derived from Charles Darwin's well-known work: *Origin of the Species* (Darwin, 1859)

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b) Technology:

Technology can be seen as the force that drives digital transformation. Digital technologies, wearables and virtual worlds have given rise to today's digitally linked opportunities (Bower & Sturman, 2015). These opportunities are more varied than ever before and become indispensable throughout the digital transformation process (Richert, Plumanns, Gross, Schuster & Jeschke, 2015). Krueger (2018) predicts that, with the dawn of AI, 3D printing, digital computing and robotics, the next decade will be a time of astounding transition and change. Therefore, Chetty (2018) advises that South African universities should respond by, on the one hand, supporting the adoption of and experimentation with new technological innovations to improve the university's technological ability. On the other hand, Daniels (2017) suggests implementing professional staff development (PSD) policies to empower staff and make the university more innovative and resilient (Lee *et al.*, 2018).

While this era offers unlimited opportunities, it raises questions about universities' future and learning (Vey *et al.*, 2017). What are the implications, in particular, for the skills needed to succeed over the next two decades? How can universities guarantee that the future workforce is prepared for these exponential changes? (Krueger, 2018). South African universities are unquestionably answerable for developing the digital literacy of students and supporting responsible and suitable use of technology (Pellini *et al.*, 2019; Pollitzer, 2019). This growing importance of digital skills has a broad impact on curriculum design, PSD, operational services, and resources, amongst others, all oriented towards students (Adams Becker *et al.*, 2018). In being able to apply digital, data, communication and technology skills to particular workplace issues, students are expected to add value to the workplace, making them more desirable as employees (Chetty, 2018).

According to De Propis (2016), the main components that bolster the competitiveness and sustainability of future universities are technology, innovation and course offerings. Duc (2017) emphasises that as technology evolves rapidly, the adoption thereof should be the focus of any university to remain sustainable in the 4IR. In fact, the NMC Horizon Report: 2018 Higher Education Edition states that universities are by now already expected to have increasingly adopted analytical techniques. Halili (2019) agrees that universities should already be making use of big data retrieved from a variety of sources, devices, and systems, allowing interchange of data between universities, and analysing student data aimed at making predictions and

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informed decisions. Additionally, makerspaces[15] should already be integrated in the curriculum (Adams Becker *et al.*, 2018). The timing for the adoption of adaptive learning technologies and AI is estimated to be within in the next two years (Adams Becker *et al.*, 2018; Butler-Adam, 2018; Hamilton, 2018). The progress in these technologies and the promises they hold for teaching and learning must be recognised; mixed reality and robotics are anticipated to become more prominent within three years (Adams Becker *et al.*, 2018; Johannessen, 2018; Lent, 2018). Figure 5.2 below presents the technology-planning horizon for universities.

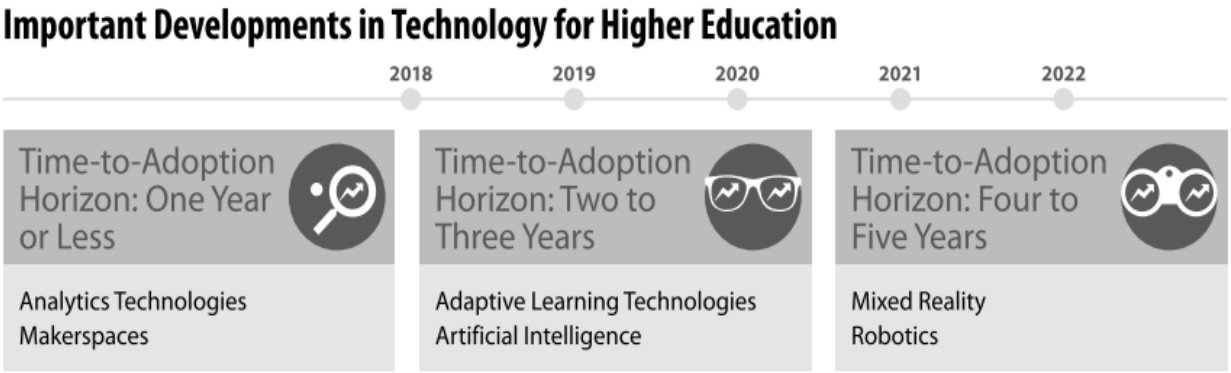

FIGURE 5.2: Timeline of important developments in technology for HE
(Adams Becker *et al.*, 2018)

The NMC Horizon Report (2018) indicates that South African universities should take stock and evaluate their technological position on this continuum. Elbeck (2018) postulates, that there are many approaches to incorporating technology into both curriculum and pedagogy, although these are contingent on student knowledge and require a commitment to prepare meaningfully for the future. However, before the integration and digital transformation process can even begin, South African universities need the pertinent infrastructure (Tvenge & Martinsen, 2018; Beliz *et al.*, 2019). It is a crucial requirement to invest in modernising infrastructure that supports the university's digital transformation by building the best-in-class ICT[16] infrastructure (Liao, Loures, Deschamps, Brezinski & Venâncio, 2018).

[15] A place where students can work together on projects, share ideas, thoughts and knowledge.
[16]See support services for elaboration on ICTs

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Technology and digital transformation are seen as the most disruptive forces or concepts in the 4IR, which will have an impact on every single aspect and process of the university (Spiro, Alexander, Lawrence & Ramanujam, 2019). These technologies and digital transformation, highlighted by a preponderance of studies, were therefore used to conceptualise the macro model for universities.

5.2.1.1.1 The top structure of the macro conceptual model

Pragmatically, a new business model defining the view of technology implementation and digital transformation must be formulated as a conceptual framework for the university (Lee *et al.*, 2018). The University 4.0 as envisaged will not emerge unless these innovative inferences, reformed services and new kind of leadership to oversee the implementation of the new business model are generated (Abeid *et al.*, 2018; Doepker, 2019). Ultimately, the latter two components, new business model and new leadership, will form the apex of the macro conceptual model.

a) New Business Models:

Various key studies have contended that universities are urgently in need of new business models so as to remain relevant and sustainable in the 4IR (Baxter, 2017; Selamat, 2017; Abeid *et al.*, 2018). According to Nordin and Norman (2018), digital disruptions have challenged the existing business models to such an extent that new business models are required. Such innovative models will accommodate transformations and future innovations, while at the same time guaranteeing worthwhile teaching and learning still relevant to students (Selamat, 2017). Moreover, in the 4IR, these business models should be innovative and distinctive, focusing on niche areas for attracting industry investments and partnerships (Abeid *et al.*, 2018). Carillo (2017) agrees, by saying that previous efficacious business models, strategies, processes, or structures for that matter, will not withstand the amount of disruption to be caused by the 4IR. Therefore, although these new business models should be innovative, South African universities should also strategically align their business models with the service and products they wish to deliver in order to survive these 4IR forces (Sledge & Fishman, 2014).

Sledge and Fishman (2014) further elaborate that South African universities should assess and establish their uniqueness in value. In other words they should identify what products and services set them apart from their counterparts (Kim, 2017). At the same time, the recommended business model for the University 4.0 is one that “depends largely on the cost and funding generated by the university” (Abeid *et al.*, 2018:107).

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In as much as the University 4.0 will need a new business model, it will also need strong leadership to implement the plan, steering the university through the transformation of the 4IR.

b) Leadership:

As a result of the 4IR, universities find themselves in a permanent condition of reform, posing huge challenges to university leaders (Schwab, 2016). Several studies proposed the characteristics and qualities leaders in the 4IR should have to strive and succeed. According to Smith and Pourdehnad (2018), university leaders should constantly exploit new opportunities, adapting to the rapid changes brought about by the 4IR with caution, wisdom and responsibility, in order to steer the university in the right direction. Penprase (2018) believes that these adaptations will not be subtle; rather, they will be large-scale transformations. Therefore, the new digital world does not only call for the development of digital literacy to manage the incorporation of digital technology in the new university (Butler-Adam, 2018); it now also calls for a new kind of leadership approach that can holistically lead these digital ramifications in universities (Shave, 2017).

Moreover, providing digital leadership and culture-shaping are now considered two of the most important prerequisites for 4IR leaders, as “digital transformation is the very heart” of the 4IR (Vey *et al.*, 2017:22). Therefore, leading with purpose, reason and mission to succeed in the 4IR requires legitimate leadership, trust, and honest-to-goodness straightforwardness, all competencies and skills leaders need to equip themselves with, in facing this digital storm aroused by the 4IR (Butler-Adam, 2018).

It must be stressed that reskilling should start at the highest level - without digital skills and knowledge of these disruptive technologies, leaders will be unsuccessful (Shook & Knickrehm, 2017). Butler-Adam (2018) adds the following competencies: the ability to explore and adopt digital and AI solutions and to acquire “the scarce skills required to implement, manage and work alongside the new technology”; obtaining such skills is crucial in staying relevant and leading optimistically in a soon-to-be automated world (Butler-Adam, 2018:1). Schwab (2016) agrees but on the other hand, also believes that the 4IR requires a different kind of leader, possessing emotional intelligence and mentor qualities, driven by sympathy and not sense of self (Schwab, 2016). Therefore, Smith and Pourdehnad (2018) believe these leaders should be uplifting yet quieting, visionary yet practical, rulers, likewise extremely human, accepting not knowing, but willing to explore and to upskill. By these means, such leaders will find answers

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and navigate progressively, while being trustworthy, so as to gain the buy-in of their followers (Smith & Pourdehnad, 2018).

Although there were no clear pointers from the studies in terms of the most appropriate leadership style for the 4IR, some studies leaned towards transformational leadership. Reasons given included that transformational leaders first "*think ahead"*, setting the vision and strategy for the university, to meet future projections about remaining relevant and sustainable. Secondly, they "*deliver within"*, managing the university amidst the change and reform, with the specific end goal of assembling new capacities; thirdly, and most vitally, transformational leaders *"lead across",* specifically captivating subordinates during the planning and implementation phase of transformation (PWC, 2017:13-18). This ability of transformational leaders to connect, to motivate and to empower staff, and, more importantly, to ascertain the desired change and transformation, positions them well for leading universities through this period of fundamental change (Smith & Pourdehnad, 2018). By comparison, Leurent *et al.*(2019) also especially find the supportive behaviours of transformational leaders to be the most successful in the 4IR. Nonetheless, transformational leadership is by no means the be-all and end-all solution. However, it is certainly a step in the right direction towards accomplishing the ultimate aim in the 4IR: a new *University 4.0*, promoting an innovative working environment and sustainable future (Schafer, 2018).

Some sceptics posit that South African leaders have slipped into a leadership abyss or "protectionist mode" (Venter, cited in Balkaran, 2016:11). South African universities therefore require bold and brave leaders (Schwab, 2016), as universities are perceived to have tinkered around at the edge of real transformation for far too long (WEF, 2017b). It is now crucial to step up to the looming 4IR, to drive innovation, implement new business models and establish new partnerships within the triple helix logic (Miron & Gherasim, 2018).

5.2.1.1.2 The core of the macro conceptual model

Encompassed by the need, as expressed in some studies (Etzkowitz & Leydesdorff, 1995; Kim, 2017; Miron & Gherasim, 2018), to form partnerships and to collaborate with industry, the centre of the macro conceptual model will be based on the triple helix concept of innovation. The triple helix model first saw the light in the 1990s, originated by Etzkowitz (1993) and Etzkowitz and Leydesdorff (1995).

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In recent years, the triple helix concept has been revisited by many leading universities, such as MIT[17] and Stanford University, for innovation, economic growth and building an entrepreneurial university (Leydesdorff, 2018). In many ways, university-industry-government partnerships have produced innovative formats for the invention, transmission and application of knowledge and technology with beneficial impacts on national competitiveness (Miron & Gherasim, 2018). Additionally, Leydesdorff (2018) postulates that, in these partnerships, each of the three partners play a distinctive role at structural level: “wealth generation (by industry), novelty production (academia), and legislation and regulation (government)” (Leydesdorff, 2018:1). Kim (2017) confirms that the triple helix of university-industry-government partnerships has undoubtedly turned into the true central subsystem of an innovation model (Kim, 2017).

Moreover, Miron and Gherasim (2018) emphasise that the adoption of the triple helix model could be beneficial for universities in generating extra income, initiating more relevant strategic research and development suggestions, training a highly skilled and qualified workforce, and enhancing graduate employment opportunities, amongst others (Miron & Gherasim, 2018).

The cooperation, collaboration and partnerships between the university, industry and government, as outlined in the Triple Helix model of innovation (Figure 5.3), illustrate how innovation and skills enhancement, and entrepreneurship, can be advanced (Compagnucci & Spigarelli, 2018).

[17] Massachusetts Institute of Technology

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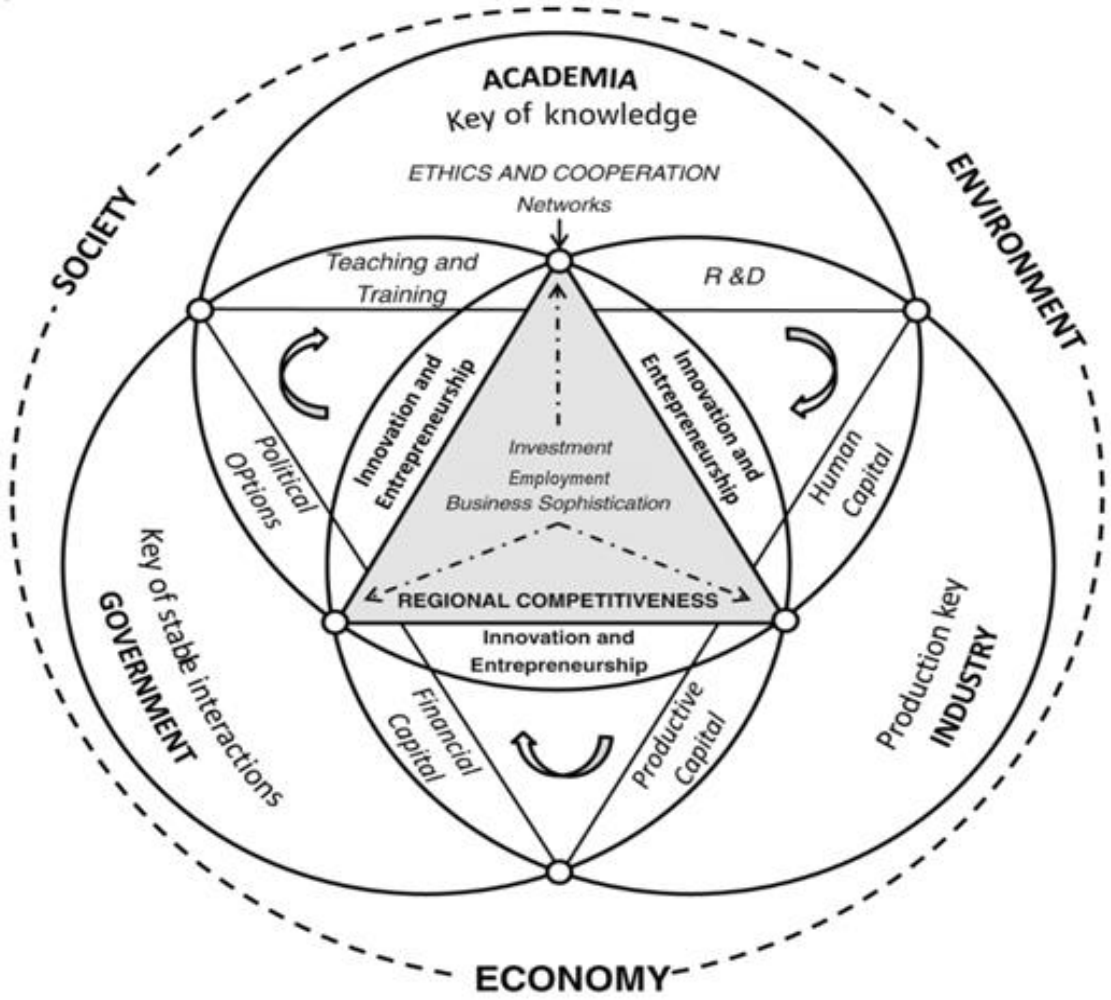

FIGURE 5.3: Triple helix model of innovation

(Compagnucci & Spigarelli, 2018:5)

Pasha (2019) believes that these partnerships contribute to economic growth and generally speaking, increased graduate employment. However, Miron and Gherasim (2018) add another partner to this trio relationship, which is civil society, to create a holistic view, converting the triple helix to the “quadruple helix model” (Miron & Gherasim, 2018:618).

For the development of the macro conceptual model in this study the triple helix was used, seeing that the partnerships and collaboration will have an automatic beneficial spill-over effect on society and the economy, as illustrated in the above figure by the gridline outer circle.

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In the proposed macro conceptual model, the key concepts from the scoping review are identified (indicated on the right-hand side of the model). Collaborative findings between partners of the triple helix system feed into the innovation triangle at the core of the triple helix triangle. Transformation of these key concepts will be enforced downwards from the apex or upper structure of the model, consisting of the new envisaged leadership empowered by the new business model, as schematically illustrated in Figure 5.4 below.

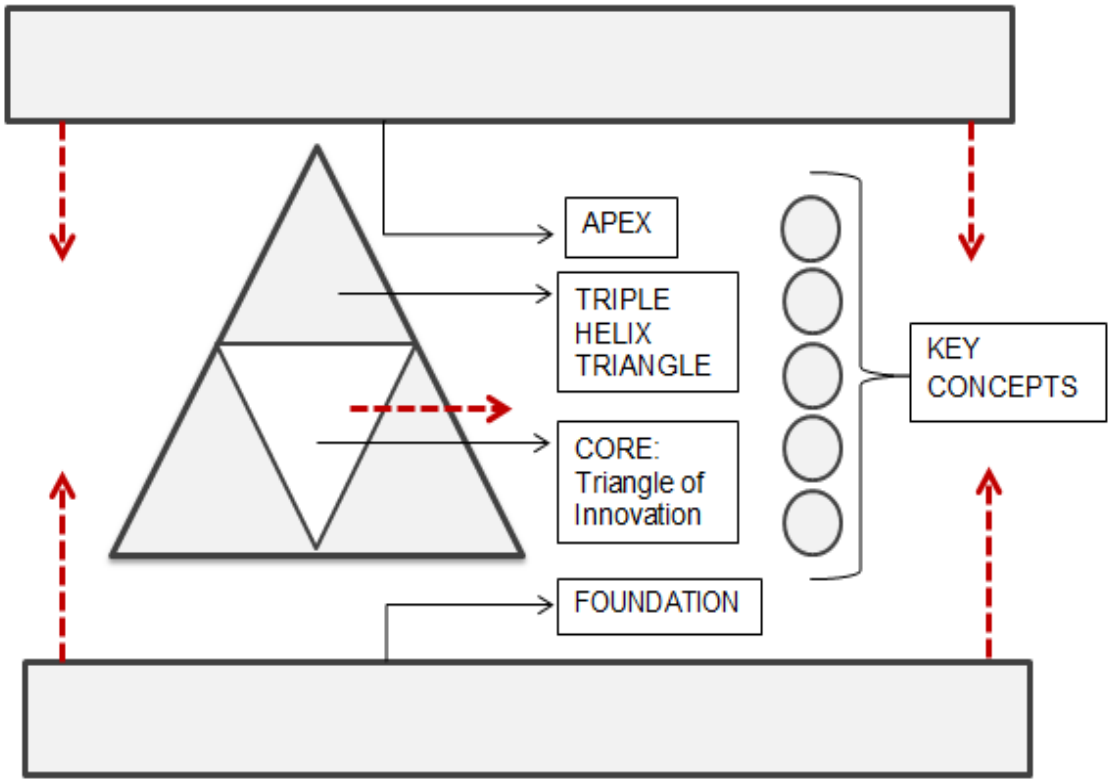

FIGURE 5.4: Schematic representation of the proposed macro conceptual model

These five key concepts or functions comprise research and development, support services, culture and environment, qualifications, and teaching and learning.

5.2.1.1.3 The key concepts of the macro conceptual model

The five key concepts are considered essential, as a starting point within the transformation process on the complex road towards University 4.0.

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a) Research and Development:

One of the most important and challenging tasks in the 4IR, is to transform the research and development environment of HE to advance in innovative research and the formulation of new ideas (Beliz *et al.*, 2019). Such research may lead to new models, frameworks and theories replacing current models, frameworks and theories of disciplines that may not fully address the new 4IR developments and requirements (Buasuwan, 2018). Universities will have to align degree and programme offerings with workplace needs, thus preparing the future workforce (Ernst & Young, 2018b). Market-related research is important for bringing research in line with practice, delivering real-time research, in other words "responsible research" towards guiding curricular innovation and sustainability (Abeid *et al.*, 2018:112). It has become evident that research and development has a significant responsibility "to guide policy and curriculum development" (Twinomurinzi & Ismail, 2018:6). Therefore, it is crucial that research and development spur the implementation of technology and propel the utilisation of innovative practices to assist teaching and learning (Schuster, Plumanns, Groß, Vossen, Richert & Jeschke, 2015). Most studies concur that universities that make this transition will become successful and sustainable in the 4IR. In the 4IR, finding ways to think and plan differently is crucial; universities should play a leading role in this search.

