Research study on the impact of the 4th Industrial Revolution (4IR).

Final Report

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ACRONYMS

4IR	4th Industrial Revolution
AI	Artificial Intelligence
AR	Augmented Reality
CATHSSETA	Culture, Arts, Tourism, Hospitality and Sport SETA
CSIR	Council for Scientific and Industrial Research
GDP	Gross Domestic Produce
GGR	Gross Gambling Revenue
ICT	Information and communications technology
IoT	Internet of things
IT	Information technology
NSDP 2030	National Skills Development Plan 2030
PWC	Price Waterhouse Coopers
SE	Small enterprise
SETA	Sector Education and Training Authority
SMME	Small, Medium and Micro Enterprises
THETA	Tourism and Hospitality Education and Training Authority
Tor	Terms of Reference
TVET Colleges	Technical Vocational Educational and Training (TVET) colleges
VR	Virtual Reality
WEF	World Economic Forum

1. INTRODUCTION

The 4th Industrial Revolution (4IR) relates to the advent of "cyber-physical systems", which involve brand new capabilities for people and technology[1]. While this revolution is reliant on the technologies of the 3rd Industrial Revolution, 4IR represents entirely new ways in which the lines between the digital, physical and biological worlds will merge[2]. These innovations are predicted to bring about disruption and displacement in how the world works; national and individual security; the job market and how work is done; and potential increases in inequality[3].

This research aims to understand the impact of the 4IR on six sub-sectors within the South African economy: Arts, Culture and Heritage, Conservation, Gaming and Lotteries, Hospitality, Sport, Recreation and Fitness, and Travel and Tourism. The focus of this research is on skills development and delivery, as per the mandate of the Culture, Art, Tourism, Hospitality and Sport Sector Education and Training Authority (CATHSSETA), who commissioned this research.

1.1. Rationale and objectives

The increase in technology, that is the hallmark of the 4IR, brings with it important implications for employment, equality and the world of work. Increases in technology are likely to displace many workers, with jobs being replaced by automated processes[4].

In South Africa, reducing inequality and unemployment are some of the primary goals outlined by the National Development Plan (NDP)[5]. Beyond a current unemployment rate of 34.4%[6], South Africa's education system and infrastructure – particularly with regards to internet access – place it at a disadvantage during the expansion of the

[1] Nicholas Davis, 'What Is the Fourth Industrial Revolution?', *World Economic Forum*, 2016 <https://www.weforum.org/agenda/2016/01/what-is-the-fourth-industrial-revolution/>.
[2] Devon McGinnis, 'What Is the Fourth Industrial Revolution?', *The 360 Blog*, 2020 <https://www.salesforce.com/blog/what-is-the-fourth-industrial-revolution-4ir/>.
[3] Davis.
[4] Klaus Schwab, *The Fourth Industrial Revolution* (London, England: Portfolio Penguin, 2017).
[5] National Planning Commission, *National Development Plan 2030: Our Future - Make It Work* (Pretoria: The Office of the Presidency, 2012) <https://www.gov.za/issues/national-development-plan-2030>.
[6] Lameez Omarjee, 'SA's Unemployment Rate Hits Record 34.4%', *Fin24*, 2021 <https://www.news24.com/fin24/economy/sas-unemployment-rate-hits-record-344-20210824>.

4IR[7]. Despite the risks of increased unemployment and inequality, the 4IR also brings with it opportunities for the country.

1.1.1. Problem statement

Early identification of the impact of the 4IR on CATHSSETA's sub-sectors is crucial for early planning and intervention. The complexity of the technologies driving the 4IR and the extent of their impact means that all relevant stakeholder groups should work together on innovative strategic approaches, to ensure that the emerging technologies brought on by the 4IR will improve lives in as broad-based and meaningful a way as possible.

1.1.2. Objectives

The main objective of this study is to research the impact of the 4IR on CATHSSETA, as well as its impact on each of the six sub-sectors. Specifically, the research questions can be summarised as:

- What should CATHSSETA do to strategically support its sub-sectors, through skills development, to respond to the 4IR?
- What skills and qualifications should CATHSSETA, its sub-sectors and South Africa be focusing on?
- How should CATHSSETA and South Africa be building these skills?
- Does South Africa have the human resources to teach these skills to others? If not, how do we develop them?
- What strategy should each sub-sector take to prepare for the 4th Industrial Revolution?
- What role should Skills Development Facilitators play in the context of the 4th Industrial Revolution?

In addition to the above, it should be noted that the coronavirus (COVID-19) pandemic has accelerated the 4IR[8] and this research is presented within the context of COVID-19.

[7] F Dijkstal, M Stankovic, and M Ploeg, *Potential of the Fourth Industrial Revolution in Africa*, *Research ICT Africa*, 2019.
[8] Bernard Marr, 'What's Been The Impact Of Covid-19 On The 4th Industrial Revolution?', *Forbes*, 2020 <https://www.forbes.com/sites/bernardmarr/2020/12/21/whats-been-the-impact-of-covid-19-on-the-4th-industrial-revolution/?sh=5f4fde4b5c0d>.

1.2. Background and context

The Culture, Art, Tourism, Hospitality and Sport Sector Education and Training Authority (CATHSSETA), previously known as the Tourism and Hospitality Education and Training Authority (THETA), is one of 21 Sector Education and Training Authorities (SETAs) that were established under the Skills Development Act of 1998[9].

Mandated to facilitate skills development within the sub-sectors, CATHSSETA's obligations are to[10]:

- Develop and implement a sector skills plan.
- Support the implementation of the National Qualifications Framework.
- Conduct quality assurance on learning, in line with Quality Council for Trades and Occupations requirements.
- Disburse levies collected from employers into our sub-sectors.

The delivery of this mandate is outlined in the Sector Skills Plan[11] (SSP), which outlines the occupations, skills and qualifications required for the sub-sectors to thrive. The obligations of CATHSSETA are met through collaboration with several public and private sector partners, including Technical Vocational; Educational and Training (TVET) colleges; higher education institutions and universities; public entities; co-operatives; Non-Profit Organisations (NPOs); community organisations and large employers and industry bodies within the sector[12]. These partnerships take several forms, with CATHSSETA providing support through funding and bursaries, as well as assisting with mobilising and building partnerships; and developing skills development and training interventions alongside these institutions.

1.2.1. Arts, Culture, and Heritage

The Arts, Culture and Heritage sub-sector is described by CATHSSETA as representing "artists, cultural practitioners, creative professionals and associated administrative and operational professionals"[13]. The sub-sector contributed an

[9] Republic of South Africa, *Skills Development Act*, 1998.
[10] 'About Us', *CATHSSETA*, 2021 <https://cathsseta.org.za/about-us/>.
[11] CATHSSETA, *Sector Skills Plan 2020/21 - 2024/5*, 2019.
[12] CATHSSETA, *Sector Skills Plan 2020/21 - 2024/5*.
[13] CATHSSETA, *Career Guide: Arts, Culture and Heritage*, 2016.

estimated R74,39 billion to the South African Gross Domestic Product (GDP) in 2018, accounting for 1,7% of GDP[14]. In 2017, 7,03% of jobs in the country were from the "creative economy", with the employment in the industry growing significantly between 2015 and 2017[15].

The qualifications needed in the sector, as detailed in the SSP[16], include dance; design and applied arts; drama/theatre arts; film/video and photographic arts; fine and studio arts; music, visual and performance arts. The skills that are most relevant to those working in the sector include creativity, to develop new ideas; communication, to work effectively with others and manage clients; collaboration, to ensure that you can work with others to bring ideas to life; critical thinking, to assist with problem-solving in design; technological knowledge, to make use of technological innovations to enhance and create work; business knowledge, to ensure that freelance work can result in a sustainable income; and project management, to ensure that multiple projects can be successfully met[17].

While creative jobs are unlikely to be replaced by automation, the 4IR cannot be dismissed in the sector[18]. Technologies introduced through the 4IR have a role to play in both the creation and distribution of creative work: technologies, such as computer-aided design and improved audio-visual software, can enhance traditional works, while technologies, such as virtual reality (VR) and improved communications, give those in the industry the opportunity to reach wider audiences with their work[19].

1.2.2. Conservation

Estimating the contribution of this sub-sector to South Africa's GDP is difficult, as the sector itself is strongly linked to tourism and much of the value created through

[14] Unathi Lutshaba, Sybert Liebenberg, and Jen Snowball, *The Economic Mapping of the Cultural and Creative Industries in South Africa 2020*, *Capstone Report*, 2020, II <http://jurnal.globalhealthsciencegroup.com/index.php/JPPP/article/download/83/65%0Ahttp://www.embase.com/search/results?subaction=viewrecord&from=export&id=L603546864%5Cnhttp://dx.doi.org/10.1155/2015/420723%0Ahttp://link.springer.com/10.1007/978-3-319-76>.
[15] Lutshaba, Liebenberg, and Snowball, II.
[16] CATHSSETA, *Sector Skills Plan 2020/21 - 2024/5*.
[17] Troy Jennings, 'Top Skills Needed for Careers in Art and Design', *Classes and Careers* <https://blog.classesandcareers.com/advisor/top-skills-needed-for-careers-in-art-and-design/>.
[18] Art Times, 'Creativity Is Currency in 4th Industrial Revolution', *South Africa Cultural Observatory* <https://arttimes.co.za/creativity-currency-4th-industrial-revolution/>.
[19] Aspire Art Auctions, 'The Art Market in the Fourth Industrial Revolution', *ABSA* <https://www.absa.africa/world-economic-forum/africa/absa-at-wef/op-ed-piece-3/>.

conservation is captured in the tourism industry. When including non-timber forest products, wildlife trade, wildlife filming and photography, hunting, ecotourism, fisheries and wildlife ranching, the total value added by conservation to the South African economy, in 2020, was estimated to be R73 billion, or 7% of GDP.[20]

While not all work in the sector requires high skill levels, the skills and qualifications needed in the sector include forestry, agriculture, horticulture, biology and environmental sciences[21]. This is traditionally a very physical sector and the 4IR is becoming more prevalent within the industry. Artificial Intelligence (AI) is being used to create "biological search engines", which enable a greater understanding of ecosystems and developing biologically inspired innovations[22]. In addition, communication technology, machine learning and improved videography and photographic technologies can improve the industry's ability to gather data and carry out their work, such as preventing poaching[23].