In the midst of the 4IR, it is therefore important for universities to "prioritize investments in research and development that could attract world-class academics and researchers who ultimately drive innovation" (Spiro *et al.*, 2019:36). In support of this, Xing and Marwala (2017) suggest that South African universities invest a vast measure of energy in research and development efforts to remain competitive in the global sphere. These efforts could vary from "new technology deployment to global cooperation and collaboration" (Xing & Marwala, 2017:3). Buasuwan (2018) reiterates that research and development have a vital role in securing the growth and sustainability of the future university. In close conjunction with industry, research and development can generate new knowledge and ideas. Research and development can also prompt innovative services and products, placing the university at the forefront of the 4IR (Abeid *et al.*, 2018). A number of studies have stated the valuable role of innovative research and development projects in generating funds for universities, stimulating economic growth and ensuring a knowledgeable society.

In many ways, deploying such research efforts or services could expand consensual perspectives among the research network, permitting more realistic views regarding 4IR impacts and future requirements (Beliz *et al.*, 2019). Research and development will play a

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significant role in the 4IR to ensure that the university as a whole remains relevant to the community and the interests of stakeholders are taken into account.

Now more than ever, industry is consulting universities, increasingly applying research and development to seek solutions to challenging issues of the 4IR (Buasuwan, 2018). Research helps universities keep abreast of the latest developments and cutting-edge knowledge in order to remain relevant and sustainable in times of rapid change. Likewise, universities will increasingly see the benefits of establishing cross-sector collaboration and partnerships with industry. Also, designing, establishing and managing these universities includes proper research (Bates, 2015). In sum, South African universities should establish interdisciplinary research teams with a strong global emphasis, to focus on development and innovation within the 4IR sphere. Furthermore, through innovative research outputs and by investing in their human capital, thus preparing a skilled workforce for future jobs, South African universities will increase their prospects of climbing the global universities rankings and remain relevant. Global ranking successes validate a university's efforts to prepare and reposition itself for the 4IR. What becomes evident is that in taking a prepared stance in the 4IR, proper and innovative research should be conducted to develop and enhance processes and support services in an innovative manner.

b) Support Services:

The University 4.0 has to digitally transform its processes to offer new technologically enhanced services and reliable fast infrastructures. Such enhancements will support the utilisation of big data for better service delivery and in aligning services with 4IR requirements (Abeid *et al.*, 2018). Both ICT and PSD play a vital role in the success of the 4IR transformation process and form an integral part in both models. Therefore, it is vital for South African universities to invest in their ICT and technology infrastructure, as these improvements demand topmost priority for any university nowadays, to remain sustainable (Lambrechts & Sinha, 2018).

- ***ICT:***

A well-functioning ICT infrastructure will facilitate the incorporation of digital technologies to enhance processes (Pfeiffer, 2015). Balkaran (2016) warns that these technologies should be carefully considered, as they will differ for operating systems and functions within the university. Rather than go by the ‘out with the old and in with the new’ principle, South African universities should consider, as a starting point, investing in ICT and the phasing-in principle. Whatever approach is taken, it should be treated as a matter of urgency. Delaying the upgrading and

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implementation strategies will come at a cost. Installing ICT that meets 4IR standards holds numerous advantages that are priceless (Halili, 2019). Schwab (2016) adds that many time-consuming tasks can be automated by these technologies, freeing up time for more important tasks. Therefore it is crucial for South African universities to revisit their information technology systems as such technologies are being "primarily driven on ICT platforms" (Twinomurinzi & Ismail, 2018:1).

More than ever, ICT plays a vital part in the 4IR; without an ICT supported environment, no universities' envisaged 4IR strategies will come to life (Tvenge & Martinsen, 2018). Pollitzer (2019) argues that it is the potential and ability of ICT that drives the 4IR vision of a university. However, accepting the need for a reliable ICT infrastructure, these technologies also need data to work with. In fact, data has morphed to become the new digital oil that runs through the pipelines of universities (Carillo, 2017). Data evolves and becomes bigger (big data), growing and gleaning valuable information along the way (Chetty, 2018). *Big data* and disruptive technology have heralded the transformation of the business world. Such transformation extends to society at large, not excluding the HE system (Gleason, 2018). Most studies described the HE system as seriously affected. Big data and the process of collecting data, analysing the data to understand and use it to add value as displayed in the Figure 5.5 below, play a significant role in the 4IR (Lee *et al.*, 2018).

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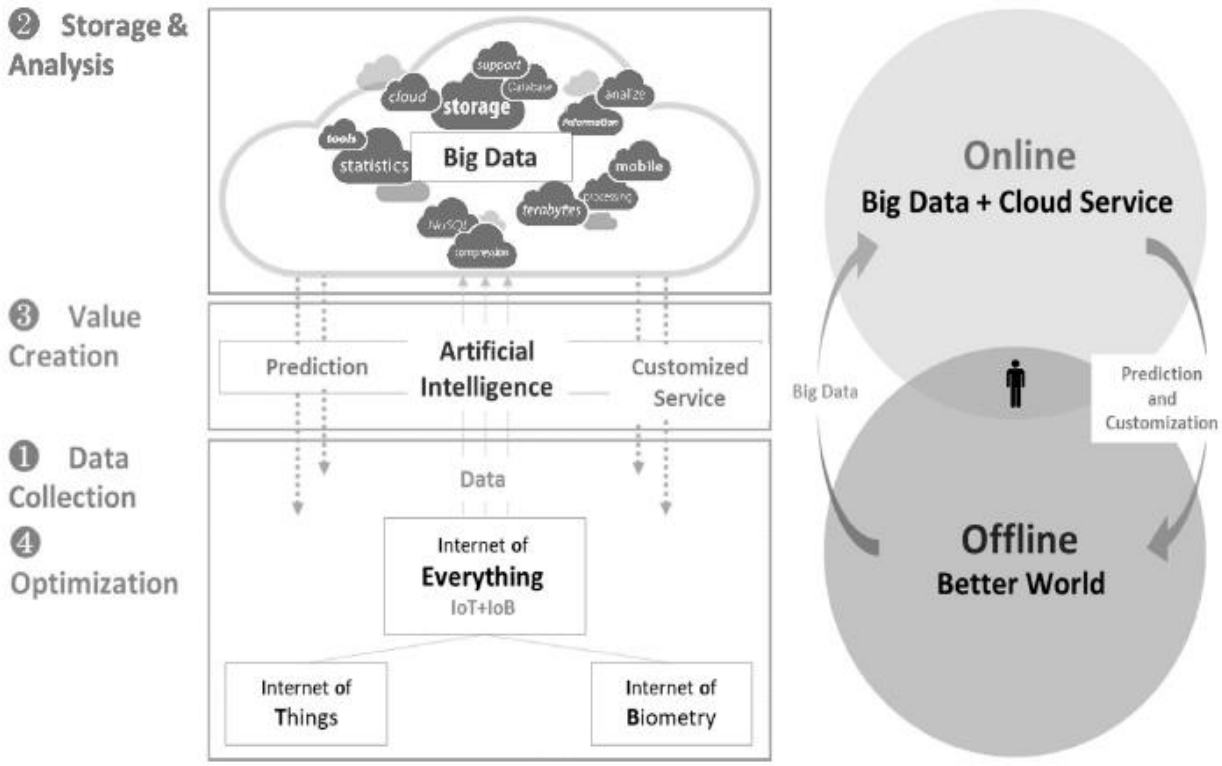

FIGURE 5.5: Fourth Industrial Revolution dynamics model (Lee *et al.,* 2018:11)

Four necessary steps, as displayed in Figure 5.5, should be taken for each university to organise itself, thus converting real-world time and space into big data optimisation in a virtual environment (Lee *et al.,* 2018). AI, as a commodity can then be based on big data estimates, resulting in big data becoming the most critical asset of initiation, as shown in Figure 5.5.

Therefore, to become data-driven would be the logical next step for South African universities, as gathered from the findings. In support of this, Adams Becker *et al.*(2018) highlight that there already exists a significant degree of evidence on ways in which observations drawn from big data in the university context can transform and enhance key functions and operational processes. This applies to, for instance, marketing, finance, support services to students and human resources, to name a few (Carillo, 2017).

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- ***Artificial Intelligence (AI)***

Within the technology infrastructure domain of any university AI will become more and more mainstream for streamlining processes and services. Kim (2017) ruminates that AI can be seen as a 4IR tool for enhancing the human knowledge that involves different insights, by stimulating thinking that is more creative, achieving better results. According to Balkaran (2016), the value of AI lies in "future-ready training programs" that provide only "what we need to know, when we need to know it" (Balkaran, 2016:13). AI is essential in making decisions and predictions (Carillo, 2017). An important component of AI is machine learning and deep learning, known for their language comprehension and pattern or image recognition abilities, amongst others, which can create value for universities (Liu, Gao, Wang & Liu, 2018). The capabilities of AI and machine learning to modify and enhance services, if used wisely, can hold many beneficial prospects for universities (Lee *et al.*, 2018).

- ***Professional Staff Development (PSD)***

What also becomes apparent from a vast number of studies was that South African universities urgently need to focus on rendering support services towards PSD. The reason for this so called need for PSD can be found in that the 4IR knowledge, skills and practices rapidly go out of date, as new digital technologies surface; therefore such resources continually need to be refreshed and updated (Leibowitz *et al.*, 2017).

Greater emphasis is placed on PSD owing to the impact of the 4IR and accelerating digital transformation on practices within universities causing professional "staff development [to become] a fast-growing practice" (Roxå & Mårtensson, 2017:95). This enables universities to keep up with these innovations and digital transformation in order to remain sustainable (Daniels, 2017).

It is by and large acknowledged, that PSD involves, among other things, the enhancement of digital knowledge and skills of the staff of a university, which augments the value of the university (Leibowitz *et al.*, 2017). Moreover, Daniels (2017) concurs that PSD is the practice whereby employees continuously upgrade their knowledge and skills to promote the implementation of innovative methods and technology-enhanced practices that prove to be both beneficial and worthwhile to the university.

This leads to the question: How do lifelong professional learning and growth take place in the 4IR? According to Leibowitz *et al.* (2017), this type of learning can be developed by events, for

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example, workshops, breakaway days, conferences and gatherings. This is despite the challenges of introducing such learning into the work environment being well-known (Nørgaard & Guerra, 2018). Research from the scoping review demonstrates that much professional learning is non-formal, which is to say that it emerges through the promotion of such events (Roxå & Mårtensson, 2017). The point here is that such non-formal events can foster continuous learning and upskilling, and increase new understandings, introduce new technologies, motivating staff to take new actions, or to improve an old way of thinking and remain employable in the 4IR (Jackson, 2017).

Another key finding is that the scope of professional learning and PSD opportunities are very important in the 4IR workplace, spanning the range from formal learning opportunities to the most casual of all, involving being adventurous, taking risks, making mistakes and gaining from one's own continuous practice (Daniels, 2017). The connection between the more formal and the more casual development opportunities is "complementary and mutually reinforcing" (Leibowitz *et al*., 2017:67).

Although diverse opinions are to be found concerning the underlying role of PSD, authors concur that it must be result- and best practice-orientated (Coswatte Mohr & Shelton, 2017); it must encourage proficient change at an individual and institutional level (Schwab, 2016); it must herald improvement of the person's full potential and thus self-development, and it must be continuous in nature (Janíková & Kowaliková, 2017). Therefore, PSD can be conceptualised as an on-going process of training, preparing, learning and support activities to enable employees to develop in their respective roles within the new University 4.0 (Leibowitz *et al.*, 2017).

Under the digital umbrella of the 4IR, lifelong learning, upskilling, retraining and being able to adjust should be accentuated, as echoed by almost all studies. Brynjolfsson and McAfee (2016) underline the significance of sustainable self-improvement in order to remain employable in these changing times. It is also important to stress the need for academic and support staff to understand these digital and technological changes, especially the impact thereof on the work and learning environment, to be able to embrace it (Jackson, 2017).

Every day academic and support staff are challenged by innovations and developments in their professional lives, causing stress levels to escalate. In the 4IR, there is no U-turn, only a fast forward. How staff experience these changes becomes their truth and a fear thereof can be self-

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limiting. Schwab (2016) warns that there is no place for *technophobia*[18] in the 4IR work environment.

As previously mentioned, PSD and more so lifelong learning is an ongoing process supported by "the facilitation of contextually situated, innovative, agentic, and continually developing professional practice" (Daniels, 2017:80). This indicates the critical role of, for example, digital innovation, structures, time, space, standards and policies, which are all part of professional development and learning (Leibowitz *et al.*, 2017). Therefore, on the one hand staff should be inspired to explore the hidden values and benefits of PSD and self-improvement (Roxå & Mårtensson, 2017). However, on the other hand, for staff to feel inspired to participate, it is of cardinal importance that the recalibrating of these programme offerings must contribute to them remaining relevant (Daniels, 2017).

In view of that, South African universities should expand their PSD programme mix, increase budget allocations and incorporate innovative lifecycles in response to global market drivers by ensuring the constant upskilling and retraining of staff (Schwab, 2017).

These responses should be rapid and flexible in light of the 4IR, as there can no longer be a *one size fits all* approach. Digital literacy and adequately equipping staff with the skills to utilise and implement these digital technologies, will not only enhance practices, but also positively influence the culture and environment of the university.

c) Culture and Environment:

Digital transformation is perceived as the axis around which the 4IR rotates. However, before digital transformation in any university can commence, it is imperative to first trigger an in-house transformation that changes the culture or the "DNA with its norms and values" (Vey *et al.*, 2017:25). True change and innovation start from within; universities need to foster an innovative, captivating and collaborative team culture (Gebauer, Adams, Nan & Bingham, 2016). However, for such a culture to flourish and grow it needs innovative physical and virtual surroundings (Richert *et al.*, 2015). At the same time, Schäfer (2018) insists that for any university to be successful in the 4IR, it must establish a "vibrant environment that is open to new technologies" (Schäfer, 2018:6). Most studies from the scoping review are in agreement when it comes to the crucial role that culture and environment plays in transforming a university

[18] Fear, dislike or the deliberate avoidance of the latest technology.

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towards compatibility and sustainability in the 4IR. Some studies also added entrepreneurial culture and environment to the mix (Farrell & Hurt, 2014; Hattingh, 2017; Kim, 2017; Naudé, 2017; Pasha, 2019). However, the key function that all the studies avowed is sorely in need of transformation is teaching and learning.

d) Teaching and Learning:

Most studies in the dataset agreed that the effect of the 4IR on HE, particularly the practices and methods used in teaching and learning, will be enormous. This is mostly because the current status is found to be incompatible with the virtual environment of the future university. However, a large number of the studies also concurred that modifications to traditional teaching and learning practices in order for them to be appropriate for virtual spaces, will not come easily nor without resistance. Therefore, it is important to take the scaffolding approach, adapting, evaluating, reflecting and altering practices constantly to foster innovation, as demonstrated in the model for HE innovation below (Hutchings & Quinney, 2015).

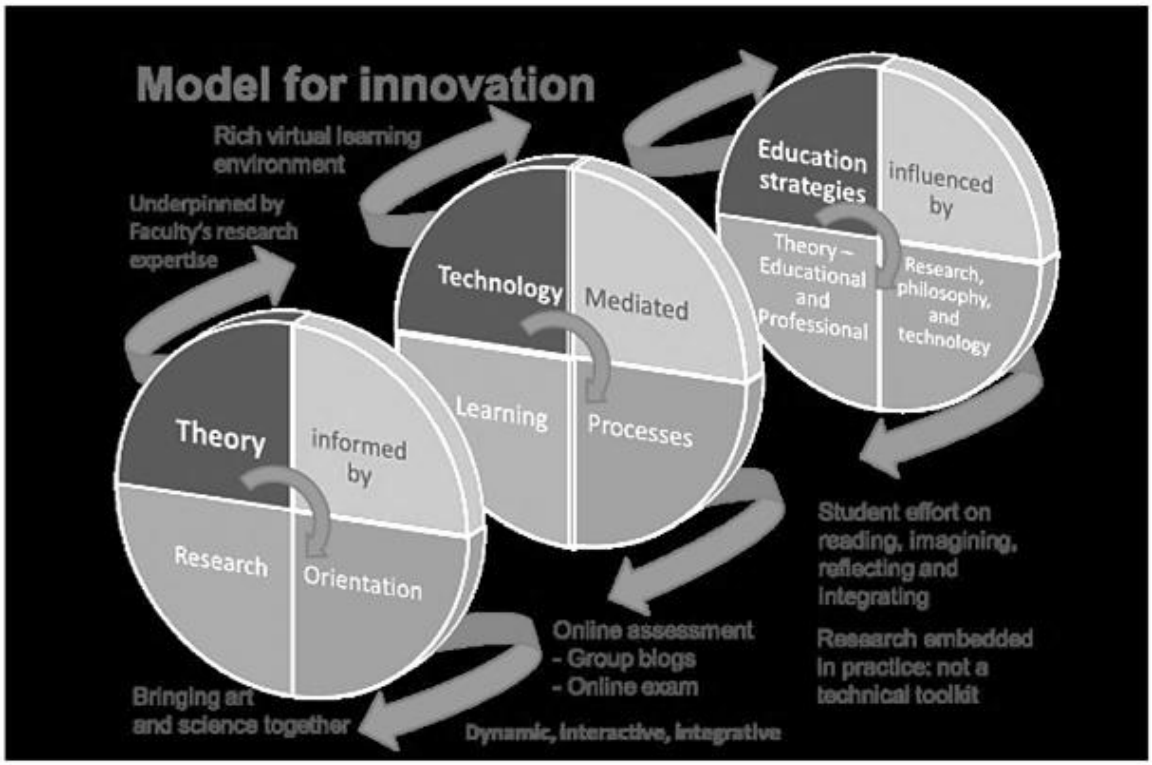

FIGURE 5.6: Model for HE innovation (Hutchings & Quinney, 2015:115)

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The model of HE innovative modification is “dynamic, intuitive, and integrative“ (Hutchings & Quinney, 2015:115); it is also enabling in the sense of dealing with constant change and difficulties, but at the same time harnessing technologies in such a way that is empowering both to academia and students (Hutchings & Quinney, 2015). Hutchings and Quinney (2015) explain that the model is built on three key and interconnected components of the innovation process, first, integrating interdisciplinary and transformative learning; second, informing collective learning based on students own efforts and third, taking advantage of the ability of a variety of technologies to enhance training for students.

An interesting aspect emerging from virtually all studies focusing primarily on teaching and learning was that millennials’ and post millennials’ expertise in technology is mostly undervalued by academics. Such expertise should be utilised and focused on for a richer and meaningful student experience. In order to understand the 4IR, communication is essential (Ghislieri *et al.*, 2018). In addition, this epoch will involve universities pushing the teaching and learning limits (Osman, 2018). The responsible innovation of teaching and learning, as a key function of every university, may be seen as the *sine qua non* of the entire University 4.0 transformation process. Therefore, teaching and learning with all its related components, for instance innovative teaching and learning practices, curriculum innovation, students’ skills transfer, learning environment, collaborations, upskilling and reskilling, and PSD, amongst others, will be dealt with in the next section under the micro conceptual model construction.

Another vital role of teaching and learning, ensuring the sustainability of South African universities, lies in relevancy of qualification offerings and how they are delivered.

e) Qualifications:

Universities are amongst the most affected of all sectors by the 4IR, and it is not difficult to see why and how. Digital technologies are altering both research methods and teaching and learning practices (Dewar, 2017). According to Dewar (2017), the changing workforce demands directly impinge on universities’ qualification structures, because graduates now require new skills and expertise. The prospects of teaching and training qualifications that are completely immersed in virtual environments enable the reinforcement of literacies and skills that will be part of the future workforce’s professional and personal lives (Richert *et al.*, 2015). In addition, Nørgaard and Guerra (2018) believe that graduates with multidisciplinary skills are increasingly valued in the workplace. Therefore, these kinds of programmes and qualifications may well be tailored to meet the particular requirements of the Industry 4.0 workplace (Nørgaard & Guerra,

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2018). Xing and Marwala (2017) suggest that delivering more flexible qualifications between universities locally and abroad is necessary.