1.2.3. Gaming and Lotteries

The gaming and lotteries sector in South Africa is made up out of casinos, limited pay-out machines, bingo, betting and the National Lottery. The sector contributed an estimated R32.7 billion to the South African economy in 2020, with casinos making up the largest portion of the sector[24].

Research suggests that the Digital Gaming industry (DGI) has been revolutionised through the technologies introduced by the 4IR[25]. The result has been an increase in the size of the industry, as well as its economic contribution across countries[26]. The primary technologies that have impacted the industry, for gaming, gambling and lotteries in South Africa, are discussed by the National Gambling Board[27]. These are identified as Artificial Intelligence (AI), which drives operational improvements; AR and

[20] N Adami and others, *State of the Wildlife Economy in Africa: South Africa*, 2020.
[21] Dawn Rosenberg McKay, 'Conservationist - Career Information', *The Balance Careers*, 2019 <https://www.thebalancecareers.com/conservationist-526002>.
[22] PwC, *Fourth Industrial Revolution for the Earth*, 2018.
[23] PwC, *Fourth Industrial Revolution for the Earth*.
[24] T Mashiane, 'How Large Is the Gambling Industry in South Africa?', *TechFinancials*, 2021, pp. 2020–22 <https://www.techfinancials.co.za/2020/02/28/how-large-is-the-gambling-industry-in-south-africa/>.
[25] F.I.G. Cesar and others, 'The Contribution of Industry 4.0 to the Digital Games Industry', *International Journal of Recent Scientific Research*, 10.01 (2019), 37471–72 <https://doi.org/10.24327/IJRSR>.
[26] Cesar and others.
[27] National Gambling Board, *4IR and the Current and Future Regulation of Gambling in South Africa*, 2020.

VR, which make virtual games and casinos possible; and blockchain, which improves the security of transactions. Based on these, many of the skills that are needed in the sector include data analytics, web design, computer programming and law (to respond to the legal and regulatory implications and advancements in the sector).

1.2.4. Hospitality

Given the overlap between hospitality and tourism, it is difficult to estimate the contribution of the hospitality sub-sector to South Africa's GDP. The total income generated in the food and beverages industry in 2020 was R43 654,9 million[28]. Of course, COVID-19 reduced the contribution of the sector considerably, due to the national lockdowns, with a year-on-year decrease in income of 24,6% in 2020[29].

The SSP[30] identifies food science and technology, and hospitality administration and management, as the top qualifications required in the sector. Further research identified the following as the most needed skills by the hospitality industry: leadership, communication, problem-solving, oral and written communication, teamwork, customer service, professional and ethical standards, personnel management, time management, decision-making and information technology[31].

Skills in technology are also increasing in importance as 4IR technologies continue to grow in the industry. Internet of Things (IoT) devices can be used in hotels to improve guest experiences, and blockchain can be used to prevent fraud and facilitate secure payments and AI and robotics are being used to serve guests and manage back-end operations[32].

1.2.5. Sports, Recreation and Fitness

While this research was not able to identify the contribution of the Sports, Recreation and Fitness sub-sector to the South African economy, research conducted by Coning[33] in 2018 identified that the industry contributed 2.2% to the GDP of the Western Cape province and provided 60 000 jobs. While COVID-19 impacted the

[28] StatsSA, *Food and Beverages*, 2021 <https://doi.org/10.1007/978-3-642-55309-7_21>.
[29] StatsSA.
[30] CATHSSETA, *Sector Skills Plan 2020/21 - 2024/5*.
[31] R.S. Dhaliwal and P. Misra, 'View of Employability Skills Needed in Hospitality Industry: A Scopious Review', *Asian Journal of Education and Social Studies*, 10.1 (2020) <https://journalajess.com/index.php/AJESS/article/view/30258/56746> [accessed 30 September 2021].
[32] S.B. Al-Otaibi, 'Transform Tomorrow – Dur Hospitality', *Hospitality Net*, 2020 <https://www.hospitalitynet.org/opinion/4096389.html>.
[33] Christo Coning, *The Case for Sport in the Western Cape: Socio-Economic Benefits and Impacts of Sport and Recreation*, 2018.

sector in recent years, the introduction of e-sports has seen an increase in activity within in industry once more[34].

In the SSP[35], CATHSSETA identifies sports administrators, biokineticists, sport psychologists and sports coaches as the primary qualifications required in the sector. In a review of employer perceptions, the following skills were identified as being essential for work within the industry: professional behaviour and development; leadership and influence; problem solving, organisation and time management; communication ability; and (inter)personal skills[36].

4IR technologies are revolutionising the industry across the globe, where AI is directing sports coaching, gene sequencing and nanotechnology are improving athletes' performance and IoT systems are improving monitoring of physical wellbeing[37].

1.2.6. Travel and Tourism

The sub-sector of Travel and Tourism makes a substantial contribution to the South African economy. In 2017, this sub-sector contributed 2.9% to total GDP and 6.9% in 2019, but dropped to 3.7% in 2020, due to the impact of the coronavirus pandemic[38]. According to The World Travel and Tourism Council (WTTC), the total GDP is likely to reach 3.3% of total GDP in 2028. The increase in GDP contributions over the years has been a result of domestic spending, business domestic spending and visitor exports.

According to the National Department of Tourism (NDT), the Human Sciences Research Council (HSRC) briefing of the Committee on the Tourism Sector Skills Audit and the Tourism Sector Human Resource Development (TSHRD) Strategy, the top

[34] Dimakatso Ramagole and others, 'Implications of COVID-19 for Resumption of Sport in South Africa: A South African Sports Medicine Association (SASMA) Position Statement – Part 2', *South African Journal of Sports Medicine*, 32.1 (2020), 1–5 <https://doi.org/10.17159/2078-516x/2020/v32i1a8986>.
[35] CATHSSETA, *Sector Skills Plan 2020/21 - 2024/5*.
[36] E. Tsitskari and others, 'Employers' Expectations of the Employability Skills Needed in the Sport and Recreation Environment', *Journal of Hospitality, Leisure, Sport and Tourism Education*, 20 (2017), 1–9 <https://doi.org/10.1016/J.JHLSTE.2016.11.002>.
[37] Jabulani Sikhakhani, 'The Fourth Industrial Revolution and Sport: Why We Need to Be Vigilant', *The Conversation*, 2019 <https://theconversation.com/the-fourth-industrial-revolution-and-sport-why-we-need-to-be-vigilant-110380>.
[38] StatSA, *Quarterly Labour Force Survey Quarter 2: 2020 Results*, 2020.

five most needed skills identified were customer service skills, leadership skills, communication skills, generic management skills and financial management skills[39].

The applications of the 4th Industrial Revolution will lead to new threats and opportunities, especially in transportation, marketing, tourist expectation and service types. Big data analysis, cloud system, internet of objects and simulation can cause changes in service delivery and marketing in the tourism industry, while the digitisation of products, big data and cloud computing will make it easier to understand and meet customer needs more accurately[40].

1.3. Structure of the report

This report is structured into seven chapters:

Chapter 1: **Introduction** gives an overview of the context, rationale and objectives of the research, as well as an introduction to CATHSSETA and the six sub-sectors being researched.

Chapter 2: **Methodology** outlines the methodology used for this research, as well as the limitations of the study.

Chapter 3: **The 4th Industrial Revolution in Context** defines the 4IR, examines the ways in which it has been used within the sub-sectors and considers the implications of the 4IR for these subsectors. This chapter concludes with a summary of the strengths, challenges, opportunities and solutions of the 4IR for the sub-sectors.

Chapter 4: **What's Missing in The Current South African Workforce?** investigates the occupations and skills that are required for the sub-sectors to thrive in the 4IR. The chapter goes on to investigate the opportunities and obstacles that the sub-sectors faces when developing these skills further.

Chapter 5: **Responding to the 4th Industrial Revolution** develops a skills framework that can be used to understand the skills required for the 4IR, along with the existing

[39] B Ngcobo, 'Tourism Sector Skills Audit & Tourism Sector Human Resource Development Strategy: National Department of Tourism Briefing', *Parliamentary Monitoring Group*, 2017 <https://pmg.org.za/committee-meeting/25574/>.
[40] Freddy M. Mgiba and Norman Chiliya, 'Online Reputation, Virtual Experience and Tourists' Revisit Intentions. The Case of Vilakazi Street Tourism Corridor in Soweto.', *South African Journal of Economic and Management Sciences*, 23.1 (2020), NA-NA <https://go.gale.com/ps/i.do?p=AONE&sw=w&issn=10158812&v=2.1&it=r&id=GALE%7CA634900693&sid=googleScholar&linkaccess=fulltext> [accessed 30 September 2021].

capabilities of the workforce. Thereafter, the chapter considers the strategies that the sub-sectors should take to respond to the 4IR, as well as the strategy that CATHSSETA can take to best support them in their skills development.

Chapter 6: **Discussion and Recommendations** concludes the report with a synthesised discussion on the primary insights from the report. The chapter concludes with a series of recommendations that address the research objectives outlined in Section 1.1.2 above.

2. METHODOLOGY

This chapter outlines the methodological approach used to carry out the study on the impact of the 4IR on CATHSSETA's six sub-sectors. Based on the objectives of the study, it was decided that a mixed-method approach will be utilised.

Literature review

A document review was conducted on all documents provided by CATHSSETA. This was supported using secondary literature from various publications and documents on the 4IR, which were available. The literature review was used as the basis for the development of the primary data collection tools and, further, was used to support and validate the findings from the primary data collected.

2.2. Key Stakeholder Interviews

Based on the desktop and literature review conducted, key stakeholders, who had vast knowledge and experience of the 4IR in their respective sub-sectors, were identified to comprise a database of potential interview respondents.

The main aim of the interviews was to gain a deeper understanding of the 4IR within each of the six sub-sectors that these interviewees represented. The impact of the 4IR on the sub-sectors and the views on how to align CATHSSETA and its stakeholders to innovative strategies to compete in the future were also assessed.