The following suggestions for more flexible qualifications were made (Xing & Marwala, 2017:8): firstly, combined programs in which a local university works with a foreign university to create a linked scheme for taking credits at various sites. The foreign university awards a qualification upon completion of the combined programme. Secondly, franchise programmes in which foreign universities authorise a local university to offer their courses / programmes, and the foreign university grants the qualification. Thirdly, double or joint qualifications which are an agreement in which local and foreign universities work together to deliver a programme for which a qualification is granted collectively, or from any of the universities. Fourthly, blended or mixed learning when universities locally and internationally offer educational programmes in multiple mixed modes such as online or e-learning, as well as on-campus learning.

Some studies stress that South African university qualifications should be thoroughly redesigned to provide the future workforce with 4IR relevant qualifications and appropriate digital skills to operate effectively beside machines (Neufeind *et al.*, 2018). In support of this, Sledge and Fishman (2014) emphasise the value of triple helix partnerships, in which industry partners have the option of specifying and identifying the skills they need. In doing so, these partners will increase their workforce and both HE and students will understand which abilities are needed for employability (Sledge & Fishman, 2014).

Against this backdrop, Menon and Castrillon (2019) question whether traditional qualifications of three to four years will provide the skills required to meet the 4IR requirements and whether the rigidity of the present qualification systems is in the interests of the future workforce. The authors elaborate by suggesting “flexible hop-on / hop-off” syllabuses (Menon & Castrillon, 2019:1) that provide students with the capacity to break out of rigid qualification silos. Students can instead take a variety of courses to better prepare themselves for a radically distinct, complicated and flexible Industry 4.0 workplace (Menon & Castrillon, 2019).

Hattingh (2017) warns that many current qualifications prepare the workforce for jobs that will be non-existent within five years' time, or that, at the very least, will be drastically different. Therefore, as gathered from the findings, it is crucial for departments and faculties to take hands in finding innovative solutions, for example to introduce cross-disciplinary programme offerings that will safeguard sustainability.

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5.2.1.1.4 The foundation of the macro conceptual model

If all of the above is carefully considered, planned and implemented, a strong foundation can be built to sustain the new University 4.0.

Many studies expressed the importance of overall excellent service delivery, quality relevant qualifications, cost effectiveness (Duc, 2017; Dew, Beitel, & Hare, 2018; Hamilton, 2018; Hattingh, 2018; Doepker, 2019; Menon & Castrillon, 2019); Industry 4.0 related career guidance and most importantly, technologically enhanced practices (Adams Becker *et al*., 2018; Feldman, 2018; Gleason, 2018; Miron & Gherasim, 2018; Halili, 2019; Leurent *et al*., 2019; Spiro *et al*., 2019), for universities to remain sustainable in the 4IR. In addition, Compagnucci and Spigarelli (2018) highlight that innovative business models, products and support services also play a key role in ensuring sustainable growth.

What transpired from the findings was that technology is central to contemporary innovation, economic growth and sustainability in the long term. In support of this, Lambrechts and Sinha (2018) draw attention to the current inconsistencies between the HE undertaken by students and digital skills demanded from the Industry 4.0 workplace, particularly in developing countries. Butler-Adam (2018) claims that everyone can benefit from technology especially from advanced AI applications for sustainable development goals. Whether the objective is quality teaching and learning, employability or competitiveness, value-added AI alternatives are available right now (Butler-Adam, 2018).

The collective HE 4IR mantra is clear: *prepare students for an unknown future.* If fully realised and adopted, this will assist universities in remaining sustainable (Lambrechts & Sinha, 2018), one of the most important and apparently impenetrable issues in the 4IR.

5.2.1.2 Proposed macro conceptual model

Drawing from the canvas of findings, the creation of a macro conceptual model was complex. The process necessitated not only dealing with the blurred lines of uncertainty, but it also had to incorporate the triple helix model, collaborations and partnerships, as some studies predicted this to be the future of universities and the way forward (Etzkowitz & Leydesdorff, 1995; Kim, 2017; Miron & Gherasim, 2018). It was crucial to address and integrate the diversity of themes and concepts emerging from the scoping review. This had to be accomplished in such a way that it would speak to problems related to the skills mismatch and graduate unemployability. The

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challenge was to propose a model that would better prepare the future workforce and create a sustainable university.

The result was a new macro conceptual model, representing the key findings and demonstrating the relationship between them, as illustrated in Figure 5.7.

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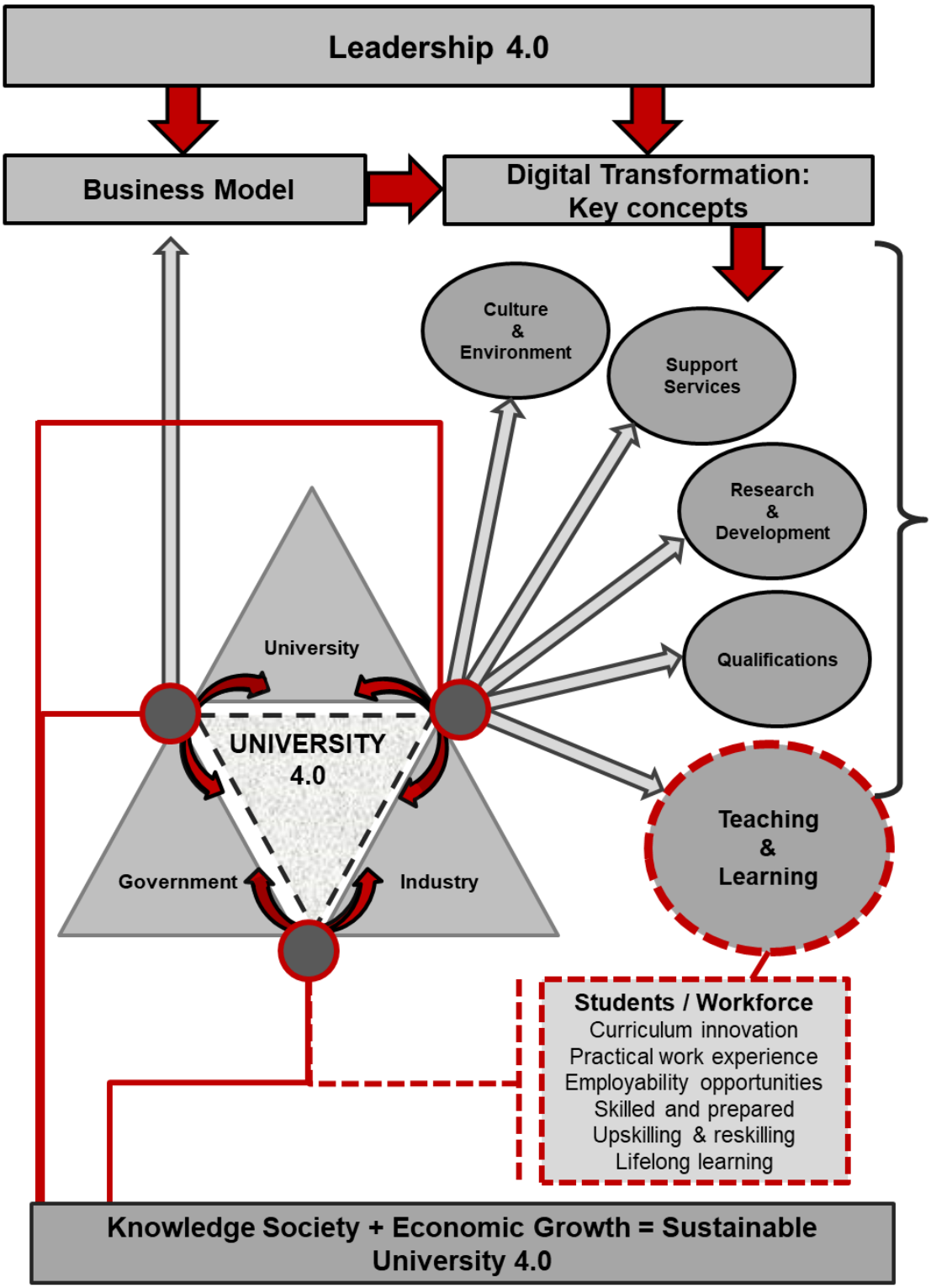

FIGURE 5.7: Macro conceptual model - University 4.0

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5.2.1.3 Relationships and interactions within the macro conceptual model

Indicating the relationships among concepts in the macro conceptual model was essential to highlight key concepts within the university, while contextualising the research findings around the 4IR. Leadership 4.0 and a new business model emerged from the consulted studies as the overseeing functions in influencing cultures and attitudes towards the digital transformation of the other functions. While the new business model should be creative and innovative, South African universities should also align their business model strategically with their services and products. Therefore, leadership will have a significant role in the macro conceptual model, South African universities will need dynamic and courageous leaders to implement these changes ethically, while regulating and managing the transition phase towards a University 4.0.

The main concepts or functions, as indicated in the macro conceptual model, are mostly impacted by the 4IR and in need of transformation. Such concepts or functions consist of: research and development, support services, culture and environment, qualifications, and teaching and learning, each playing a vital role in the transformation process of the university.

The triple helix triangle in the centre demonstrates the dissemination of innovative ideas, sharing of knowledge, creation of innovation hubs, virtual spaces and a start-up ecosystem to produce entrepreneurs and a workforce with a digital future. Both direct and indirect enablers in the triangle of innovation are the collaborations and partnerships among the university, industry, and government. These collaborations can be cross-sectional between disciplines or departments and industry. On the one hand, industry has a vital role to play in practical work experience opportunities for students, which can result in employment possibilities after graduation. On the other hand, for “governments and policy makers, it is vital that the enabling mechanisms are put in place for the 4IR to be a sustainable revolution” (Herweijer *et al.*, 2017:2). These direct and indirect outcomes of collaboration between the triple helix partners drive the transformation process and feedback on the key functions and the business model of the envisaged University 4.0. Key functions or concepts constantly need re-evaluation in quick cycles to prevent them from becoming obsolete. Therefore, regular updating and enhancement of these digital technologies are required (Adams Becker *et al.*, 2018).

Many studies support the view that universities should both create financial stability and show responsibility towards society. On the one hand the 4IR will bring about periods of instability and complexity for universities. On the other hand, such times hold immense opportunities and room for future growth and development. Financial security could stem from upskilling and reskilling

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the current workforce in the workplace. Economic growth should be stimulated through skilled graduate employability, in other words guaranteeing graduates' relevance within the 4IR context (Abeid *et al.*, 2018). Investing in a knowledgeable society and an employable future workforce, forms part of the University 4.0 vision. Therefore, the need to develop a second model for teaching and learning as the most disrupted key function which directly involved with preparing skilled graduates will be discussed in the next section.

No single action is going to be enough. However, each concept, as indicated within the macro conceptual model, could be crucial in assisting universities in responding to and minimising the implications of the 4IR. Yet, as a first step, establishing sound partnerships and innovative collaborations through the triple helix concept may well guarantee a sustainable University 4.0.

5.2.2 The micro conceptual model

The macro conceptual model escalates the need for developing a second micro conceptual model for teaching and learning as one of the most important functions in HE and also the one that is most affected by the 4IR. According to a large number of studies, there will be many changes in teaching and learning methods in the near future. Shahroom and Hussin (2018) argue that reform will not only apply to the teaching content, but also to the lecturers' and students' roles. It is therefore necessary to reverse the logic of HE schemes, so that it is the system that conforms to the student, rather than the student to the system (Shahroom & Hussin, 2018). This is the principle of personalisation. Personalisation means establishing a lecturer-student relationship that is uniquely personal and responsive to the many distinct ways in which students can become more successful (Brown-Martin, 2017).

As universities proceed into the 4IR, data analytics will play an even greater part in enhancing teaching and learning, as the related issues become big data issues and data will be crucial in finding solutions (Pillay, Maharaj & Eeden, 2018). Halili (2019) elaborates that big data analytics is extremely valuable, for example, by allowing HE to ascertain how well students learn, student drop out patterns, student academic performance, or to predict any data linked to attendance patterns. According to Hutchings and Quinney (2015), technologies offer unprecedented possibilities to make use of the available time and space for teaching and learning. Nevertheless, the challenges presented by the 4IR are so enormous that any society that is not adequately developed is likely to fall behind without exposure to modernisation, innovation and growth (Akor, Noordin, Subari, Jambari, Nasir & Pairan, 2018).

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Evident from the findings was that the complexity of teaching and learning lies in the multiplicity of methods, practices, disciplines, curriculums, to name a few of the affected concepts that will need transformation in the future university. Therefore, it is important that these findings derived from the scoping review studies and experts' viewpoints regarding the crucial concepts of teaching and learning are carefully discussed and scrutinised.

5.2.2.1 Discussion of findings underpinning the micro conceptual model

It became obvious from the majority of studies that a paradigm shift in the transformation of current teaching and learning practices is required to meet the 4IR demands and challenges. Now, more than ever, creating a renewed, integrated, flexible, sustainable and lifelong HE system that meets the requirements of the future is critical (Doucet, Evers, Guerra, Lopez, Soskil & Timmers, 2018). Fortunately, a take-away from almost all studies was that new methods of teaching and learning have started to emerge and can point the way forward. Therefore, in order to develop a micro conceptual model for teaching and learning, these new methods and concepts were investigated. What has been highlighted by most studies as an important point of departure for teaching and learning, is the need to first understand today's students, their characteristics, abilities and also their needs *(Farrell & Hurt, 2014; Eberhard et al*., 2017; Aziz Hussin, 2018; Shahroom & Hussin, 2018).

a) Students:

The present student population is identified by many terms, but most commonly known as *millennials* or *post-millennials* (Farrell & Hurt, 2014). Integrating millennials and post-millennials as students into a *baby boomer* culture, to which the majority of academics belong, holds a substantial challenge for universities, especially in the technology-driven era of the 4IR. Therefore, unravelling the characteristics and diversity of this generation in an attempt to better understand the students and their abilities is vital (Shook & Knickrehm, 2017). According to Bates (2015), dealing with this progressively diversified generation of students is possibly the most challenging task facing academia in the digital age (Bates, 2015:452). Farrell and Hurt (2014) suggest asking questions such as: Who are these students? and How do they learn?, to become conversant with the student profile of a university. Only after gathering this valuable information, can academics identify preferred methods of learning and engaging with the so-called millennials (Farrell & Hurt, 2014). Pfeiffer (2015) draws attention to the fact that millennials "get excited about technology" (Pfeiffer, 2015:35). Millennials and post-millennials have been described by some studies as being "technologically savvy", in that they are fast learners and a skillful generation when it comes to computers and technology (Farrell & Hurt,

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2014:49). In other words, the modern student has grown up with technology, is connected at all times, and possesses technological sophistication. This, according to Shook and Knickrehm (2017), has led to such students' ability to multitask as second nature to them, through the regular use of these technologies. Likewise it appears that these "techno-addicts and Wi-Fi generation" are also inclined towards more innovative ways of dealing with learning (Shahroom & Hussin, 2018:316).

It is not surprising, then, that the current student population is "demanding greater flexibility and delivery models that leverage technology to foster more ubiquitous access to learning experiences" (Johnson, Adams Becker, Cummins, Estrada, Freeman & Hall, 2016:26). Moreover, it must be taken into consideration that the millennial group is predicted to make up the largest composition of the workforce by 2025 (Gebauer *et al.*, 2016; Shahroom & Hussin, 2018).

Overall, it is thus of paramount importance that South African universities and in particular the teaching and learning function take this information seriously.

b) Curriculum innovation:

Most studies from the scoping review arrived at an assumption similar to that of Sood (2018) above, noting that the 4IR could have a staggering effect on existing degree programmes, current curricula, and future employability. What becomes evident is that the curricula need to be reformed and updated across all disciplines to "provide a holistic curriculum and experience" (Doucet *et al.*, 2018:6). South African universities that embrace new developments and technology, incorporating it into curricula to ensure graduate employability, could expand their markets.

According to Menon and Castrillon (2019), the curriculum of the future will focus on more flexible and interdisciplinary ways to ensure the "future-readiness" of curricula (Menon & Castrillon, 2019:1). Butler-Adam (2018) emphasises this by adding that the curriculum of the future will equip students with cross-disciplinary knowledge, for instance "students who study the humanities and social sciences need to understand at least the foundations on which AI is based", and contrariwise those in applied or health sciences will most probably need the humanities or social sciences to obtain a better understanding of the 4IR world (Butler-Adam, 2018:1). Buasuwan (2018) suggests establishing interdisciplinary research groups to investigate connecting crevices across disciplines and between operational and academic divisions to

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accomplish a more profound type of integration. Such an accomplishment may be vital for the sustainability of teaching and learning for South African universities that are attempting to innovate existing practices, and designing curriculums that are competence based (Hwang & Kwon, 2019).

Many studies support the view that the only way for South African universities to remain sustainable in the 4IR, is through more interdisciplinary and integrative approaches (Carillo, 2017; Herweijer *et al*., 2017; Kim, 2017; Naudé, 2017; Xing & Marwala, 2017*; Adams Becker et al*., 2018; Gleason, 2018; Osman, 2018; Rigg, 2018). However complex and challenging, especially in reaching agreements between departments on where the individual responsibility will reside, one cannot deny that this indicates the way forward in terms of future curricula.

In addition to interdisciplinary, some studies emphasize components of “competency-based” (Hwang & Kwon, 2019:2), “problem-based” (Bates, 2015:93), “digital / technological/STEM-related” (Herweijer *et al.*, 2017:13), “humanizing” (Abeid *et al.*, 2018:106), “transferable / employability skills” (Cotterill, 2015:410), “industry-endorsed” (WEF, 2016:42), “hands-on” (Johnson *et al.*, 2016:8), “contemporariness, up-to-date and usefulness” (Aziz Hussin, 2018:93) as important for the already complex curriculum mix. Moreover, Nørgaard and Guerra (2018) confirm the complexity of designing this type of curriculum in a 4IR landscape, by linking all stakeholders’ viewpoints, whether differently depicted, based on through which lens they are viewed, to arrive at the envisaged curriculum goals. Irrespective of which lens is used, technological, philosophical or employability, stakeholders in the curriculum innovation process have a responsibility towards delivering a better prepared and more successful workforce.

It appears from some studies (Nasir, 2018; Hwang & Kwon, 2019); however, that conceptualising curriculum rationale or logic depends on what the enquiry concentrates on: What is the expansive motivation behind the curriculum? What gives it coherence? What makes it extraordinary? Where is its quality or strength? Where does it reside? The logic will apply to the professional or occupational requirements, in other words, as suggested by Menon and Castrillon (2019), taking a holistic approach in curriculum innovation.

What also becomes evident is that although South African universities’ role of dispensing data and information is still regarded as valuable, it is growing noticeably out of date as the world of disruptive technology and computer-network-provided information assumes control. Never before have universities been so overpowered by data which is often disorganised and

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undigested (Pellini *et al.*, 2019). Data-literacy skills should be incorporated in curriculums to better equip students, as data literacy has become the new communication tool in the AI era (Aoun, 2017).

In moving forward, the first step will be to review existing curricula (Hwang & Kwon, 2019). Relying on delivering content is no longer sustainable, because it is all about the student's thinking and holistic experience (Menon & Castrillon, 2019). Bates (2015) emphasises how important it is for students in this digital era to become independent, self-driven stakeholders in the learning process.

In this innovation-driven world, the student will be in the driver's seat, which leaves universities with no choice but to revisit curricula to "produce independent, creative and innovative graduates" who are able to embrace this world (Zaharah *et al.*, 2018:71). Nørgaard and Guerra (2018) agree that both curriculum and assessment methods should be innovated in order to develop self-directed students who are ready for the Industry 4.0 workplace requirements while participating in lifelong learning. Therefore, the theory of constructivism, as explained by Bates (2015:145), where the student participates in the learning process, seems to be the best-suited approach for curriculum and assessment innovation. Such innovations will inevitably lead to a hands-on and competence-based approach.

c) Assessment innovation:

In the 4IR, assessment methods should become meaningful and should contribute to a meaningful learning experience (Ernst & Young, 2018b). Pragmatically, innovative assessments should include the broad range of techniques and instruments available to assess, measure and document student readiness, progress and acquired skills (Adams Becker *et al.*, 2018). Throughout the assessment process, millennials feel entitled to receive feedback, guaranteeing that suitable progress is made (Farrell & Hurt, 2014). For many millennials, post-training evaluations alone are not an optimal feedback measure.

Assessment methods by which students simply reproduce information to fulfil examination requirements, which often take the form of multiple-choice assessments based on memorisation of facts, are rapidly becoming outdated (Johnson *et al.*, 2016). Moving away from those traditional ex post-facto evaluations which focus solely on grading and scores, South African universities now have to develop examination systems that test general subject skills and expertise (Ernst & Young, 2018b).

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Formative assessment has long been advocated and it can now be implemented by applying blockchain and smart contract (Chen, Xu, Lu & Chen, 2018). Notably, blockchain's unchangeable, trackable and dependable abilities mean more particular, genuine, and secure information can be collected in the blockchain network (Chen *et al.*, 2018).