Table 1: Distribution of Key Informant Interviews

Sub-sector	Total
Hospitality Sector	2
Arts, Culture and Heritage Sector	2

Conservation Sector	2
Travel and Tourism	3
Gaming and Lotteries	2
Sports and Recreation Sector	2

2.3. Focus group discussions

Based on the outcomes of the surveys and interviews conducted, gaps within the data collection were identified. The focus group discussions sought to close these gaps in information. A semi-structured focus group discussion guide was developed for each of CATHSSETA's six sub-sectors. From the respondents who participated in the interviews, snowball sampling was done to put together a group of 4-6 individuals who would participate in a virtual focus group discussion. A total of six focus groups took place (one for each sub-sector). As with the interviews, questions for the focus groups were posed at a strategic and policy level.

2.4. Quantitative survey

Employer surveys were conducted across CATHSSETA's six sub-sectors (i.e., training providers, university or TVET representatives, or employers) with operational staff at various businesses listed under each of CATHSSETA's sub-sectors.

The initial target for the surveys was 100 participants. The entire CATHSSETA database was contacted for participation in the surveys. Due to a high response rate, a total of 204 completed and quality controlled surveys were obtained. The distribution of these surveys is represented in the table below.

Table 2: Survey distribution, by sub-sector

Sub-sector	Target achieved
Arts, Culture, and Heritage	20
Conservation	7
Gaming and Lotteries	17
Hospitality	95
Sports, Recreation and Fitness	27
Travel and Tourism	38

Total	204

The table below presents the demographic information of the 204 participants who were surveyed. Demographic information is segmented in terms of age, location, home language, education level, work experience and the sub-sector group of CATHSSETA, under which they fall. Further details on the composition of the survey respondents in terms of home language, age, education levels and work experience are shown in Appendix L.

Table 3: Demographic composition of survey sample

Demographic variable		**Percentages %**
Age	years	7.8%
	years	33.2%
	years	32.7%
	years	18.0%
	60+ years	8.3%
Province	Gauteng	39.0%
	Western Cape	22.0%
	KwaZulu-Natal	12.7%
	Eastern Cape	9.8%
	Mpumalanga	5.4%
	Limpopo	4.4%
	North West	2.9%
	Free State	1.5%
	Northern Cape	1.5%
	Other	1.0%

Most participants were between the ages of 31-40 (33.2%) and 41-40 (32.7%), with only 7,8% of the respondents under 30 years of age. The surveyed respondents represented all 9 provinces, with most participants coming from Gauteng (39.0%) and the Western Cape (22.0%). This distribution is reflective of the demographic composition of the sub-sectors, as these two provinces make up the economic hubs within the country. Furthermore, the high representation of the hospitality sub-sector

is reflective of the sector, as this sub-sector accounts for the largest portion of CATHSSETA's sub-sectors.

2.5. Research limitations

Participants in the focus groups, interviews and surveys were drawn from a convenient sample, therefore generalisability of the result should be inferred with caution. To address this concern, the study used triangulation cross-referencing from different perspectives.

All focus group discussions and key stakeholder interviews were conducted virtually through Microsoft Teams, Zoom and WhatsApp video call. Connectivity was a challenge at times when utilising this form of data collection and some of the target groups were unable to take part in the focus groups. In mitigating this issue, telephonic interviews were proposed as an alternative and additional focus group sessions were conducted to ensure that no-one was excluded based on their lack of access to the internet.

Based on the demographics of the survey respondents, 39% of respondents were from the Gauteng Province, 22% from the Western Cape and the remaining 39% split between the other provinces. These results are not surprising, given that Gauteng and the Western Cape are considered the economic powerhouses of the country and have the highest absorption rates, coupled with the largest working age group of people,[41] but need to be taken into consideration when interpreting the results.

The Hospitality sub-sector accounted for the majority of responses, despite ample efforts being made to try and achieve as equal representation across the sub-sectors as possible. Some of the possible reasons for this included a larger database of contact details of respondents within the Hospitality sub-sector, as well as outdated and unreachable contact details in some of the other sub-sectors. Furthermore, the hospitality sub-sector accounts for the largest proportion of enterprises within CATHSSETA's sub-sectors.

[41] 'These Metros Have the Highest Rates of Employment in South Africa', *Business Tech*, 2017 <https://businesstech.co.za/news/lifestyle/197978/these-metros-have-the-highest-rates-of-employment-in-south-africa/>.

3. THE 4TH INDUSTRIAL REVOLUTION IN CONTEXT

In 1760, the world began to change forever. The beginning of the Industrial Revolution and the transition to new manufacturing processes would last nearly 100 years and end with innovations that include the telephone, the steam engine, the lightbulb and the combustible engine[42]. Now, in 2021, we are amidst another such revolution – the fourth in a series of innovative periods that has led us from lightbulbs to LEDs, from steam engines to solar power. This revolution, however, is different. In this chapter, we define the 4th Industrial Revolution and examine the implications and impact of it within the context of the six sectors under investigation in this report.

3.1. Defining the 4th Industrial Revolution

While many parts of the world have yet to experience the second and third industrial revolutions, the 4IR is emerging while the third, digital revolution spreads and matures across countries[43]. Nicely described as "the blurring of boundaries between the physical, digital and biological worlds"[44], the 4IR is most simply defined as the "advent of cyber-physical systems"[45].

3.1.1. The impact of the 4th Industrial Revolution on the world

Although the impacts of the 4IR are still unfolding, there are many ways in which the revolution can improve the world and work. One of the key innovations from the 4IR is automation, which increases production capacity, reduces costs of production and speeds up production processes[46]. 4IR technology can also improve supply chains, through digitisation, automation and increased tracking and communications[47]. These improvements decrease transport costs and time, allowing for faster delivery.

[42] Davis.
[43] Davis.
[44] McGinnis.
[45] Davis.
[46] PwC, *The Fourth Industrial Revolution : A Recovery Plan for Today's Economic Storm*, 2019.
[47] PwC, *The Fourth Industrial Revolution : A Recovery Plan for Today's Economic Storm*.

Table 4: Top 10 technologies from the 4th Industrial Revolution[48]

Technology	Impact
Artificial Intelligence The ability of machines to learn and act intelligently.	The nature of AI is that it has the ability to complement and augment human capabilities, taking over routine tasks that do not rely on creativity or complex problem solving. While there has been much fear that AI will reduce employment across the globe, evidence suggests that this has not been the case. Rather, AI will likely lead to the reorganisation of tasks within an occupation.
Internet of Things Everyday devices and objects that are connected to the internet to gather and transmit data.	IoT connected devices have resulted in both the development of new products and services, such as smartwatches, and improved monitoring of behaviour and health. The impact of IoT on future work and employment is not yet clear.
Big Data The analysis of data sets that are too large or complex to be analysed using traditional data-processing techniques.	Big data is changing the nature of virtually every industry, including insurance, law enforcement, recruitment and education. Large data sets require specialist analysts to make sense of them, creating a new set of occupations through the introduction of the technology. As the prevalence of Big Data grows, the need for such analysis will also increase.
Blockchains A digital ledger of transactions that is duplicated and distributed across a network of peer-to-peer computer systems for increased security.	The largest impact that blockchain has had in the world is in payments and capital markets. However, there have also been innovations in identity verification, fraud detection, and third-party verification. Blockchain development has also been identified as one of the top 20 fastest-

[48] Bernard Marr, 'The Top 10 Technology Trends Of The 4th Industrial Revolution', *Forbes*, 2020 <https://www.forbes.com/sites/bernardmarr/2020/05/04/here-are-the-top-10-technology-trends-of-the-4th-industrial-revolution/?sh=5e835bba1fbe> [accessed 30 September 2021].

	growing job skills across the globe, with 23% of large enterprises now working on blockchain apps.
Cloud computing Storing and processing data on other computers in a data centre via a network.	Cloud computing is possibly the most influential of the 4IR technologies, in terms of the spread of its adoption. The technology has allowed companies to reduce investment and spending in IT, while improving the speed, security and reliability of their IT systems. The spread of cloud computing creates several new occupations in technology development, project management and online security.
Robotics Intelligent machines that can understand and respond to their environment to perform tasks autonomously.	Robotics has been applied to several industries, with the focus primarily being on manual tasks. The impact of the technology on labour and skills depends largely on the industry, with the automotive, electronics and plastics and chemical industries seeing the largest impact from this technology.
5G Network The 5th generation of cellular technology, which gives faster and more stable wireless networking, while allowing more devices to be connected.	5G technologies have had an impact on almost every industry, but there remain areas where significant innovation and improvements are still to come. These include smart agriculture, manufacturing automation, improved logistics and real-time digital education.
Genomics An interdisciplinary field of biology that focuses on the manipulation of DNA and genomes, allowing for gene editing.	Genomics has been used in several fields, including environmental studies, epidemiology, health, pharmacology and genetic editing. The technology is not expected to reduce employment but, rather, to improve functioning of existing roles and to create new occupations and roles in the future, including manufacturing of biomedical instruments, biotech researchers and

	servicing of biotech and bioinformation software[49].
Quantum computing An area of computing focused on developing computer technology based on the principles of quantum physics, allowing for increased computing power and speed.	Quantum computing is likely to impact every part of the global economy and has been used in areas like energy distribution, climate change and drug discovery. Requirements for working in this field are high, with advanced degrees in physics, computer science and quantum information being needed. While the technology is unlikely to reduce employment, the primary concern with the technology is a lack of skills for effectively leveraging it to improve economies.

Alongside incredible innovations and opportunities, the 4IR also brings with it several significant concerns. Klaus Schwab, who first coined the term, described this period as one where "the changes are so profound that, from the perspective of human history, there has never been a time of greater promise or potential peril"[50].

Among these perils is the concern that the 4IR will result in an increase in inequality, both between countries and within them[51]. While this revolution operates under "old" rules of ownership and production, the new world context shifts the borders and boundaries of both of these to a global scale. Like the third revolution before it, the 4th Industrial Revolution lends advantage to the educated, the highly skilled and to those who are exceptionally familiar with technology[52]. These same individuals are, of course, those who are already at a socio-economic advantage in the current world system.