Other assessment trends as gathered from the findings were the use of real-time adaptive evaluations with course correction feedback (Shook & Knickrehm, 2017), and self-assessment, in which the student judges his or her own work according to prior set criteria (Leurent *et al.*, 2019). Aziz Hussin (2018) comments that portfolios, team projects, skills demonstration and rating scales, are among today's assessment methods.

Another equally significant aspect of inculcating assessment innovation is by reducing the stigma of failure while trying something fresh and ensuring that the evaluation method properly compensates for any out of the box attitude to teaching (Aziz Hussin, 2018). Besides modifications to the current assessment types, the traditional classroom design is also in need of innovative modifications.

d) Learning environment:

The shape of the conventional lecture room is about to be transformed to suit new, revised teaching and learning methods and curricula in accommodating the millennial and post-millennial generations. It has become evident from the scoping review that when the student-centred approach is taken, the podium should no longer be in front. Rather, the podium should be surrounded by tables to encourage group activity and interaction. These overhauled spaces bolster what is frequently referred to as adaptable, active, or dynamic learning (Johnson *et al.*, 2016:16).

In the search for new ways of teaching and learning enhanced with new technologies, it is important to “transform the teaching and learning environment to the benefit of both students and academics” (Xing & Marwala, 2017:7). However, Bates (2015) emphasises that before the learning environment can be transformed, the following questions should be asked. What kind of environment is envisaged for the teaching approach? Can the existing environment be revamped, or, because “space impacts learning”, should the creation of the environment begin afresh to inspire the teaching goal? (Bates, 2015:331). In the creation of an effective learning environment it is important to realise that such an environment goes beyond the physical

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components but rather focuses on the experience of the students within a given space in which they can participate actively in the learning process (Cotterill, 2015).

Xing and Marwala (2017) posit that it is also important for students to be educated in an "interdisciplinary environment where technologists should understand humanities and social science and vice versa", as was also previously suggested under curriculum innovation (Xing & Marwala, 2017:4). Therefore, designing new learning environments or redesigning current learning environments cannot occur haphazardly. Decision-making must be done inclusively. Bates (2015) opined that such designs should include consideration of the characteristics of the students, the teaching and learning goals, and the technologies and activities planned to be used in support of the pedagogy strategy (Bates 2015:449). These learning environments may best be redesigned by experienced professionals to create a virtual space, enhanced by technologies, that is conducive to innovative learning (Vey *et al.*, 2017).

The ideal innovative environment will offer various opportunities within the framework of new technologies, while focusing on a variety of crucial aspects such as learning outcomes, student engagement, PSD, and also "psychological assistance and training support" (Schuster *et al.*, 2015:15). The point here is that innovative learning spaces should provide possibilities for instituting active assistance through virtual mentors. This will prove beneficial even in critical thinking and problem-solving settings, when such collaborative learning environments will support meaningful teaching and learning events (Richert *et al.*, 2015).

From the review, it appears that in a digitalised society, learning spaces need to attract students: with online learning in virtual collaboration spaces, students can connect and participate remotely (Plumanns *et al.*, 2016). Therefore, it is core that these learning spaces stimulate creative thinking and generate ideas, being innovative hubs or "think tanks" to synthesise information and consolidate thoughts and link them to context (Pellini *et al.*, 2019:14). In the end it is all about designing a state-of-the-art learning environment that is "open and flexible" that will keep students intrigued (Buasuwan, 2018:163). Bates (2015) suggests that the learning environment must be designed in a creative and innovative manner, in which learning processes and technologies are interactive and influenced in such a way that it will be meaningful for students to visit the campus (Bates, 2015:333). The success of innovative, digitally supported teaching methods lies in a well-designed learning environment (Schuster *et al.*, 2015).

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In essence, Bates (2015) argues that these emerging technologies and moves towards more hybrid learning compel lecturers and architects to rethink the traditional classroom, creating environments that will initiate student engagement to develop knowledge and skills that are essential in a digital era (Bates, 2015:334). Therefore, when closely considering and incorporating such pedagogy, space and technology become blended in describing the new active learning environment.

Thus, to summarise, in the midst of the 4IR, the curriculum, assessment and learning environment of the future should contain *new* global developments, *new* technologies to support *new* ways of knowledge-sharing under the digital umbrella of *new* teaching and learning practices.

e) Innovative teaching and learning practices:

When teaching the digital generation there is a range of digital technologies and tools that can match certain teaching and learning circumstances effectively. In view of these digital trends, Johnson (2015) elaborates on exciting new developments, for example, bringing one's own device to class, a flipped lecture room, wearable technological tools, makerspaces, and the Internet of Things are predicted to have become mainstream in universities by 2020 (cited in NMC Horizon Report, 2015:1).

As inferred, the above-mentioned new developments will also eventually become obsolescent. Therefore, the challenge for South African universities to remain current and relevant is a decisive factor. As previously expressed, MOOCs have become a popular trend. This is a form of education providing internet-independent training (Xing & Marwala, 2017:4). However, Doyle (2015) warns that MOOCs on the one hand have the ability to diminish the lecturers' role in the long run, while on the other hand they may cause more imbalances in society through a division between a small group of mostly rich, well-educated elites, and the poorly educated masses (Doyle, 2015:45).

In addition to the above, Xing and Marwala (2017) add that wearable technologies, which at the point of need enable real-time learning, hold valuable possibilities in certain fields. Bower and Sturman (2015) share the notion that wearable devices are capable of initiating a new learning era, especially in student fieldwork and logging of real-time activities (Bower & Sturman, 2015:10). With these technologies the learning process takes on a totally new character, in which the lecturer becomes the facilitator and students become substantially involved in one

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another's learning experience, in other words learning from and with each other (Aziz Hussin, 2018).

Buasuwan (2018) points out that if universities are beginning to realise that the best effect on learning lies in these boundary-crossing, integrative and socially networked encounters, and integrated connections will become the nexus in directing and reshaping the student learning process. There is also a range of new web tools, blogs and applications (apps) within the domain of social media or popular gamification which, according to Bates (2015), may be most useful for interacting and engaging with students (Bates, 2015:253).

What becomes essential is to acknowledge that technology, AI and digitalisation are intertwined with social media. This triple blend therefore plays a powerful role in connecting local, national and international social structures (Avis, 2018). Seven such technological development categories were outlined by the 2018 NMC Higher Education Expert Panel. Agreement was reached by the panel, on the potential of these developments to foster significant changes in HE. This would be predominantly in the development of innovative teaching practices, curriculum and content delivery (Adams Becker *et al.*, 2018). These seven technological development categories are presented in Figure 5.8 below.

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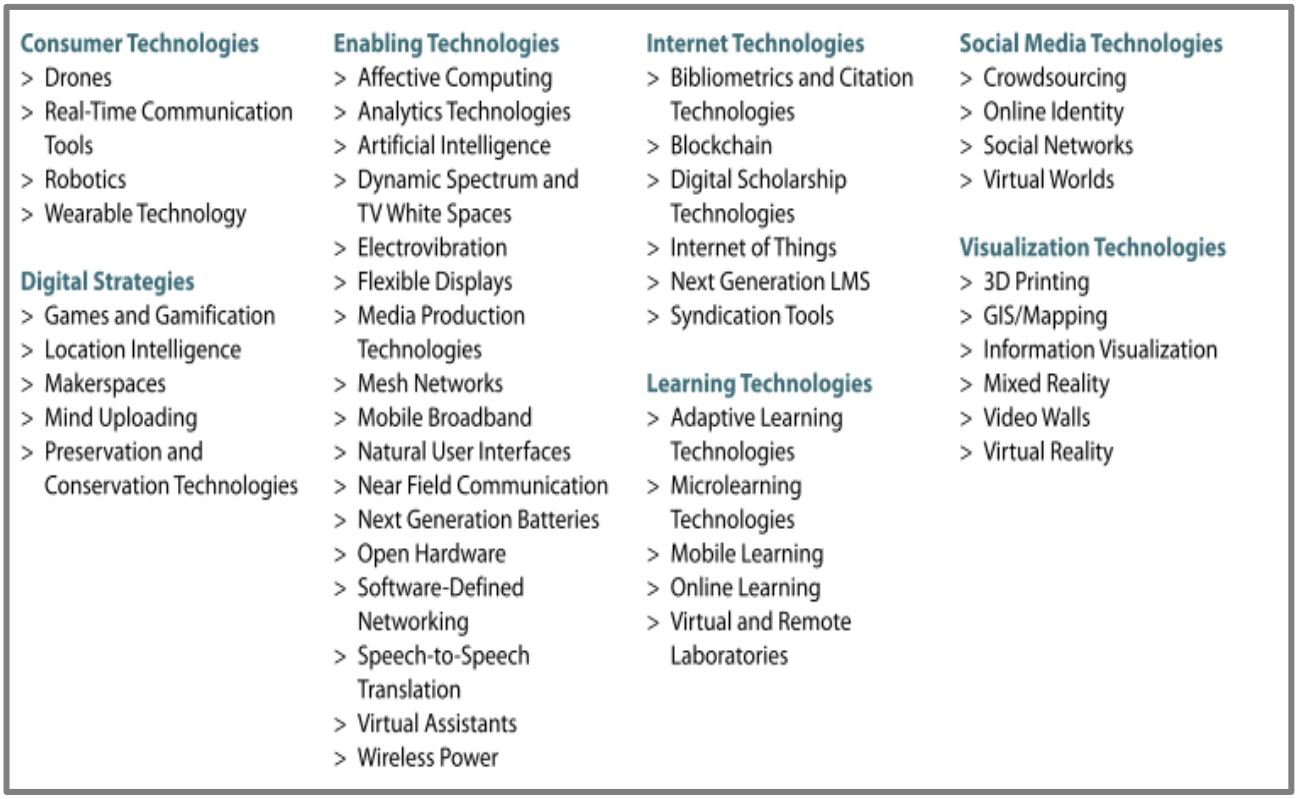

FIGURE 5.8: Seven categories of technological developments in the teaching and learning landscape (Adams Becker *et al.*, 2018:37)

Even though many of the above-mentioned technological developments seem revolutionary today, it is important to keep in mind that they require regular upgrading, as technology constantly becomes outdated and replaced by newer technological developments. This explains the increasing demand for enhancing teaching and learning practices with the latest technological developments (Abeid *et al.*, 2018). In support of this, Hariharasudan and Kot (2018) reiterate that teaching and learning practices supported by the latest technology are the key concepts of *Teaching and Learning 4.0*.

The term *Teaching and Learning 4.0* seeks to enhance digital technological skills at all levels and to increase the use of digital teaching and learning practices. In the next table, a closer look is taken at the seven categories of technological development, descriptions and relevant use in teaching and learning.

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TABLE 5.1: Seven technological development categories, description and relevance to teaching and learning (adapted from Adams Becker *et al.*, 2018:37)

CATEGORY	DESCRIPTION	RELEVANCE TO TEACHING AND LEARNING
Consumer technology	Instruments intended for leisure and specialised use, which were not intended for instructional use, at least not originally	Can serve as teaching and learning tools and be perfectly adaptable for HE teaching use.
Digital technology	Digital technology to supplement and enhance teaching and learning, whether on campus or at home, as a means of using equipment, tools and software.	Efficient digital approaches may be utilised equally in formal and informal training settings; they transcend standard thoughts in order to generate something that appears unique, meaningful and innovative.
Enabling technology	Technologies that can transform what is expected from tools, appliances and devices.	There is less evidence of the link to teaching in this category. However, this technology category is one in which fundamental technology improvements start to be noticeable. Supporting technologies are designed to broaden the scope of devices and instruments to be more useful, enabling and worthwhile.
Internet technology	Includes methods, vital facilities and reliable infrastructure to make the underlying systems more transparent, less obstructive and faster to use	The most helpful modern-day technology that assists with gathering data and doing research or adding to the understanding of different topics.
Learning technology	Contains joint instruments and assets specifically created on behalf of teaching and learning with development processes that may include instruments tailored for other reasons that match	Comprising of innovations which can change the teaching and learning domain by creating a more accessible and personalised learning, whether it is an informal or a formal learning experience.

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	approaches to enhance them to be more beneficially used in teaching and learning practices	
Social media technology	This could be sub-categorised into the category of consumer or mobile technology. However, it has grown to become so popular and commonly utilised in all aspects of civilisation that it has been raised to its own specified classification.	Social media technology is well-established and develops at a fast pace with fresh concepts, tools and trends continuously impending online.
Visualisation technology	Such technology ranges from a variety of simple charts and graphs to complicated types of evaluation of visual information. What they have in common is the capacity of the brain to process visual data quickly, recognise patterns and sense order in complicated circumstances.	These technological methods are an increasing collection of tools and procedures for mining big information sets, exploring vibrant procedures for making the complicated simpler in general.

In light of these technological developments, *Teaching and Learning 4.0* cornerstones are inventiveness, innovation, skills transfer and reduction of physical, time-consuming tasks, in other words freeing up time for more important tasks (Hariharasudan & Kot, 2018). There were many suggestions of best available technologies and new trends from the scoping review findings; lecturers will have to evaluate these new developments strategically, which will differ for every discipline or module, thus enabling the transferal of skills needed within that specific subject field.

f) Trends in skills transfer:

Besides technological enhancements to practices, there are also other potentially beneficial and innovative trends in teaching and learning. For example, Halili (2019) suggests using a variety of 4IR pedagogies, namely, heutagogy, peeragogy or cybergogy. Heutagogy is the move to self-directed learning, offering innovative perspectives into how a student learns through self-directed education (Leurent *et al.*, 2019). Peeragogy involves peer participatory learning in an

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open environment, to develop necessary 4IR skills, while cybergogy involves creating a more active and engaging online learning environment (Halili, 2019).

Conceptually, doing away with the prescriptive educational approach to a more encouraging approach makes access to appropriate content less complex and based on need. This will empower the future workforce to individualise efforts in ways and formats that are most conducive to their learning styles based on the distinctive combination of abilities required at any specified time (Leurent *et al.*, 2019). Sledge and Fishman (2014) acknowledge the growing interest in on-demand training, but warn that navigating the changing HE landscape can be hard, especially when deciding which alternatives best satisfy the requirements of the prospective Industry 4.0 workplace.

As can be seen from studies' research results in various areas, the teaching and learning prospects of using a blend of project and problem-based learning are indeed beneficial. This combination can promote learning flexibility as well as self-directed learning in that its organised strategy integrates research elements and real-life, problem solving abilities in students (Akor *et al.*, 2018).

Virtual reality[19] technologies, unlike traditional user interfaces, place the students inside a virtual experience (Halili, 2019). Rather than watching a screen in front of them, students are interacting inside 3D worlds, which delivers new possibilities for hands-on experience and intensifies a more engaging involvement in the practical learning experience (Janssen, Tummel, Richert & Isenhardt, 2016).

OERs and the distribution of open education resources is a mid-term trend that has progressed toward identifying full programmatic projects beyond reusable, low-cost content (Adams Becker *et al.*, 2018). OERs have the potential to increase access to quality education material, especially if they are shared by many universities, locally and abroad.

Frisk (2017:1) predicts that the following nine teaching and learning trends will better prepare students for the 4IR workplace:

- Anywhere and anytime learning: Students in diverse locations will have more possibilities to learn at distinct times. Online and e-Learning instruments promote

[19] Virtual reality is using computer technology to generate a replicated scenario of real-life.

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distant education possibilities. Classrooms are flipped, meaning that the theoretical part is learned outside the classroom, while the practical part is trained face to face and interactively.

- Personalised or customised learning: Individual students will only after a certain level of mastery is attained, be introduced to more challenging assignments. If lecturers see a need for it, more exercises will be given. Supportive assistance is used to encourage positive learning experiences and increase the trust of the student and enhance academic skills. This will lead to reducing student dropout rates.
- Freedom of choice: Although every course that is taught is aimed at the same goal, the path that leads to that goal may differ from student to student. Similar to the personalised learning process, students will be able to change their teaching and learning process by choosing their own preferences of distinct tools, distinct programs and methods, namely blended learning, BYOD[20], and flipped classroom, amongst others. Students will also be allowed to study at their own pace.
- Project-oriented learning: Today's students will adapt to more project-based learning; in completing a few short-term projects, students must apply their understanding and skills. By becoming involved in the projects, they practise their organisational, cooperative and time management abilities that will be helpful in being prepared for the future freelance workplace. This implies that students must learn how to apply their abilities to a variety of circumstances in the shorter term.
- Practical experience: Through field experiences such as internships, mentoring and collaborative projects, students will gain more practical experience as part of their learning. More space will thus be created for the acquisition of skills that contribute to human understanding and face-to-face contact.
- Data interpretation: Students will increasingly be subjected to data interpretation requiring them to apply their theoretical understanding to numbers and to use their reasoning abilities to create inferences based on the logic and patterns of the data set. This should be expediently incorporated into current curriculums.
- Examinations and assessments will be totally altered: As courseware platforms will evaluate student capacities at each step, measuring their competencies through question and answer methods will become obsolete and may not be sufficient anymore. Whereas a student's factual knowledge can be evaluated during their

[20] Bring Your Own Device to class approach.

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learning phase, the implementation of their expertise is best tested when working on field projects.

- Students take ownership: Students are becoming increasingly engaged in the development of their own curricula. Maintaining a modern, up-to-date and relevant curriculum is only realistic when it involves both experts and millennials. For an all-encompassing curriculum, critical input from students on the content, relevance and skills needed across disciplines must be seriously considered.
- Mentoring is set to become essential: Students will become more autonomous in their own learning, forcing lecturers to take on a new role as mentors to guide these students through their learning experience.

Many studies have arrived at similar conclusions as those listed above. Aziz Hussin (2018) emphasises that these nine developments will shift the majority of teaching and learning liabilities to the students. Cotterill (2015) encourages lecturers to support this shift and embrace their new roles and not consider this a threat to the standard of the lecturing profession.

Global connectivity, technological developments and innovative media are just a few of the drivers that reshape the way in which students learn and develop abilities for the future workplace (Brown & Keep, 2018). Therefore, the future of HE is a new teaching and learning vision (Kodama, 2018), beginning right now.

5.2.2.2 Proposed micro conceptual model

During the micro conceptual modelling phase, all the key concepts that emerged from the findings were combined in an attempt to develop a functional model. The construction process seemed daunting, comparable to building a complicated jigsaw puzzle. Every piece plays a significant role in the end-result and therefore took careful consideration and planning. For that reason, each of these concepts or puzzle pieces was discussed in an effort to explain the significance but also the functionality and possible future role thereof, in the complicated teaching and learning 4IR landscape. The finished model had to deliver a well-rounded, balanced and skilled, thus, prepared student.

Integrating the key concepts of teaching and learning resulted in a depiction of the connection of concepts, as demonstrated in the proposed micro conceptual model.

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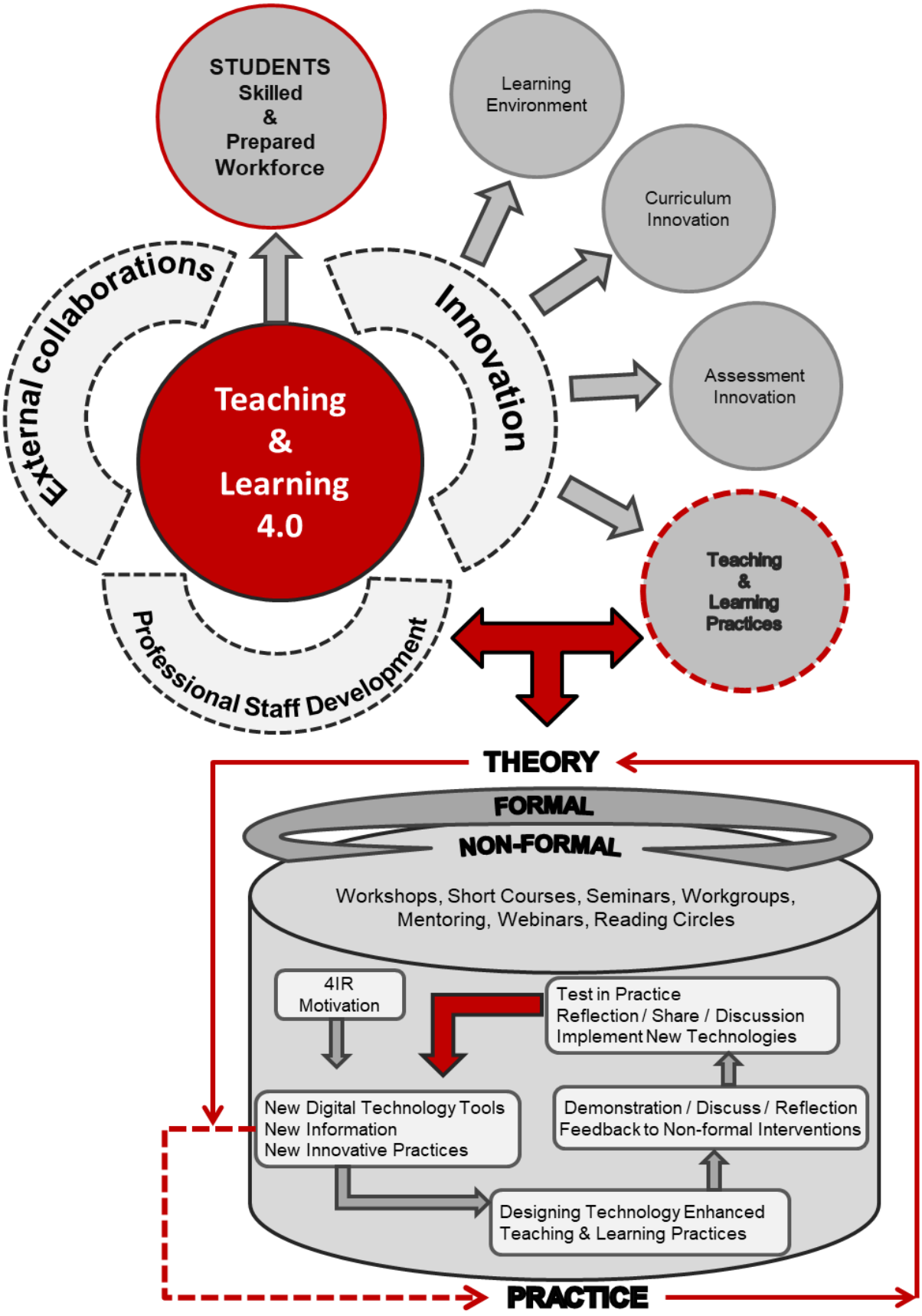

FIGURE 5.9: Micro conceptual model - Teaching and Learning 4.0

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The micro conceptual model as presented above, assists in the holistic conceptualisation of key findings relevant to this study as a crucial first step in transforming teaching and learning. The model includes the identification of concepts in need of transformation, together with the key drivers of transformation in the model. These are external collaborations, PSD and innovation with their integration into a coherent model, to produce a skilled and prepared workforce.

The discussion of interactions and relationships between concepts in the micro conceptual model will be the focus point of the next section.

5.2.2.3 Relationships and interactions within the micro conceptual model

From the scoping review studies (see Annexure C) it was derived that PSD, external collaborations and innovation were the enablers for the *Teaching and Learning 4.0* vision. Others found PSD to be the missing link that interrelates the technology and innovation with curricular design and teaching and learning practices in HE. PSD is therefore the first crucial enabler that is driven by the 4IR as motivator in closing the aforementioned gap in lack of implementation of innovative teaching and learning practices.

The model also illustrates the importance of both formal and non-formal development components. PSD could be placed along a continuum, with to a large degree, theoretical and more formal learning at one end of the continuum and informal or non-formal, more practical learning at the other end. The interrelation between formal and non-formal interventions is that formal learning occurs when staff participate in the activity with the expectation of learning. Non-formal learning assumes a range of formats in which staff acquire new information through cooperation, observation, exploration and reflection.

Underpinning most studies is the critical reflection and testing of new strategies and innovative practices before and during implementation. Therefore, the wider participation in discussions on implementation of supportive technologies and innovative approaches in the model was built on Schön's (1990) work on reflection-in-practice and reflection-on-practice. The importance of reflecting, evaluating and adjusting these practices and strategies regularly should not be under-estimated. So the efficiency and relevance thereof are ensured, thereby fulfilling the needs of the students. The resulting outcome will then feed back into theory to keep the knowledge relevant to 4IR demands. This will be a continuous process of upskilling and enhancing practices with new technologies replacing those that are outdated.

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The second enabler for a new teaching and learning 4.0 vision, is innovation which was discussed broadly in the previous section. Contextualising innovation in the model comprises an overview of new 4IR developments, trends, technology, new careers, and inventions amongst others. Innovation will feed into curriculum, assessment, learning environment, and teaching and learning practices, ensuring that each of these concepts remains relevant in the 4IR context. This will also necessitate regularly revisiting, continually innovating and updating thereof.

The third enabler, external collaborations, will link teaching and learning with the Industry 4.0 workplace. These collaborations can be fruitful in establishing skills needed, becoming aware of new developments, linking students with the workplace and gaining practical experience. Such collaborations can be a win-win situation from which both parties' profit. Teaching and learning can contribute in upskilling and reskilling of the current workforce. A skilled future workforce will be prepared, as will problem-solving of 4IR research and knowledge challenges, to name a few. Industry can contribute by generating funds, providing opportunities for practical work experience for students and possible employment.

The digital transformation of learning is inevitable, and much needed as postulated by 85% of the studies (see Annexure B). The digital transformation process can be seen as the paradigm shift towards a *Teaching and Learning 4.0 vision.* The new digitally transformed learning will be similar to what is illustrated in Figure 5.10 below:

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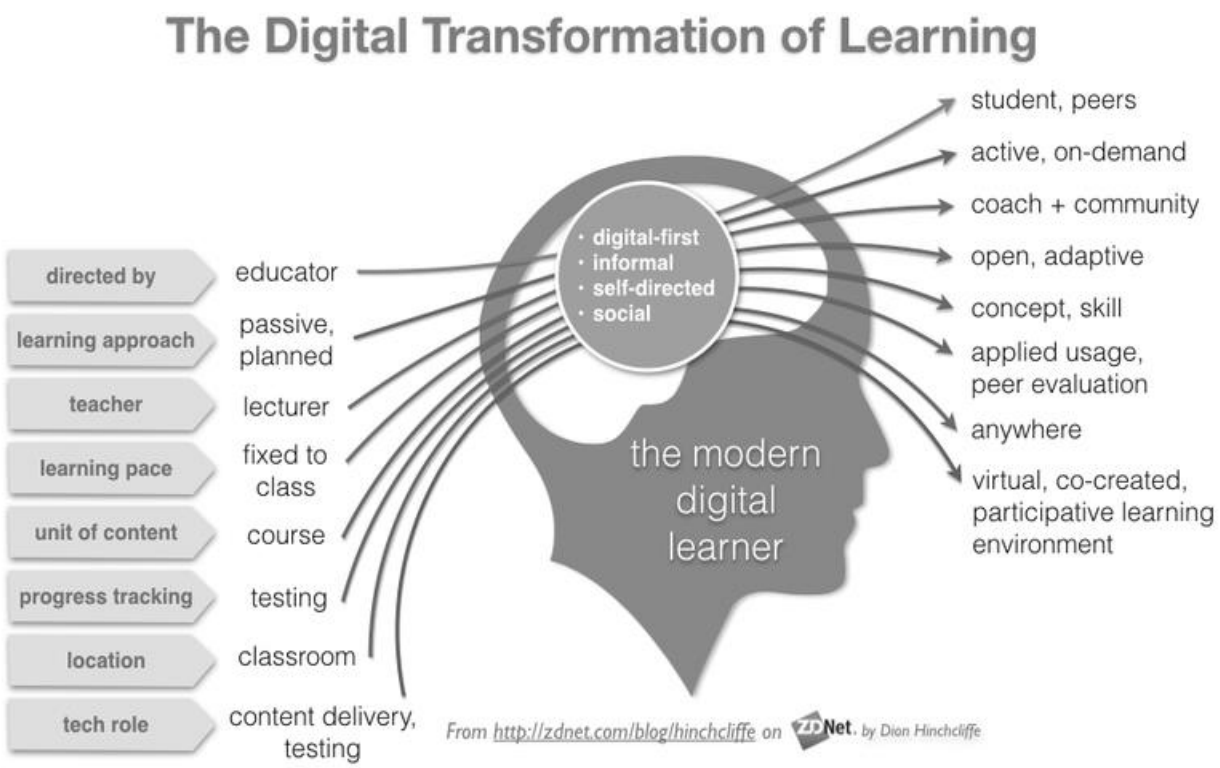

FIGURE 5.10: Digital transformation of learning (Hinchcliffe, 2017:1)

Hinchcliffe (2017) reflects this new digitally transformed learning in yet another way by declaring it to be far more social, casual, self-service, more circumstantial, on-demand, self-directed, highly customised and even completely enjoyable, based on the student's experience, all of which leads to deeper student involvement. Regardless which of all these possibilities of technologies are found most suitable for a specific subject, the digital transformation of learning will undoubtedly empower the future workforce.

Owing to work procedures becoming more complicated, interconnected and digital, the demands on the future workforce will increase. Lifelong learning and the capacity to think across disciplines are imperative. However, also vitally important is the development of digital skills for enhancing employability of students, not only in technology-oriented jobs (Janssen *et al.*, 2016). According to Brown-Martin (2017), subjects from STEM, often with the addition of the arts and philosophy, have been commonly recognised as an urgent necessity for future-proofing students. Notwithstanding STEM, robotics and other specialised mastery, social abilities of the future workforce are likewise in demand. Simultaneously, the adaptability and versatility of these applicants are underlined. The crucial part of their employability is the preparation for the

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workplace changes and the capacity for continuous learning (Gleason, 2018). Transferring these skills to students may equip and prepare them to prosper in the Industry 4.0 workplace, balancing out their economic wellbeing and preventing them from joining the unemployable group (Janíková & Kowaliková, 2017).

Many recent studies have focused on the need for a skilled workforce; therefore, the envisaged and wanted outcome of the micro conceptual model has a pre-eminent position and is impelled by the innovative core that is: *Teaching and Learning 4.0.*

5.3 SUMMARY

This chapter has addressed the first part of the main RQ, through highlighting those functions of universities that need to be transformed, as well as S-RQ3, by identifying innovative teaching and learning practices and trends to better prepare and equip students with the required skills for future jobs in the Industry 4.0 workplace. In addition, S-RQ4 was addressed by the development of the macro and micro conceptual models in this chapter. The two proposed conceptual models connect universities, and teaching and learning, with the different 4IR drivers for change, as identified by the scoping review of this study. To align these concepts for transformation along the two axes - university, and teaching and learning, considering the uncertainty of the 4IR, implications versus no-implications and international versus national, proved highly complex. However, the exploration and design processes led to two desirable outcomes: a sustainable university and a prepared, skilled workforce. The achievability of both these desired outcomes depends on the lens of complexity through which these proposed models are viewed and how the implications of the 4IR in its entirety are perceived. The point here is that the complexity, in both instances, will only intensify over time. Thus, there is great value in highlighting these complexities by summarising the main findings.

New business models will have to facilitate the digital transformation processes. This demands courageous and tenacious leaders, who must demonstrate an absence of bias in a multifaceted role by being open to all stakeholders' views. However, leaders by themselves cannot be responsible for instilling the data-driven DNA and digital transformation processes into the veins of the university. Without a doubt the new kind of leadership will need the buy-in of all stakeholders to warrant these changes and much needed cultural and environmental innovation.

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These transformations will also include drastic, costly, complex but much needed changes, namely, upgrading ICT infrastructure, PSD, and eliminating silo-based operations (Carillo, 2017). The latter will not be without resistance but penetrating the walls of academic disciplines have become imperative for South African universities to remain sustainable in this data- and technology-driven era.

Establishing partnerships whether triple helix[21] or mono helix[22], is predicted to be the future, although it will demand conscientiousness and commitment. Throughout the helix chain, two or three-fold, it must be recognised that tomorrow's achievement depends on the sustainability of the initiatives taken today (Miron & Gherasim, 2018). This will require openness, diligence, creativity, strength, courage, drive, and being proactive in addressing these barriers to transformation. Carillo (2017) arrived at a similar assumption, noting that there is not any magical wand to ease this type of innovation; it will take time and sustained effort. It will not be easy to transform the current university into a sustainable University 4.0.

Therefore, it has become clear that by improving the teaching and learning practices through technology enhancement and by putting students' needs first, South African universities will deliver a new, quality service that can bring significant change to the workforce of tomorrow. Reviewing the findings, one cannot but agree with Hutchings and Quinney (2015) that the only way to move forward is through the urgent and optimistic adopting of these triggers for change.

Thus, the *new* University 4.0 will have to convey new knowledge in a *new* learning environment, enhanced by *new* technologies, empowering students with a n*ew* set of skills under a *new* innovative leadership (Abeid *et al.*, 2018). In the end, the effort is all about the students - investing in their future - as this will also determine our future as a South African nation. The most urgent 4IR requirements remain the upskilling of the current workforce, and the preparing of the future workforce with the skill sets required to be part of the future's disruptive workplace (Miron & Gherasim, 2018).

Finally, it is better to be at the forefront of understanding these new 4IR possibilities in meeting students' requirements and improving their future employability success than to be stagnating and becoming outdated.

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[21] Triple Helix: government, university and industry partnership.
[22] Mono Helix: university and industry partnership.

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In view of the 4IR disruption, *'notyetness*' and rapid change, the new leadership 4.0 imperative should be clear: Prepare the future workforce. *Now*

The next and concluding chapter will provide a summary of findings and challenges within the South African context. Suggestions for further research, predicted future university scenarios and recommendations will be presented.

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CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

6.1 BRIEF OVERVIEW OF THE STUDY

The aim of this study was to investigate the implications of the 4IR for the main functions of South African universities, more particularly those functions linked to teaching and learning, and how they need to be transformed in order to better equip and prepare the future workforce. Chapter One provided the introduction and background. The chapter also highlighted the research problem, research questions and research aim of this study. Chapter Two discussed the theoretical framework and research methodology that applied to this non-empirical study. In Chapter Three, I presented the scoping review that was performed to accomplish the aim of the study. The scoping review proved a helpful tool to gain an overview of a broad spectrum of available sources on the 4IR. The data analysis in this chapter disclosed valuable insights and through thematic analysis the main concepts were successfully identified. Chapter Four focused on the second part of the primary RQ and S-RQ3. The scoping review revealed perspectives on better equipping the future workforce for the Industry 4.0 workplace in South Africa. The country's profile was elaborated on in terms of employability, the future workforce, future careers, and the future workplace. This section also outlined the skills required to succeed in this Industry 4.0 workplace. Chapter Five discussed the key findings of the study by proposing two conceptual models. On a macro level, the model predicted the functions most impacted by the 4IR, positioning the university as a whole in a future context. On a micro level, a model for teaching and learning concentrating on preparing graduates for the future workplace was developed. In addition, this chapter outlined the interactions between the main concepts of this study as proposed in the conceptual approach of the two suggested models. Chapter Six concludes with a summary of the most important research findings, 4IR challenges for South African universities, and future predictions for universities. This chapter ends with limitations to this study, recommendations for further research, and final conclusions.

6.2 INTRODUCTORY REMARKS

The idea of the dawn of a 4IR has been popularised by Schwab (2016), causing much debate and many discussions and predictions about this phenomenon since its onset. What distinguishes the 4IR from past industrial revolutions is the speed of technological innovations, which is exceptional. Similarly, the scale and complexity of the transformation is beyond any other previously seen (Pellini *et al.*, 2019).

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The 4IR world is running on AI: calendars are managed by Siri, friends are being suggested by Facebook, associates by LinkedIn, shares are traded by computers, vehicles are automatically parked, and air-traffic controlling is almost completely automatic, to name a few of the advances. Selamat (2017), however, argues that these developments in AI have benefited approximately every sector except the HE sector, as almost none of the latest AI advances are being utilised currently to develop or enhance the HE sector. Therefore, Penprase (2018) suggests that perhaps the HE sector itself needs a revolution. I believe, however, that this revolution is already materialising and is reflected in different ways. An avalanche of technological innovation is about to bring dramatic change to HE (Diwan, 2017). Change will not only be decisive in retrofitting the status quo, but also in ensuring students' future success and employability in the 4IR workplace (Ernst & Young, 2018b). Busteed (2019) agrees and is of the opinion that this will be the largest HE disruption ever. No wonder the 4IR is also referred to as the "fourth education revolution" (Sheldon & Abidoye, 2018:221).

The question then is: why does HE lag behind? No ready answer seems available. Penprase (2018) warns that the substantial time lag between admitting and adapting to these much needed HE changes and transformations, as discussed in Chapter Five, will come at a high price. Therefore, HE needs to commence preparing for the future: South African universities should begin this process by encouraging the implementation of 4IR innovation across all levels (Ernst & Young, 2018b).

The next section briefly captures the main findings related to the research questions of this study. Conclusions are drawn from the results to recommend how best to pave the way for HE and South African universities entering the 4IR.

6.3 SUMMARY OF MAIN FINDINGS THAT ADDRESSED THE MAIN RQ AND S-RQs

The decision to highlight once more the observed and foreseen 4IR implications and main findings for universities, especially teaching and learning, is based on the answering of the main RQ and S-RQs underpinning this study.

The complexity and scale of these 4IR implications have become a conceptual cul-de-sac for most universities, rather than a pathway to better practices. As a result of the 4IR, new demands on the roles and functions of South African universities, especially those of teaching and learning, are being made. Therefore, two conceptual models are proposed for this study (see Chapter Five, sections 5.2.1.2 and 5.2.2.2) in an attempt to explain and illustrate the main

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findings and implications for South African universities and addressing the research questions, more particularly S-RQ4.

6.3.1 Implications for South African universities

For South African universities and in particular for teaching and learning, the two significant and inevitable implications that the 4IR holds are innovative change and the digital transformation of key functions and practices. South African universities (refer to Chapter Five, section 5.2.1.1 for a more detailed description) should respond to these new demands in order to remain relevant.

The primary RQ that steered the study was: How should the core functions of South African universities, especially those linked to teaching and learning, be transformed to better prepare the future workers for the 4IR? Addressing the *how* of this RQ - *to better prepare the future workforce* - is crucial. Answering the main RQ was achieved by using Braun and Clarke's (2006) six-step thematic analysis approach (outlined in Chapter Three, section 3.4.1). The report on the identified themes (see Annexure C) answered S-RQ2 by *identifying the key themes related to the implications of the 4IR for South African universities from the relevant scoping review studies* in Chapter Three. In Chapters Four and Five, these *how* findings were further discussed.

In summary: The identified enablers for HE transformation are new innovative business models incorporating the triple helix logic. The much-emphasised digital transformation entails disruptive modifications and requires rapid adaptation of current practices. In the 4IR, digital transformation will be challenging and will require powerful digital leadership to navigate and drive change. The new envisaged leadership 4.0 will have to oversee the implementation and achievement of the new institutional vision. For this to occur, the new leadership 4.0 need to be imbued with an entrepreneurial spirit to effectively drive digital transformation. Leadership must proceed to convince, sustain, promote and enthuse the future digital embryonic workforce through this era of upheaval (Shave, 2017). Being guided by a new kind of leadership with a new vision will play a crucial part in the transformation of institutions and will cause a positive ripple effect in the next stage of conversion, when full staff buy-in and culture-shaping will be the main priorities. The only way South African universities could mitigate the implications of the 4IR is by being steered by brave leadership knowing *how* to proceed in the digital transformation of the identified key functions.

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In relation to S-RQ2, the identified key themes or functions of universities in need of transformation (comprehensively discussed in Chapter Five, section 5.2.1.1.3; also tabled in Annexure B), are restated and summarised below:

Digitally transforming the key functions of universities can act as enablers to moderate the implications of the 4IR for South African universities.

Teaching and Learning: This function is mostly affected by and in need of innovative practices for developing skills and preparing students for the Industry 4.0 workplace requirements. A new conceptualisation of a digitally transformed HE is needed to foster growth and sustainability in the future. Duc (2017) supports this view and emphasises that a major shift from traditional HE towards innovative HE has to take place. The transformation process should be radical, involving innovation of curricula to be more aligned with workplace needs. The learning environment must be supported by appropriate ICT, to enable the incorporation of technology-enhanced innovative teaching, learning and assessment practices. This also implies becoming data-driven and revisiting current qualification structures and programme offerings. Neglect of such effort will result in HE failing to address current skills gaps in the fields of big data, AI, and machine learning. If these fields remain underdeveloped, workplace opportunities for students will be negligible, thus failing graduates and society as a whole (Carillo, 2017). New, emerging jobs must be promoted, and weighed against those jobs at risk of being automated. Such at-risk jobs include routine, predictable duties which are readily performed by advanced algorithms. The future of students must be invested in. Curricula should be altered accordingly. Increasing student employability will benefit the country both economically and socially. Furthermore, South African universities will need to be forward thinking. Universities must, now more than ever before, develop a fresh, integrated, flexible, sustainable and lifelong learning environment that meets the requirements of the future (Doucet *et al.*, 2018).