[49] Martin Grueber and Simon Tripp, 'The Economic Impact and Functional Applications of Human Genetics and Genomics', ASHG, 2021.
[50] Schwab.
[51] Susan E. Cozzens, 'Inequalities and the Fourth Industrial Revolution', *UNCTAD*, 2019 <https://unctad.org/news/inequalities-and-fourth-industrial-revolution>.
[52] Cozzens.

Additional concerns arise in the form of national and human security within the 4th Industrial Revolution. As the Internet of Things grows and expands, countries and individuals become more open to cyberattacks, internet fraud, data theft and, even, increased radicalisation of individuals[53]. Combined access to the internet, social media, AI, data analytics and more advanced behavioural analytics, the internet becomes a breeding ground for violence and radicalisation, while simultaneously making it easier to organise large-scale attacks on governments and groups across the world[54].

Now, in 2021, it is not possible to speak of the 4th Industrial Revolution without also considering the impacts of COVID-19 on the world and on the revolution itself. All our analysis and research must also account for the ways in which the pandemic has impacted the world. This is even more true when considering the 4IR.

> *"The first wave [of disruption from the virus] is associated with health issues and the second one with economic issues. [We] suggest that this global pandemic is fostering a third wave, which in the long run can be more impactful to our lives than the first two. This third wave consists of accelerating the implementation of the fourth industrial revolution[55]."*

Amidst the health, social and economic impacts of COVID-19, there has also been a fundamental shift in the way in which the 4th Industrial Revolution is being implemented in our world. The move to increased adoption of technology has accelerated even further, as the pandemic has made this shift a matter of survival.

3.1.2. Understanding of the 4th Industrial Revolution among the sub-sectors

During the qualitative interviews and focus group discussions conducted for this research, participants were asked whether they know what the term "the 4th Industrial

[53] Ljubomir Mitrović, 'Challenges, Risks and Threats to Human Security in the 4th Industrial Revolution', *Nauka, Bezbednost, Policija*, 25.1 (2020), 81–97 <https://doi.org/10.5937/nabepo25-26316>.
[54] Mitrović.
[55] Ruy de Castro Sobrosa Neto and others, 'The Fourth Industrial Revolution and the Coronavirus: A New Era Catalyzed by a Virus', *Research in Globalization*, 2 (2020), 100024 <https://doi.org/10.1016/j.resglo.2020.100024>.

Revolution" means. While none of the respondents stated that they fully understood the term, 91% reported having some idea. Table 5 summarises this understanding across sub-sectors, showing that the Sports, Recreation and Fitness sub-sector is least confident in their understanding of the term.

Table 5: Sub-sector understanding of 4IR

Sub-sector	No idea	Have some idea
Arts, Culture and Heritage	0%	100%
Conservation	12%	88%
Gaming and Lotteries	6%	94%
Hospitality	8%	91%
Sports, Recreation and Fitness	15%	85%
Travel and Tourism	11%	89%

Despite the confidence shown by participants in their answers to this direct question, the qualitative research showed that a lack of understanding of what the 4IR is and what technologies it encompasses was a consistent finding across all sub-sectors. When asked to detail their understanding of the 4IR, most participants listed technologies with which they were familiar. The results of this are shown in Table 6:

Table 6: Familiar technologies, by sector

Technology	Arts, Culture and Heritage	Conservation	Gaming and Lotteries	Hospitality	Sports, Recreation and Fitness	Travel and Tourism
Artificial Intelligence						
Internet of Things						
Big Data						
Blockchains						
Cloud computing						
Robotics						
5G Network						
Genomics						

Technology	Arts, Culture and Heritage	Conservation	Gaming and Lotteries	Hospitality	Sports, Recreation and Fitness	Travel and Tourism
Quantum computing						
VR and AR						

The table shows, by sub-sector (in green), technologies that were mentioned at least twice in these interviews. This analysis shows that the Gaming and Lotteries sub-sector is most familiar with 4IR technologies, followed by the Conservation sub-sector. Importantly, most of those interviewed struggled to identify ways in which these technologies could be implemented within their sector and industries, except for Gaming and Lotteries.

3.2. The 4th Industrial Revolution in practice

There are four main elements of business in which the 4IR is likely to have an impact. These are: customer expectations, product enhancements, collaborative innovations and organisational forms[56].

In terms of customer expectations, the 4IR has brought with it a more demanding customer, who is looking for better experiences and more innovation from the businesses that they support[57]. In terms of product enhancements, the 4IR brings with it the technologies that allow for new, innovative products that become more and more integrated into daily life.

The 4IR, combined with COVID-19, has seen incredible acceleration in collaborative innovations, with remote work, cloud computing, 5G and video conferencing tools changing the way that the world is able to work. Finally, organisational forms are changing away from optimised resources and, rather, building organisations that are driven by learning and innovation[58]. Table 7 summarises some ways in which 4IR

[56] Schwab.
[57] Simon Mulcahy, *State of the Connected World*, 2020 <http://www3.weforum.org/docs/WEF_The_State_of_the_Connected_World_2020.pdf>.
[58] 'Industry 4.0 Impact on Organisations, Leadership and Management', *Cranefield College*, 2018 <https://www.businessessentials.co.za/2018/06/07/industry-4-0-impact-on-organisations-leadership-and-management/>.

technologies have been implemented, both globally and within South Africa. The local data was collected through the qualitative interviews conducted for this research.