Research and Development: For South African universities to become forward thinking, they must be familiar with the steps to be taken in moving ahead. Comprehensive research is therefore needed before reconsidering their current position to deliver within the 4IR context a more equitable and socially just experience. Successful strategies must be sought. Research and development activities must be pursued between faculties and through engaging with industry and global counterparts in finding best practices and successful strategies that will better prepare graduates for the future. Market-related research plays a significant role in linking

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research to workplace needs and ensuring relevance, growth and sustainability of the future university.

Support Services: Universities must create conditions that will optimise and support their reconstructed view and transformed landscape. Favourable conditions will emerge through deliberate leveraging and investing in their resources. In developing ICT, universities should invest in a reliable infrastructure, and high-tech support systems. Universities also need to facilitate efficient PSD opportunities. Staff should be empowered with digital skills and digital literacies, thus taking informed decisions regarding digital technologies.

Culture and Environment: Innovation starts from within every university. An inventive and creative culture would benefit from state-of-the-art physical and virtual surroundings to nurture and produce original ideas.

The above-mentioned transformation of the key functions will be crucial for South African universities. Substantially rethinking HE systems is complex, therefore this study proposes two conceptual models to guide the way forward.

6.3.2 The macro conceptual model: University 4.0

A macro-level conceptual model has been developed and proposed (see Chapter Five, section 5.2.1.2), as part of this study and in answering S-RQ4. Integrating the variety of themes and concepts, that emerged from the scoping review data analysis (consult Annexure B), was essential. This had to be achieved in such a manner that skills mismatch and graduate unemployment issues would be dealt with effectively. This model includes the main findings and key functions most impacted by the 4IR to demonstrate the operational outlook of a future South African university.

The triple helix triangle in the model foregrounds the importance of promoting collaboration, incubating creative ideas and driving innovation. The establishment of sound partnerships and innovative collaboration through the concept of triple helix may well spur productive discussions around preparing the future workforce in times of controversy and uncertainty. Innovation thrives on controversy as do creative individuals who are responsive to complex and ambiguous issues (Wilson *et al.*, 2017). Although flexibility and reforming the university's core function - teaching and learning - cannot be the only way forward, it certainly could be the most efficient way to approach this uncertain future. It is evident from the findings that South African universities need

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to reform teaching and learning in terms of preparing the future workforce. A new variety of content will be required, which suggests the fundamental rethinking of curricula, shift towards more interdisciplinary programme offerings and intensive re-curriculation, as the 4IR disrupts almost every single discipline.

6.3.3 The micro conceptual model: Teaching and Learning 4.0

In Chapter Three, I reported on the scoping review in which research sources were identified and reviewed, based on the second part of S-RQ3 and the main RQ. In Chapter Four, the future workplace requirements (see section 4.3) and the skills required by students (see section 4.5) were discussed, also in response to S-RQ3.

The results of the scoping review have disclosed that completely new methods of teaching and learning are required to better prepare the student for the future workplace (refer to Chapter Five, section 5.2.2). Chetty (2018) elaborates on this, suggesting that new methods of teaching and learning must be tailored to students' requirements and must respond to changes in the workplace. Furthermore, it emerges from the findings that in successfully preparing students, it will be critical to engage them with the latest technology (Doucet *et al.*, 2018).

What role does teaching and learning play within the greater university context, in the digital epoch in which technological unemployment becomes the rule instead of the exception? Buasuwan (2018) answers this question, pointing out that teaching and learning clearly have a significant role to play in metamorphosing the mind sets and skill sets of the future workforce.

Therefore, the key concepts, as listed below, have been identified as requiring transformation within the teaching and learning domain:

- Students: Gain knowledge on the current student population, the millennial and post-millennial generations' characteristics, needs and abilities.
- Curriculum: Innovative interdisciplinary, future-ready and relevant curricula adaptable and linked to Industry 4.0 workplace needs.
- Assessment: Innovative tools to re-imagine assessment of students. AI or innovative experiential learning, among others, must supplant summative examinations. A more skills-orientated and meaningful learning experience will thus be supported.
- Learning environment: Open-flexible, virtual and technology-supported spaces for cultivating innovative thinking.

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- Teaching and learning practices: Adjust teaching and learning practices to complement the virtual learning environment. Enhance practices with innovative trends and technologies and re-evaluate, reflect, and update regularly. Flexible delivery methods, including the use of technology are essential in guaranteeing inclusiveness of students' diverse requirements.

Teaching and learning fulfil a vital role in developing skills to prepare students for the new workplace. Therefore, market-relevant and interdisciplinary teaching and learning methods will have to apply. Alternatively, innovative practices enhancing with appropriate technologies as discussed in detail in Chapter Five (see section 5.2.2.2, (e) and Table 5.1), would be the first step in bridging the skills gap.

The micro conceptual model was therefore constructed to assist this vital first step in transforming teaching and learning, by incorporating the key concepts listed above and the important findings from this research. Together with the main drivers of innovation, the initial process involves external collaborations with industry in creating curricula apposite to workplace needs, and PSD, thus enhancing the incorporation of technological developments to prepare skilled and 4IR-ready graduates. PSD plays an especially important part in the micro model. South African universities should prioritise PSD through judicious capacity building interventions by well-qualified and expert staff of teaching and learning centres and academic support services (Leibowitz *et al.*, 2017). Accordingly, academics must be enabled and empowered through PSD programmes for developing the much-needed skills and digital literacies, in preparing students for future careers.

The role of innovation, digital transformation, and technology is clearly understood as an important consideration in dealing with the demands of the 4IR. However, what is the defined role of South African universities in all of these developments?

6.3.4 South African universities' role in preparing the future workforce

In the 4IR context, HE has a significant role to play. No single, clearly defined role for universities emerged from the scoping review. However, it became apparent that, within the uncertain and rapidly changing 4IR environment, there can be no cast-in-stone role for universities. That being said, important components did surface from the studies to outline the perceived role of South African universities in the 4IR, thus answering S-RQ1.

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As a starting point, South African universities have a vital role in delivering innovative interdisciplinary curricula, programmes, workplace-related course offerings, and student skills development strategies, all previously discussed in Chapter Four.

Apart from what is already known, South African universities also have responsibility for curriculum benchmarking and workplace responsiveness. Chetty (2018) strongly believes that programme offerings must constantly be adapted in a responsive way to the modifications in the workplace in order to be adequately aligned with employers' requirements. Therefore, understanding the South African and global employment markets and future job trends, is essential (Phillips *et al.*, 2018). Moreover, improving students' future-oriented work prospects should form a crucial part of every university's future role, along with responding to local and global workplace needs.

However, the role that South African universities' play will be tremendously challenging. Universities are in the unenviable position of having to prepare the future workforce to match specified positions with specific employment demands. The future workforce must not only be prepared to be adaptable in those employment settings; they must also be ready for future changes or disruptions of employment roles (Wilson *et al.*, 2017).

As an example, while a significant number of students are still studying accounting or finance, in a world where the trend is increasingly towards integrated AI systems, the management and interpretation of accounting data will inevitably become AI-orientated instead of human-oriented (Brynjolfsson & McAfee, 2016; Schwab, 2016). In other words, these students must be able to adjust and enhance their skills and qualifications to meet new Industry 4.0 requirements, as these occupations will be altered many times in their professional lives.

Therefore, the future workforce must be ready and prepared at the time of training to obtain employment which does not yet exist (Hanus, Revel, Marulo & Bauer, 2017). According to Pasha (2019:5), such a viewpoint of investing in "human capital" strengthens the university's role as a significant source of "knowledge, skill and expertise" transfer, enhancing Industry 4.0 workplace productivity and economic growth. However, for universities to succeed in the latter role, they need to start investing in their own human capital through the upskilling and empowering of their professional asset commodity.

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In addition, South African universities should play an important role in creating entrepreneurial environments, which foster 4IR-type innovative and creative thinking (Pasha, 2019). Schäfer (2018) reaffirms the pivotal role universities should play in developing entrepreneurial abilities and fostering the call for novel goods, services, and apps, by providing innovative hubs, laboratories, and virtual environments. Finally, in providing this type of think-tank platform, universities will better prepare the future workforce, reducing insecurity, and thus eliminating unnecessary concerns about future employment (Beliz *et al.*, 2019).

Apart from all the other roles designated to South African universities in the 4IR context, Nordin and Norman (2018) warn that there is yet another important role every South African university should take cognisance of, and that is their ethical role. To guarantee that ethical standards are upheld in universities as more open educational resources become available online, ethical benchmarks should be noted and maintained (Nordin & Norman, 2018). Akin to the role universities play in economic growth and producing a knowledgeable civil society, universities' role within the triple helix partnership has also significantly changed from what was known in the previously isolated HE and research institutions (Siemens & Dawson, 2015).

What became evident in addressing S-RQ1 was that the role of South African universities would be a multi-faceted one that would provide a talent pipeline of skilled and properly prepared graduates to promote economic growth and to achieve the requirements of Industry 4.0.

6.3.5 Strategies and skills development plans

South African universities need excellent strategies and skills-development plans to guarantee student preparation in improving abilities that can assist students to cope with accelerated technological change (Abeid *et al.*, 2018).

HE, however, sometimes finds it problematic to define precisely what kind of abilities must be cultivated in students to prepare them for the future workplace (Cacciolatti, Lee & Molinero, 2017). Schwab (2016) concurs that in this kind of quickly changing work environment, the capacity to predict and plan for future skills demands, knowledge content, and overall impact on jobs is becoming progressively daunting. It is therefore essential to make full use of the possibilities provided by these innovations, thereby reducing undesirable consequences (WEF, 2016).

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Hattingh (2017:22) suggests the following questions that need to be considered in the skills development planning process:

- How does HE reconceptualise preparation if the moment students graduate, some jobs will either vanish or evolve considerably?
- How does HE prepare the future workforce for various Industry 4.0 modifications that traverse career boundaries?
- What skills and knowledge will students require to flourish within unpredictable change in the era of unreasonableness, which no longer meets a reliable outline?
- What should HE teach if, within the next few years, what is taught is becoming obsolete?
- How should HE equip students with the abilities needed to utilise constant evolving 4IR technology?
- What skills development hypotheses prevent HE from preparing the workforce for a workplace that is exponentially interrupted by the latest technology?

One needs to acknowledge that the responses to the above questions will certainly raise additional questions, requiring redefinition conditional on the broader context of HE, or potentially also revealing harsh realities. Either way, the questions are valid to be asked and to be answered (Wilson *et al.*, 2017). Asking these types of relevant questions when formulating innovative strategies is imperative for guaranteeing the relevance, competitiveness, and sustainability of the HE sector (Ernst & Young, 2018a).

Therefore, developing and incorporating innovative strategies as part of the university's academic offering, such as, practical experience by exposure to the workplace, mentoring, job-shadowing and virtual coaching, among others, can set the university apart from other contenders in the 4IR space (Deloitte, 2018).

In order to establish what skills are needed and what a real 4IR curriculum should embrace, South African universities should consult closely with industry and government (WEF, 2016). This triple partnership approach seems to be a 4IR innovative strategy, acknowledged by many studies as the light in the uncertainty of darkness. Convergence signifies collaboration opportunities for universities; working together on research and innovation, skills development strategies, and possible employment opportunities for graduates. South African universities now more than ever before need to be committed to the successful employment of their graduates. The development of workplace-related skills has become much more important in considering

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the efficient preparing of students for the workplace, when compiling the HE strategy (Wilson *et al.*, 2017).

The question is, however, whether traditional or conventional universities have the inclination and know-how to become contemporary network hubs through networking more closely with industry in creating curricula and skills development strategies that reflect the future workplace demands (Ernst & Young, 2018a). Twinomurinzi and Ismail (2018) reiterate that such partnerships are valued, especially when having a shared vision for innovation and skills development strategies. Recent market research conducted by Ernst and Young (2018b) indicated that the majority of students articulated a need for, and supported, a curriculum and workplace integrated degree offering. Figure 6.1 illustrates the perceptions of undergraduate students on university and industry collaboration. There is an overwhelming interest in integrated programme and employment offerings. Such integration leads to a better skills match between universities and industry. This kind of strategy proved to deliver better prepared graduates with better employment prospects (Ernst & Young, 2018b:8).

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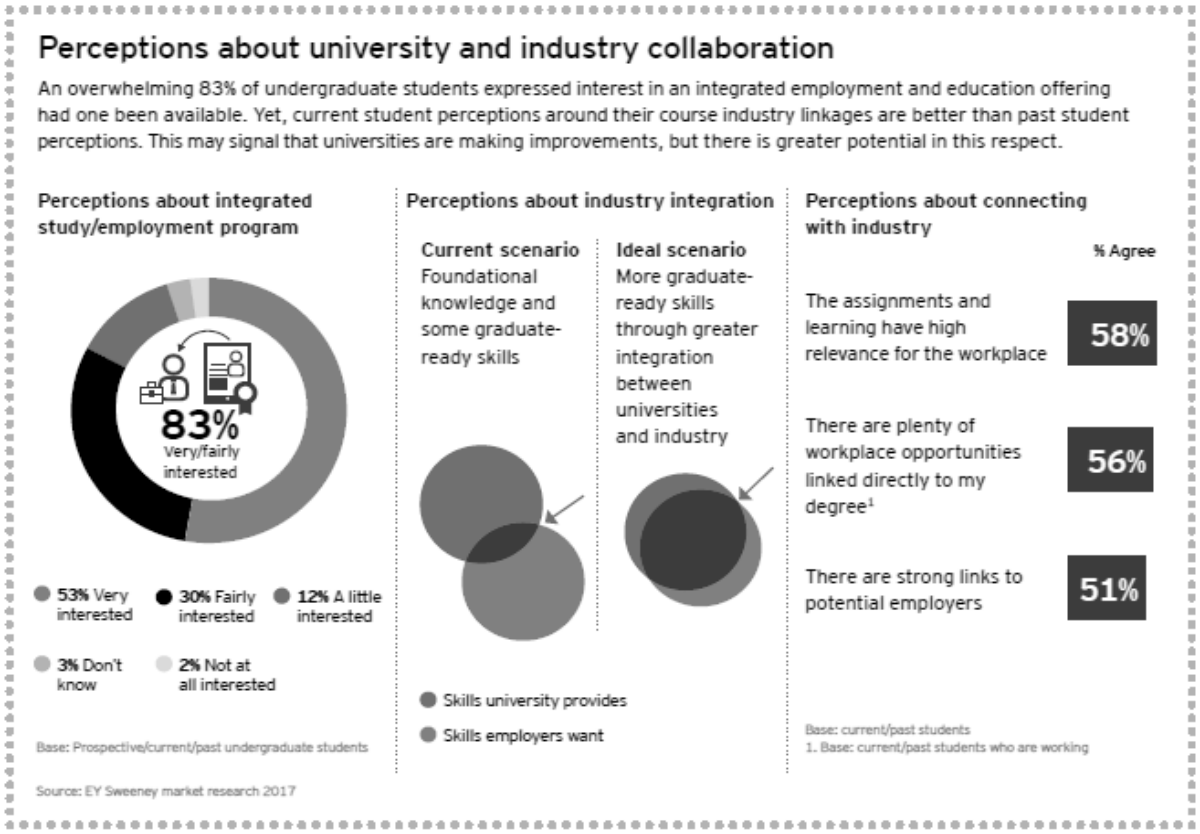

FIGURE 6.1: **Perceptions about university and industry collaboration** (Ernst & Young, 2018a:8)

In addition to establishing partnerships as a strategy, aligning these newly formulated innovative strategies with business models and imposing them on all levels in universities, are vital (Chetty, 2018). Gleason (2018) suggests setting up a multi-faceted strategic approach in preparing the future workforce, which values peer-evaluation by counterpart universities, both internationally and nationally. Such benchmarking can distinguish between what works and what does not, eliminating unnecessary costs and pitfalls. Fortier (2016) points out that universities making remarkable progression in the 4IR will not be by happenstance, but by intentional willpower and active strategic planning. Hence, gaining the buy-in of an enthused and responsive workforce, prepared with future-proof abilities, benefiting from new prospects through constant reskilling and upskilling, is fundamental to the achievement of any strategic workforce skills-development and expansion plan (Shook & Knickrehm, 2017). The second part of S-RQ3, which related to skills required for the future workplace, was discussed in Chapter Four (section 4.5) and was

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further answered in this section by reporting on the much-needed strategy and skills development plan.

To summarise, what these 21st century strategies and over-all business models of South African universities need to achieve, is empowering the future workforce with the skills needed to succeed in innovative career paths after graduation. Moreover, as was previously mentioned, to become data-driven in the 4IR is crucial for any university. The most important components in creating a sustainable future and forming a well-rounded, prepared, future- and robot-proof graduate, are depicted by Grajeck (2019) in Figure 6.2.

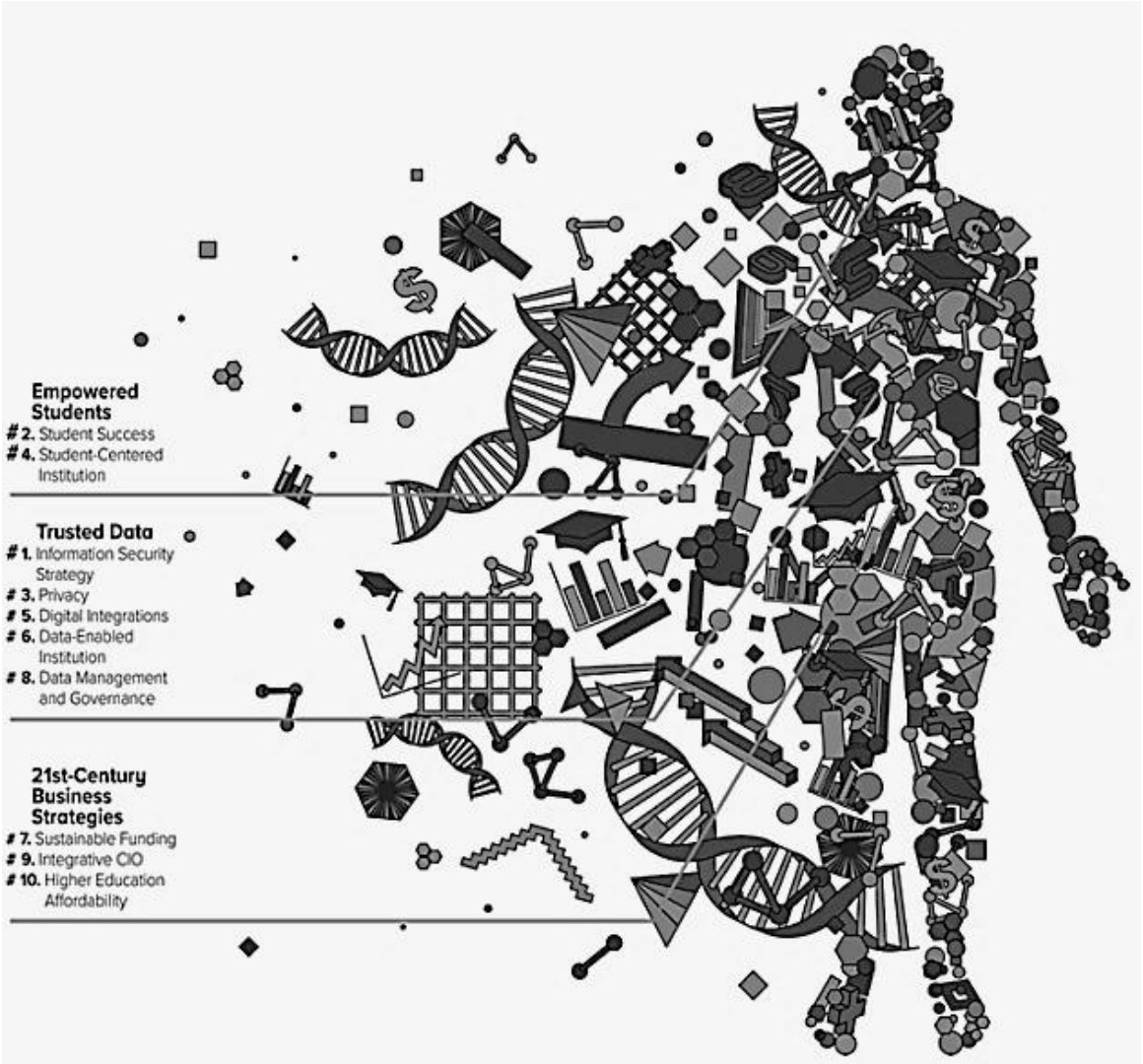

FIGURE 6.2: 2019 Top 10 IT issues: Student success (Grajeck, 2019:1)

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The 2019 Student Genome Project listed the top ten technological challenges universities should take cognisance of, as displayed in Figure 6.2. In brief, a university's student success is measured from applicant to alumni. Success is largely reliant on affordability, innovative strategies, digital, secure and reliable data, latest technology enhancements and on empowering students through student-centred approaches. Conversely, the 4IR brings possibilities and challenges, especially from a HE perspective. The possibilities are linked to the potential for effectiveness and performance gains that will open the doors to innovative practices, better services, stimulating economic growth and sustainability. Simultaneously, the 4IR presents challenges, especially in its disruptive nature, to the current workplace. This perspective will be highlighted in the next section.

6.3.6 4IR challenges for South African universities

Considering the challenges accompanying the 4IR, relevant skills and knowledge will be prerequisites for thriving in this automated world. It would seem that the future workforce and universities will encounter a constant demand for upskilling and reskilling throughout the 4IR lifespan (Brown-Martin, 2017). Therefore, the implications of the 4IR for South African universities have been prioritised and discussed throughout this study, in order to address S-RQ2. In addition, the challenges to minimise these 4IR implications are elaborated on further.

In South Africa, the two primary challenges universities are facing remain firstly, insufficient knowledge of the foreseen 4IR disruptions and secondly, a workforce skills development strategy not synchronised with the new business model or strategies for innovation (Hattingh, 2017). There was also some consensus in the scoping review results that the notion of graduate employability should be linked to a skills development strategy. This implies that universities are not only responsible for providing for effective academic encounters, but also for establishing proper linkages between students and the workplace (Jackson, 2017). Consequently, South African universities need to confront the challenge of bridging the skills gaps, and preparing the rapidly growing workforce for future employment possibilities (WEF, 2016). According to Ford (2015), addressing these aforementioned challenges is pivotal in minimising the already high unemployment rates among graduates, who require 4IR-conversant knowledge and skills. It must be stressed that a failure of correlation between workplace requirements and abilities produced by HE and training programmes will have devastating implications for employment rates (Chetty, 2018).

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Furthermore, Balkaran (2016) argues that another overall challenge for South Africa and its universities is that the leadership is caught up in a protective mode, and are yet to start the digital transformation process. Along the digital transformation lines, HE is also facing critical challenges regarding the adoption of technology: to name a few, increasing digital knowledge and abilities, evolving digital securities, and reconsidering lecturers' roles (Adams Becker *et al.*, 2018). The latter leads to the next challenge South African universities will have to confront - the resistance of academics to change and to live up to these newly created, innovative roles (Bovill *et al.*, 2016; Buasuwan, 2018). In other words, abandoning the traditional ways of working in favour of new innovative technology-enhanced ways is proving to be a very difficult obstacle to overcome. In the virtual environment, teaching and learning will bring new challenges for lecturers, students and ICT (Plumanns *et al.*, 2016). However, Miron and Gherasim (2018) confirm that the most critical, but at the same time the most pressing challenge will be to upgrade the digital skills of the current workforce through PSD programmes, thus enabling the transferring of these skills to the future workforce.

Upgrading raises the next challenge for South African universities - their readiness to deal with these changes, and the actual transformation processes (Shahroom & Hussin, 2018). Apart from the 4IR readiness of South African universities, Selamat (2017) stresses that investing in evolving technologies and connectivity, and building digital stability and an operational capacity in digital management, are important 4IR survival tactics. Ultimately, this means investing in ICT and digital infrastructure to create a modernised ICT supported environment vital for the development of digital skills, therefore these critical issues need to be overcome and addressed first (Balkaran, 2016; Tvenge & Martinsen, 2018; Beliz *et al.*, 2019).

As universities' operating costs continue to increase and funding sources are diminishing, finding new, innovative ways of generating additional funds will become an indefinite 4IR challenge for universities (Beliz *et al.*, 2019). Hence, finding available funds to finance the evolving overhead costs for covering new technological implementation, PSD programmes and learning environment upgrades, amongst others, will be fraught with difficulty. The rise of expenditure will also have a ripple effect on the affordability of HE for students (Abeid *et al.*, 2018; Liao *et al.*, 2018). Further, exacerbating these challenging environmental conditions, the general populace is starting to question the importance of HE, given students' onerous debt, and their often poor job prospects (Brown-Martin, 2017).

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Along these lines, Busteed (2019) raises another important point. Students now, in avoiding these enormous financial burdens, turn to the ‘Go Pro Early’ concept, which entails first applying for a job and then studying part-time while working (Busteed, 2019:2). This concept is predicted to cause the biggest HE disruption in history. Busteed (2019) anticipates that one-third of school leavers in the next decade will ‘Go Pro Early’ by seeking employment first and graduating from university as part of the employment package. Driven by current discontent with the job relevance of university qualifications, graduates' un- or under-preparedness for work and high tuition fees, increasing numbers of potential students are opting for this ‘Go Pro Early’ route (Deloitte, 2018). Therefore, the prediction is that this new trend of heading to the workplace in order to graduate from university, will disrupt the linear path of HE as it is currently known (Busteed, 2019:4).

Pollitzer (2019) warns that ICT’s ability to drive the 4IR vision and to generate beneficial socio-economic change at the same time poses the central problem of further widening the existing digital divide. Chetty (2018) strongly agrees that the current digital divide poses the most complex difficulty that South Africa and HE need to address. Therefore, South African universities can no longer afford to procrastinate in addressing the challenges regarding digital transformation and innovation. Diversification can simultaneously promote increased social unity and technological progress (Chetty, 2018).

Against the background of the above-mentioned challenges, it remains vital to cultivate technological progress, a constant learning mentality, and a skills-based society to remain viable in such a 4IR era of disruption and turmoil (Buasuwan, 2018). These challenges hold the potential to develop in students an entrepreneurial spirit capable of aligning societal commitment with lifelong learning (Gleason, 2018). Therefore, in a society already beset by many divisions where conventional convictions and principles are questioned, the finest components of humanity, such as imagination, compassion and friendship must be maintained and protected in the presence of dehumanising modes of existence brought about by 4IR innovation and technological advancement (Prisecaru, 2017).

Another burning challenge is the question of financial imbalance or the growing wealth gap (Johannessen, 2018). Wealth inequality in South Africa is arguably the biggest challenge to be addressed by the nation (Higgins, 2016; Chetty, 2018). In many ways, the 4IR may lead to even greater inequality. HE must mitigate this challenge by better equipping students, thereby reducing skills mismatches and disparity in the workplace (Diwan, 2017).

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Unless new policies are implemented to guard against increasing elitism that will further worsen social inequalities in the population, the 4IR impact could be devastating (Corfe, 2018; Sakhapov & Absalyamova, 2018). In this regard, policy considerations are required to balance questions about inequality and discriminatory treatment with both the technological and ethical difficulty of surveillance and prospective censorship of openly sourced big data (Herweijer *et al.*, 2017).

The issues around safety, security, morality, and equality in the 4IR are far-reaching. Security relates to the safety and informative preservation of precious data. Some individuals now have ownership but are unable to demonstrate copyright, causing disputes over intellectual property (Chen *et al.*, 2018). Suganya (2017) proclaims that security risks are the predominant HE challenge, and therefore suggests incorporating sufficient security mechanisms for optimising sustainable development attempts in HE (Suganya, 2017). However, the challenges of ethically working in partnership (Bovill, Cook-Sather, Felten, Millard & Moore-Cherry, 2016) with big data security and data privacy will continue to develop and escalate (Huba & Kozak, 2016).

To summarise: foreseen challenges include the lack of vision and strategy, combined with growing 4IR complexity, absence of dexterity, inadequate resources for innovation, inadequate relevant skills, insufficient innovating drive, new roles of academia, and obstacles to overcome before becoming new change mediators (Vey *et al.*, 2017).

The intention is not to shine the light on the disturbing uncertainty of the 4IR horizon and these 4IR-brought-about challenges and changes only. Rather, the call is to be ready and prepared in noting the challenges as drivers of innovation in order to keep up with future trends, thus maintaining sustainability in the future (Abeid *et al.*, 2018).

6.3.7 Future trends and predictions for universities

Universities around the globe can become even more diverse in future, under the pressure of economic and societal change and most of all, 4IR technological change (Sheldon & Abidoye, 2018). These worldwide 4IR-inspired changes influencing the future university are the transformed workplace, causing technological disruptive upsets to the essence of employment prospects (Ernst & Young, 2018a). Also, driving this speed-travel into the future are trends mainly based on the nexus of AI, robotics and big data, to name a few which are applied to the future university (Feldman, 2018). In fact, within only one decade the academic basis of

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universities will have been converted through AI and digital transformation (Sheldon & Abidoye, 2018).

Xing and Marwala (2017) predict that the future university will be a multidisciplinary institution with virtual lecture halls, labs, libraries and also virtual lecturers. However, this will not devalue instructional knowledge and the student experience; rather, it will enhance it (Xing & Marwala, 2017). Sheldon and Abidoye (2018) agree that lecture halls will make space for virtual hubs and smaller groups to collaborate. Libraries will become spaces for studying, and books will be replaced with electronic formats. The question is: What type of universities are those predicted to feature in future?

Within the next decade, the scenario appears to be set to change drastically, with predicted future universities falling into one of four types, as summarised below (Ernst & Young, 2018b:12-24):

A. The Championing university:

A championing university is a university characterised by a hands-on government approach, i.e. government is actively involved. Government activists take the lead in advancing university-friendly regulation, promoting HE as a primary local industry. Government financing exceeds other funding sources. Most students study Bachelor's programmes. Students experience an autonomous and well-rounded training. Technology is integrated into traditional HE models, with AI as an integrated and competitive advantage. The HE landscape is highly regulated and the top universities dominate.

B. The Commercial university:

This university type has a government hands-off approach; it stimulates customer-friendly rivalry that encourages privatisation. Industry financing exceeds public financing that leads to the uncapping of fees. Most students are enrolled for Bachelor's programmes. These students value workplace practical training and technical skills. Technology is embedded into old-style university models. AI becomes a niche in the HE sector.

There will be a diverse HE environment with current and new universities in opposition. Universities are independent, operating through industry interconnections.

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C. The Disruptor university:

The disruptor-type university is also detached from government and tends to favour fair and open competition, inspiring privatisation. Most financing is received from industry incentives rather than from government. Most students are lifelong students who pursue short-course certificates on an ongoing basis. Students appreciate customising their own career paths, having control over their HE course. Technology interferes with outmoded HE models and makes place for new digital models with worth and meaning. These digital models have replaced some jobs and impacted on employment, with AI being main-stream.

It is a fractured environment with the HE sector super-competitive with non-sector suppliers. These universities compete through innovative models and move into neighbouring areas. Training and research are disconnected and disruptor universities have a tendency to focus on only one of the two functions.

D. The Virtual university:

In the virtual university all individual activity is transformed by technology. The state promotes a student-friendly policy that draws HE and technical education into the incorporated educational system. Funds are received mainly from government. Prices are restricted, with open enrolments to students.

Most students are lifelong learners following short-courses. Students enjoy the freedom and flexibility of their HE training. Technology has disrupted traditional models with learning that occurs largely online. Modern digital systems connect HE and technical education teams to networking collaborations or working groups. AI is commonplace and employment mostly automated.

The environment is integrated: universities are connected both to service providers and several other institutions. Virtual universities compete by gaining lifelong learners. Research and training are separated.

In addition to the above universities, Sheldon and Abidoye (2018) add two more types to the futuristic mix: no university at all, and smart universities. On the one hand, it is predicted that universities can disappear, with robots and machines becoming better and better until in the end there will be no need for humans to attend university at all. Smart universities on the other hand will have a heavy reliance on all of the other future university types' smart components and will

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be completely AI driven. These smart universities will deliver 4IR skills in small fragments of studies as needed, with the focus on multidisciplinary content (Sheldon & Abidoye, 2018:243-244).

Becoming diversified and deepening global connections, is predicted as becoming prominent in future. In finding smart solutions for smart universities to address current needs and prepare for tomorrow's challenges, prioritising is recommended.

6.4 RECOMMENDATIONS: PRIORITIES GOING FORWARD

Responding to the main RQ and the four S-RQs that were extensively discussed throughout this study, a number of valid recommendations could be drawn up on the basis of the findings of this research.

It is not evident how rapidly or in which way these 4IR technological waves of innovation will flow. What is evident from the findings is that the readiness and preparedness of the HE sector will be crucial in sustaining the 4IR implications. Specifically, two overall recommendations can be suggested:

- Internal lobbying for HE reform and digital transformation: New business models with strong leadership will be needed to steer the overall reform and digital transformation process in a sustainable University 4.0 direction.
- Internal innovations and practices to help students prepare and adapt to the new technological workplace: The key here is to ensure that the teaching and learning design is relevantly aligned with the Industry 4.0 workplace to produce the required student outcome, thus a prepared and skilled, employable graduate.

Further recommendations are made on the positions that the various parties involved must take in promoting the transformation process towards the two envisaged successful outcomes of this study. This is reflected above in that a sustainable University 4.0 and prepared, skilled employable graduates should be the foreseen outcome.

Firstly, South African universities need to act swiftly in digitally transforming key functions, enhancing teaching and learning with innovative practices, and revisiting current curricula. What is evident is that these new qualification offerings should be interdisciplinary in nature. Besides internal cross-disciplinary collaborations, universities should also establish external partnerships with industry to address the skills gap and, more than ever, to better prepare graduates for the

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future workplace. Rethinking the roles within the triple helix tri-system, to collaborate and develop strategies in regulating emerging technologies, could be a valuable recommendation. These collaborations could beneficially link graduates to the workplace through intern programmes, thereby enhancing their employment prospects. Empowering staff with digital knowledge and skills will lead to digitally enhanced practices and digitally skilled graduates. This is, however, highly dependent on a reliable ICT infrastructure to support the new technology enhancements, which universities will have no choice but to invest in. It is also recommended that universities should rethink their role in society, how they invest in human capital and contribute to economic growth. These recommendations are crucial and perceived as the only way for universities to ride the 4IR wave to sustainability rather than drowning and becoming obsolete.

Secondly, graduates themselves must understand and become acquainted with the requirements of the 4IR workplace, taking responsibility for their own future. Gone are the days of spoon-feeding. The significance of creating a powerful skills profile and knowing what is expected to be considered for employability is now crucial for graduates. Becoming lifelong learners through constantly upskilling and reskilling, being able to adapt to the constantly changing work environment, staying acquainted with the latest technological development, learning how to work with robots and machines and not against them, apart from acquiring sophisticated STEM skills, building soft skills and emotional intelligence are all equally important to remain employable in the Industry 4.0 workplace.

Lastly, industry may need to review their position, working with, not against, universities, to together determine solutions regarding 4IR challenges, and establishing win-win innovative solutions. For example, the new workplace needs shorter interventions designed ‘on the run’ to develop the particular skills the future workforce requires for applying unfamiliar disruptive technologies to creative initiatives (Hattingh, 2017). Industry and universities can mutually benefit from their involvement, investing in human capital through intern programmes. The wanted outcome is achieved: prepared, skilled, employable graduates, which will enhance company productivity and increase economic growth.

These recommendations are by no means a quick fix; they should be seen together with the proposed conceptual models as a guideline. Turning these recommendations into reality will require commitment and large investments. The returns on these investments will be worthwhile, delivering the previously mentioned, foreseen outcome. In taking a being-ready and

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prepared stance, South African universities will not fall victim to the 4IR ramifications; rather, they will be innovators of change.

6.5 LIMITATIONS TO THE STUDY AND FURTHER RESEARCH

The study is limited to the analysis of non-empirical evidence by means of a scoping review. The findings are proposed in the form of two conceptual models which have not been externally scrutinised or tested in practice. This study therefore refrains from making generalisations or empirical tested claims in the context of South African universities. Rather, the study offers a summary of the findings and results from the scoping review.

Recommendations for further research include:

- The conceptual models created in Chapter Five could be enhanced by introducing new concepts, or by removing, changing, or linking concepts differently, thus enhancing and enabling the models to be more practical and usable. It may also be possible to improve the models through obtaining expert advice and input.
- Specific research in determining where on the continuum of innovation South African universities find themselves is recommended. This applies also to innovations which have been implemented on the macro level as well as on a micro level, in teaching and learning.
- Another topic for research flowing from the above would be how these innovations and transformations were applied, elaborating on the successes and failures.
- Also, it is strongly recommended that active and on-going research on the 4IR and even the vaunted Fifth Industrial Revolution should continue contributing to the proactive and productive digital globe of tomorrow. These research innovations will positively influence the chances of a fair digital future.

The challenge is to acknowledge the 4IR phenomenon and its incomparable innovation. It will take much more extensive research to find the right path in this new digital age. Discoveries made from this study have highlighted and concluded the enormity and complexity of the 4IR.

6.6 CONTRIBUTION OF THE STUDY AND CONCLUSION

As with its forerunners, the 4IR is perceived as complex and its effects as uncertain. Preparing for uncertainty is challenging, as it generates enormous opportunities, while incurring trepidation at the changes to be made (Wilson *et al.*, 2017; Gleason, 2018). It was therefore important to

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explore and investigate this phenomenon and its influences. As Feldman (2018) rightfully said, the 4IR is not science fiction, as too many sectors have already been transformed by it. Not surprisingly then, it was established through the scoping review that speedy transformation must also take place within South African universities.

Hattingh (2017) warns that South African universities must heed the 4IR warnings and review their business models and skills development strategies accordingly to prepare the future workforce for the ever-changing Industry 4.0 workplace. An uncertain future workplace, which demands skilful advance preparation to allow for adapting to it, is foreseen. Supporting and developing technological skills is the foundation of the teaching and learning 4.0 model. The model focuses on modifications in the HE sphere that respond to rapid technological innovations. Such modifications require reform of current practices regarding the digital transformation and innovation of curricula, and delivering 4IR relevant programme offerings (Janíková & Kowaliková, 2017). The intention should be to facilitate graduate employability for the future workplace. If the retrospective view of readiness and preparedness to do so is correct, then a sustainability challenge looms. This sustainability challenge is more than an unfortunate twist of fate; it is a matter of adapt or expire.

An extraordinary increase in inequality is risked, should pertinent challenges in dealing with the 4IR not be addressed. Specific reference is made here to the South African context (Pellini *et al.*, 2019). Therefore, Miron and Gherasim (2018) advocate the helix logic which has the benefit of grounding evolutionary developments that are no longer linear. The helix logic falls within the ethical moral justification that permits for discrepancies and impacts on discussion, clarification, and cooperative resolution amongst all partners. That said, universities are often considered among the most important locations for following forward-thinking ideas. In order to promote both ground-breaking research and innovative technological developments around industry and academia, government should therefore assign sufficient funding to support such innovative research programmes (Schwab, 2016). Kim (2017) strongly agrees that the indefinite and unpredictable aspect of the new technologies connected with the 4IR would make triple helix partnerships even more crucial and relevant. Conversations within this triplet would go further than merely manoeuvring technological innovation prospects. For this reason, the collaboration of HE and industry is indispensable in terms of adapting curricula to future technological innovations and career developments (Baygin, Yetis, Karakose & Akin, 2016).

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However, what also became evident and crucial is the necessity for greater cooperation between the academic disciplinary fields. The conception of interdisciplinary offerings may not have stimulated deliberation or consideration in all faculties, yet it emerged from the majority of studies that a new era of cross-discipline interaction and cooperation for HE is dawning. At this intersection between disciplines, there is both the transfer of valuable skills potential and the innovation needed to better equip graduates for their 4IR future. Hence, Brown and Keep (2018) found that what will become essential to a more competitive meritocratic HE epoch, is the transferring of those digital skills that complement robots rather than compete with them. In this way, the future workforce will be robot-proof. Therefore, lifelong learning must become an exigency and not simply a good-to-have for directing intimidating robots in the workplace. Workers must also be able and prepared to continue directing robots. In Brynjolfsson and McAfee (2016)'s compelling words, technology is not fate: South African universities will therefore shape their own fate. Consequently, if, as human beings, controlling and instructing robots is in our skilled and capable hands, investing in human beings with morals and values will define the outcome of the 4IR (Caetano & Charamba, 2017).

In the end, the future has not been properly labelled: the future is *now*. Instituting change in HE is now more indispensable than ever; so too is predicting future changes in this sphere. The main concern will be to keep pace with the digital change, and digital aspirations, knowing where to start the digital journey (Suganya, 2017). The only way graduates can compete in this race against ineluctable technology, robots and AI is by twofold means: acquiring the necessary set of skills; and being prepared for future jobs. Graduates would thus succeed in applying their emotional intelligence to the lifelong digital journey, becoming employable in the new Industry 4.0 workplace.

Whatever the future may hold, there can no longer be a *nonchalant-ness* towards the 4IR; rather, a *preparedness* to empower students must prevail. The conceptual models and findings of this study provide a transformation roadmap, attempting to make a valuable contribution - giving direction in preparing the future workforce and initiating a new *University 4.0.*

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ANNEXURE A:
SCOPING REVIEW PROTOCOL

REVIEW TITLE:

How South African universities can contribute to preparing the future workforce for the Fourth Industrial Revolution.

A. METHODS:

The methods for conducting a scoping review have been adopted from Arksey and O'Malley (2005:22). The process consists of the following five phases:

1. Formulating the research and sub-research questions to be addressed
2. Identifying sources that are relevant to the research questions
3. Evaluating and selecting sources to be included in the review
4. Charting the information and data extracted from the included sources
5. Organising, summarising and reporting extracted results of the review

1. Phase One: Formulation of the broad main RQ and S-RQs

How should the key functions of South African universities, particularly those related to teaching and learning, be transformed to better prepare the future workforce for the Fourth Industrial Revolution?

1) What is the role of South African universities in preparing the future workforce for the Fourth Industrial Revolution?
2) Which key themes can be identified from the results of the scoping review, addressing the implications of the Fourth Industrial Revolution for South African universities?
3) What innovative teaching and learning practices to better prepare and equip students with the required skills for future jobs in the Industry 4.0 workplace can be identified from relevant literature?
4) Which conceptual models (consisting of key functions and assumed relationships between these functions/practices), derived from the scoping review, can be proposed for South African universities and particularly their teaching and learning function, to better prepare the future workforce for the Fourth Industrial Revolution?

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2. Phase Two: Methods to identify relevant sources relevant to RQs

Scoping reviews allow for flexible and comprehensive searching for a variety of sources via bibliographic databases, internet browsing and reference scanning, to name a few, as an instinctive manner of retrieval sources (Arksey & O'Malley, 2005; Daudt *et al.*, 2013).

2.1 Search strategies: Key search terms and search strings:

Key concepts identified from the research questions, according to PICO model (Yensen, 2013) and assigned search terms for each concept - search terms within each concept can be combined with **"OR"**.

	Concept 1	**Concept 2**	**Concept 3**	**Concept 4**
Key concepts	Fourth Industrial Revolution	Universities	Teaching and learning	Skills
Key search terms (synonyms, more broader terms)	Industry 4.0 Disruptive technology Digital technology Workplace 4.0 Disruptive innovation Technological changes Virtual reality Digital transformation	Higher education Tertiary education University 4.0 Research and innovation Students Workforce Graduate employability Virtual collaboration Virtual learning environments Innovative hub/space Innovation culture	Teaching and Learning 4.0 Teaching 4.0 Learning 4.0 Teaching and Learning practices Curriculum 4.0 Assessment 4.0 Learning environment Transformative learning Technology-enabled learning Pedagogy 4.0 e-learning/online learning Experiential learning	Skills 4.0 Digital skills Life-long learning Design-thinking Agility Emotional intelligence Entrepreneurial skills STEM
(SA, to narrow search terms)	South African	South African	South African	South African

FIGURE A: Scoping Review: Key Concept and Search Terms

Search term (#1) + Search term (#2) + Search term (#3) + Search term (#4) = Search results

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Each concept can be joined together using **"AND"**. In most databases this can be done in the search history.

The search may be #1 AND #2 AND #3 AND #4

Search terms can be narrowed by searching for South African content.

2.2 Electronic databases and resources that will be searched:

- Sabinet – SA E-publications
- Science Direct
- Ebsco - (Eric, Education Source, Africa Wide, Academic search premier)
- Taylor & Francis
- Scopus

2.2.1 Hand-searching other sources:

- Internet search engines, websites and gateways e.g. Google Scholar
- Citations and references
- Conference proceedings/abstracts
- Newspapers
- Grey literature
- Editorials/commentaries/letters
- Professional contacts, key authors / experts

3. Phase Three: Selection criteria

3.1. Evaluation and screening process of sources

This process will apply the predetermined inclusion and exclusion criteria below as guideline.

3.1.1 Inclusion criteria:

- Publication years 2014-2018 (only last 5 years due to the current nature of the topic)
- English language
- Focus on universities and higher education within the Fourth Industrial Revolution context
- Focus on teaching and learning practices within the Fourth Industrial Revolution context
- Grey literature

3.1.2. Exclusion criteria:

- Not related to universities or higher education
- Not related to the Fourth Industrial Revolution
- Other languages than English

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3.1.3. Additional limits:

To be determined after the first round of searching and to narrow or broaden the search strategy.

3.1.4. Selection process:

The PRISMA flow diagram will be used for the scoping review selection process (Moher et al., 2009).

4. Phase Four: Data extraction and charting of results

4.1. Key data to be extracted:

Publication characteristics: title, year of publication, author, type, source, database, country of origin, field of study or discipline and theme.

4.1.1. Methods used for data extraction

- Excel spreadsheet: to extract data, organise, sort and table data.
- Mendeley desktop: to obtain full-text of selected articles, to de-duplicate selected articles and to utilise as referencing tool.

5. Phase Five: Data analysis, reporting and presentation of results and findings

- Descriptive numerical summary: Graphs, charts and tables to illustrate results exported from Excel.
- Thematic analysis: Thematic analysis refers to the process of reading selected articles and resources and filtering the results into key themes to combine research findings for a better understanding to address the research questions (Bearman & Dawson, 2013).
- Conceptual models: diagrams consisting of boxes/circles to illustrate and highlight the key themes/functions resulting from the study and arrows/lines explaining the connection amongst these concepts.

Since a scoping review can be used to map the concepts underpinning the area of research and the key sources and types of available information and research, the collected results provide an overview of the research topic rather than an evaluation of the quality of individual sources.

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ANNEXURE B:

THEMES AND OCCURRENCE IN NUMBER OF STUDIES

Broader Theme	Sub-theme	Occurrence in Number of Studies	% of Studies in Data-set
Overarching Theme: Fourth Industrial Revolution / Industry 4.0 / 4th Industrial Revolution			
South Africa / Universities / Higher education	**Technology:**	127	90%
	• big data	100	71%
	• robotics	82	58%
	• artificial intelligence	81	57%
	• automation	79	56%
	• block chain	41	29%
	Transformation:	124	88%
	• prepare for future	130	92%
	• digital	120	85%
	• disruption	79	56%
	• qualifications	48	34%
	Innovation:	110	78%
	• environment	114	81%
	• new business models	99	70%
	• teaching and learning practices	93	66%
	• partnerships - collaborations	87	62%

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	• services	81	57%
	• leadership	76	54%
	• entrepreneurial	66	47%
	• culture	63	45%
	Challenges:	98	70%
	• employable graduates	100	71%

	• professional development
	  ○ upskilling
	  ○ reskilling
		93	66%

	• sustainability	73	52%
	• funding	65	46%
	• information communication technology infrastructure (ICT)	53	38%
	• inequality	48	34%
	• cyber security	45	32%
	• ethics	36	26%
	• resistance to change	23	16%
Teaching and learning	**Students:**	83	59%
	• prepare and equip students	109	77%
	• generation / millennials	66	47%
	Trends:	81	57%
	• lifelong learning	97	69%
	• curriculum innovation ○ inter/trans/multi-disciplinary	69 53	49% 38%

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	• virtual learning, environment, collaboration	76	43%
	• Digital learning: online; blended; e-learning	33	23%
	• MOOCs	29	21%
	• mentoring	15	11%
Workforce	**Skills:**	101	72%
	• adaptability	89	64%
	• creative mind-set	67	48%
	• problem-solving	56	40%
	• STEM	46	33%
	• soft skills	28	20%
	• emotional intelligence	33	23%
	• agility	20	14%
Workplace	**Requirements:**	96	68%
	• relevant training	75	53%
	• new jobs - skills	74	52%
	• changing workplace	51	36%

	• unemployment
	  ○ skills mismatch
	  ○ job losses
	  ○ automation
		74	52%

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ANNEXURE C:
REPORT ON THEMES CLUSTERED ACCORDING TO RESEARCH QUESTIONS

Overarching Theme: FOURTH INDUSTRIAL REVOLUTION
Broader Theme 1: South Africa / Universities / Higher education
Description of Sub-themes: grouped together in clusters according to RQs
Sub-themes Cluster -1A *"How"* of RQ1:
• Technology enhanced processes, technology is accentuated as the principal enabler in accomplishing scaled education in evolving workplace requirements (Lambrechts & Sinha, 2018). o Utilise AI to streamline processes (Balkaran, 2016; Kim, 2017; Liu et al., 2018; Penprase, 2018) o Big data – analytics, utilising available information and data to predict scenarios, make better decisions (WEF, 2016; Baxter, 2017; Carillo, 2017; Selamat, 2017; Suganya, 2017; Adams Becker et al., 2018; Gleason, 2018; Lee et al., 2018; Liu, Gao, Wang & Liu, 2018; Halili, 2019) o Analytics, makerspaces, AI, mixed reality and robotics are projected to be more and more important in universities within the next five years (Adams Becker et al., 2018; Feldman, 2018) o Block chain technology is expected to transform the operational methods of universities (Schwab, 2016; Chen, Xu, Lu & Chen, 2018; Lee et al., 2018) o Become data-driven (Carillo, 2017; Gleason, 2018; Halili, 2019) • Digital transformation (Richert, Plumanns, Gross, Schuster & Jeschke, 2015; Shave, 2017; Vey, Fandel-Meyer, Zipp & Schneider, 2017; Abeid, Rahman & Dahlan, 2018; Lee et al., 2018; Neufeind, O`Reilly & Ranft, 2018) • Culture and environment: Create digital culture and environment of innovation, virtual spaces (Plumanns *et al.*, 2016; Schuster *et al.*, 2016; Selamat, 2017; Vey *et al.,* 2017; Xing & Marwala, 2017; Adams Becker, Brown, Dahlstrom, Davis, DePaul, Diaz & Pomerantz, 2018; Aziz Hussin, 2018; Lee *et al.,* 2018) o Entrepreneurial culture (Brynjolfsson & McAfee, 2016; Eberhard, Podio, Pérez, Radovica, Avotina, Peiseniece, Caamaño, Gonzales & Solé-Pla, 2017; Naudé, 2017;

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Dew, Beitel & Hare, 2018; Schäfer, 2018; Pellini, Weyrauch, Malho & Carden, 2019)
    - Digital hubs, think tanks, creating a start-up ecosystem (Baxter, 2017; Schäfer, 2018; Beliz et al., 2019)
- New business model (Sledge & Fishman, 2014; Baxter, 2017; Kim, 2017; Selamat, 2017; Abeid et al., 2018; Dew et al., 2018)
- Research and Development: market-related research; linking research to practice; real-time research to guide curriculum innovation (Xing & Marwala, 2017; Buasuwan, 2018; Deloitte, 2018; Twinomurinzi & Ismail, 2018)
- Increase in open educational resources (OER) (Adams Becker et al., 2018; Nordin & Norman, 2018; Tvenge & Martinsen, 2018)
- University-industry partnerships (Baxter, 2017; Cacciolatti, Lee & Molinero, 2017; Buasuwan, 2018; Herweijer et al., 2017; Kim, 2017; Deloitte, 2018; Gleason, 2018; Leydesdorff, 2018; Miron & Gherasim, 2018; Pellini et al., 2019; Sheperd, 2019)
- Knowledge hub with industry and society, knowledge society, research innovation (Herweijer, Combes, Johnson, McCargow, Bhardwaj & Jackson, 2017; Johannessen, 2018; Lee et al., 2018)
- Establishment of “cross-institution & cross-sector collaboration” (WEF, 2016; Baxter, 2017; Shook & Knickrehm, 2017; WEF, 2017; Adams Becker et al., 2018: 2)
- Qualifications - shorter lifecycle; “hop-on-hop-off” (Hamilton, 2018; Hattingh, 2018; Doepker, 2019; Menon & Castrillon, 2019; Spiro, Alexander, Lawrence & Ramanujam, 2019)
- Leadership that can drive innovation and change; bold and brave; digital leadership (Balkaran, 2016; Shave, 2017; Suganya, 2017; Zaharah, Selamat, Alavi & Arifin, 2018; Leurent, Betti, Shook, Fuchs & Damrath, 2019)
- Sustainable development – AI applications (Wilson, Lennox, Hughes & Brown, 2017; Butler-Adam, 2018; Miron & Gherasim, 2018; Leurent et al., 2019; Spiro et al., 2019)

Sub-themes Cluster 1B: *“role of universities”* of S-RQ1:

- Improve employability of students (Cotterill, 2015; Cacciolatti et al., 2017; Abeid et al., 2018; Johannessen, 2018b) through adhering to the Industry 4.0 workplace needs (Adams Becker et al., 2018; Hamilton, 2018) and addressing unemployment issues (Chetty, 2018; Deloitte, 2018)
- Practical work-experience as part of training (Cacciolatti et al., 2017)
- Addressing skills mismatch (Shook & Knickrehm, 2017; Martin, 2018)
- Preparing a future workforce with risk-taking creativity and entrepreneurial skills (Gleason,

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2018), a skill-set to match demand in the workplace (Brynjolfsson & McAfee, 2016; Fortier, 2016; Ayentimi & Burgess, 2018; Hattingh, 2018; Martin, 2018) • Advanced skills to keep pace with change and technological evolvement (Doyle, 2015; Balkaran, 2016; Rigg, 2018) • Innovative and adaptable curriculum or syllabus for workplace needs and requirements; work-relevancy – collaboration in research (Baygin, Yetis, Karakose & Akin, 2016; Busteed, 2019). • Rethink silo-based operations (Carillo, 2017) • Professional staff development, lifelong learning, upskilling, improve digital literacy, digital competencies for technology-based practices (Schuster, *et al.*, 2015; Balkaran, 2016; WEF, 2016; Daniels, 2017; Leibowitz, Bozalek, Garraway, Herman, Jawitz, Muhuro, Ndebele, Quinn, Van Schalkwyk, Vorster & Winberg, 2017; Shave, 2017; WEF, 2017a; Aziz Hussin, 2018; Buasuwan, 2018; Halili, 2019)
Sub-themes Cluster 1C: *"addressing implications"* of S-RQ2:
• Improved ICT infrastructure – better connectivity, accessibility (Balkaran, 2016; Johannessen, 2018; Tvenge & Martinsen, 2018; Beliz, Basco & de Azevedo, 2019) • Lack of funding (Abeid et al., 2018) Sponsoring by industry for upskilling existing workforce (WEF, 2016; Gleason, 2018) • Inequality – manage innovation and change (Schwab, 2016; Caetano & Charamba, 2017; Chetty, 2018; Johannessen, 2018; Martin, 2018; Neufeind et al., 2018; Nordin & Norman, 2018; Shahroom & Hussin, 2018; Beliz et al., 2019; Pellini et al., 2019; Pollitzer, 2019) • Ethics: ethical and moral decisions in digital, AI world (Selamat, 2017; Butler-Adam, 2018; Nordin & Norman, 2018) • "Humanizing education and technology" (Abeid et al., 2018:108) • Resistance to change of academia (Bovill et al., 2016; Wilson, Lennox, Hughes & Brown, 2017; Buasuwan, 2018) • Enhancing Cyber-security (Baxter, 2017; Suganya, 2017; Nordin & Norman, 2018), to protect the privacy of students and staff (Nasir, 2018)
Broad Theme 2: Teaching and learning
Sub-themes Cluster 2A: *"innovative practices"* of S-RQ3:
• Interdisciplinary courses (Carillo, 2017; Herweijer et al., 2017; Kim, 2017; Naudé, 2017; Xing & Marwala, 2017; Adams Becker et al., 2018; Gleason, 2018; Osman, 2018; Rigg, 2018)

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- Curriculum innovation (Hutchings & Quinney, 2015; Bovill, Cook-Sather, Felten, Millard & Moore-Cherry, 2016; Diwan, 2017; WEF, 2017a; Doucet, Evers, Guerra, Lopez, Soskil & Timmers, 2018; Media, 2019)
- Future-ready training programs / relevant courses "just what you need to know when you need to know" (Balkaran, 2016:13; Cacciolatti, Lee & Molinero, 2017; Lee et al., 2018; Sood, 2018)
- Lifelong learning (Brynjolfsson & McAfee, 2016; Leibowitz et al., 2017; Buasuwan, 2018; Feldman, 2018; Lee et al., 2018; Tvenge & Martinsen, 2018; Leurent et al., 2019)
- Learning environment, open and flexible, on demand (Sledge & Fishman, 2014; Buasuwan, 2018) with the prospects of learning at different times and in different environments (Janssen *et al.*, 2016)
- Trends:
    - Problem-based learning; project-based learning (Cacciolatti et al., 2017; Elbestawi, Centea, Singh & Wanyama, 2018; Gleason, 2018; Hariharasudan & Kot, 2018).
    - Experiential learning (Carillo, 2017; Gleason, 2018)
    - Student-centred learning and student involvement (Cotterill, 2015; Elbestawi et al., 2018; Hutchings & Quinney, 2015)
    - Interactive learning (Eberhard et al., 2017)
    - Technology enhanced practices, for example, using AI in teaching and learning practices to reduce workload of lecturers (Penprase, 2018; Shahroom & Hussin, 2018; Halili, 2019) Student-staff partnerships (Bovill et al., 2016)
    - Students co-creators of knowledge (Buasuwan, 2018)
- Innovative teaching and learning practices in the form of digital technology, online learning, blended learning; MOOCs (Bates, 2015; Doyle, 2015; Siemens & Dawson, 2015; Brynjolfsson & McAfee, 2016; Schuster et al., 2015; Coswatte Mohr & Shelton, 2017; Peters, 2017; WEF, 2017b; Abeid et al., 2018; Buasuwan, 2018; Kodama, 2018; Liu et al., 2018; Sakhapov & Absalyamova, 2018); "Adaptive learning technologies" (Adams Becker et al., 2018:3)
- Students' profile – important to recognise characteristics of generations, digital natives, millennials (Farrell & Hurt, 2014; Eberhard et al., 2017; Aziz Hussin, 2018; Shahroom & Hussin, 2018)
- Mentoring approaches, digital coaching (Richert et al., 2015; Naudé, 2017; Shook & Knickrehm, 2017; Elbestawi et al., 2018)

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Generic Theme 3: Skills
Sub-themes Cluster 3A: *"required skills"* of S-RQ3:
• Emotional intelligence - essential skill for 4IR (Schwab, 2016; Diwan, 2017; Doucet et al., 2018; Hariharasudan & Kot, 2018) • Become lifelong learners (Aoun, 2017; Abeid et al., 2018; Dew et al., 2018; Martin, 2018) • Entrepreneurial mind-set (Brynjolfsson & McAfee, 2016; Buasuwan, 2018; Chetty, 2018) • Ability to adapt and apply skills and knowledge in an ever-changing workplace (Eberhard et al., 2017; Doucet et al., 2018; Deloitte, 2018) • Agility to move across jobs; start several new careers in lifetime (Schwab, 2016; Hattingh, 2017; Vestberg, 2018) • STEM, social, soft and digital skills will be crucial (WEF, 2016; Wilson et al., 2017)
Sub-themes Cluster 3B: *"Industry 4.0 workplace"* of S-RQ3:
• Job losses due to AI capabilities, automation and robotics (Ford, 2015; Schwab, 2016; Caetano & Charamba, 2017; Lent, 2018;) • Constant creation of new jobs requires new skills (Beliz et al., 2019) • Unemployment owing to - Skills shortages, mismatch, STEM & humanities, relevant training (Cacciolatti et al., 2017; Eberhard et al., 2017; Vey et al., 2017; Vestberg, 2018; Sheperd, 2019) • Technological unemployment (Schwab, 2016; Gleason, 2018; Nair, 2018) • Upskilling and reskilling of current workforce – now crucial (WEF, 2016; Cacciolatti et al., 2017; WEF, 2017b) • Changing workplace and nature of work (Balkaran, 2016; Sheperd, 2019) • Frequent job changes, end of "one-job-for-a-lifetime" (Hattingh, 2017: 22) • Job descriptions will become obsolete (Hattingh, 2017) • Difficulties in developing countries – creating future jobs (Beliz et al., 2019)

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ANNEXURE D:
ETHICAL EXEMPTION LETTER

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

PROJECT EXEMPT FROM ETHICS CLEARANCE

14 January 2019

Project number: CUR-2018-8887

Project title: How South African universities can contribute to preparing the future workforce for the Fourth Industrial Revolution

Dear Ms Lizette Wessels

Your application received on **27 November 2018** was reviewed by the REC: Humanities.

You have confirmed in the proposal submitted for review that your project does not involve the participation of human participants or the use of their data. You also confirmed that you will collect data that is freely accessible in the public domain only.

The project is, therefore, exempt from ethics review and clearance. You may commence with research as set out in the submission to the Research Ethics Committee: Humanities.

If the research deviates from the application submitted for REC clearance, especially if there is an intention to involve human participants and/or the collection of data not in the public domain, the researcher must notify the DESC/FESC and REC of these changes well before data collection commences. In certain circumstances, a new application may be required for the project.

Please remember to use your **project number (CUR-2018-8887)** on any documents or correspondence with the REC concerning your project.

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Human Research (Humanities)