Table 7: The application of 4IR technologies, by sub-sector

Sub-sector	Application of 4IR technologies	
	Local	Global
Arts, Culture and Heritage	AR, VR and computer-aided design were used to assist in the documenting of historical buildings to assist with their restoration.	The use of science, technology, and artwork to bring together the 4IR Bio Lab.
Conservation	The use of infrared cameras, advanced filming technologies and communications technologies are being used to assist with anti-poaching efforts.	VR and AR game used to increase awareness and knowledge surrounding environmental conservation.
Gaming and Lotteries	Advanced data analytics, big data, machine learning and AI are being used to improve operations and the provision of online gambling.	VR gambling games used to attract the public and bring about the opportunity of future growth. AI-assisted targeted messaging used for smarter ad and offer serving to current lottery players.
Hospitality	AI is used in chatbots to assist with managing bookings and back-end systems. VR technologies have been used to assist with events organisation to reduce travel requirements and improve the organisation process.	Robots used to free up the time of human staff *and* help personalise the guest's stay. AR menu and ordering system that provides a vivid image of the dish, enlighten the customers about their order, ingredients, food allergens, grades of spiciness and price.
Sports, Recreation and Fitness	VR and AR technologies are being incorporated into the sub-sector to improve athlete	AI chatbot which operates on social media platforms for the

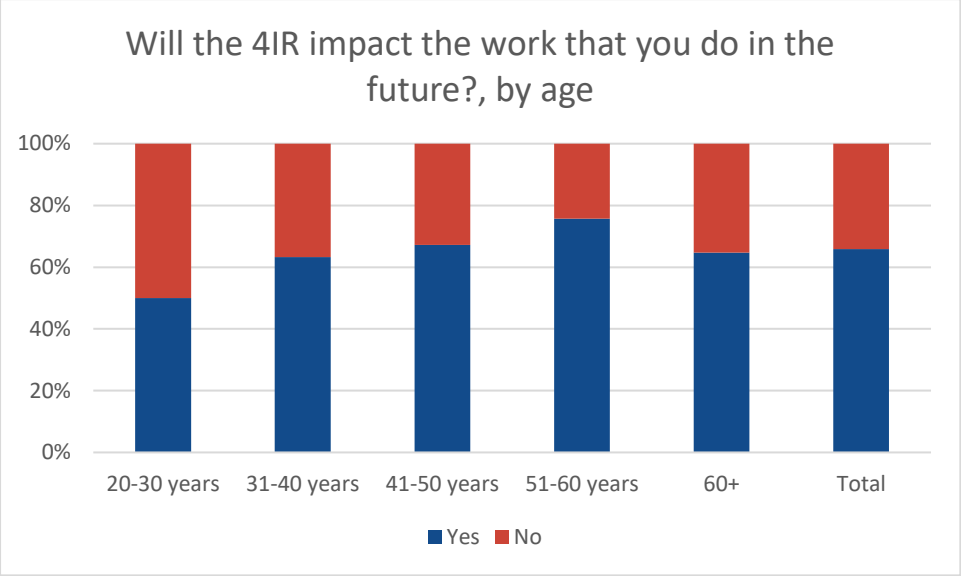
	training. Big data is being used to improve decision-making within the sector.	purpose of answering fan enquiries. AI powered wearable devices for combat sports are capable of tracking and analysing microscopic variations in boxing movements to maximise the efficiency of workouts and training. Blockchain used by sports teams to expand their advertising budgets with new and upcoming crypto-currency exchange platforms, in order to gain further brand recognition.
Travel and Tourism	AI technology is being used for powering chatbots and backend systems to improve client experience and to assist rural providers with bookings and marketing.	Blockchain used to track travelling luggage baggage and put customers in touch with hosts, so that they can book and pay for stays. Virtual Reality (VR) technology for virtual hotel tours, virtual travel experiences, Virtual Booking Interface in the form of 3 D-video.

Figure 1 shows the perceptions that survey participants had about the impact of 4IR technologies on the future work of their organisations, decomposed by age. While a little over 60% of participants believed that these technologies would have an impact on their work, the results showed that older individuals were more likely than younger individuals to believe that these technologies would impact their work[59]. This is in line with the research conducted by the OECD[60], which showed that age did not correlate

[59] Differences statistically significant at the 10% level.
[60] Ljubica Nedelkoska and Glenda Quintini, *Automation, Skills Use and Training*, Social, Employment and Migration Working Papers, 2018 <https://doi.org/10.1787/2e2f4eea-en>.

with a higher risk of automation, and that older individuals tended to be more aware of the changes that these technologies would bring to their work life.

Figure 1: Impact of 4IR on future work, by age



There were no statistically significant differences in the belief about the impact of 4IR technologies between sectors, although Gaming and Lotteries was most likely to believe that there would be an impact (82%), followed by Arts, Culture and Heritage (80%). The Conservation sub-sector was least likely to believe that 4IR technologies would have an impact on their work, with 100% of respondents stating that they did not believe it would have an impact on the work that their organisation does.

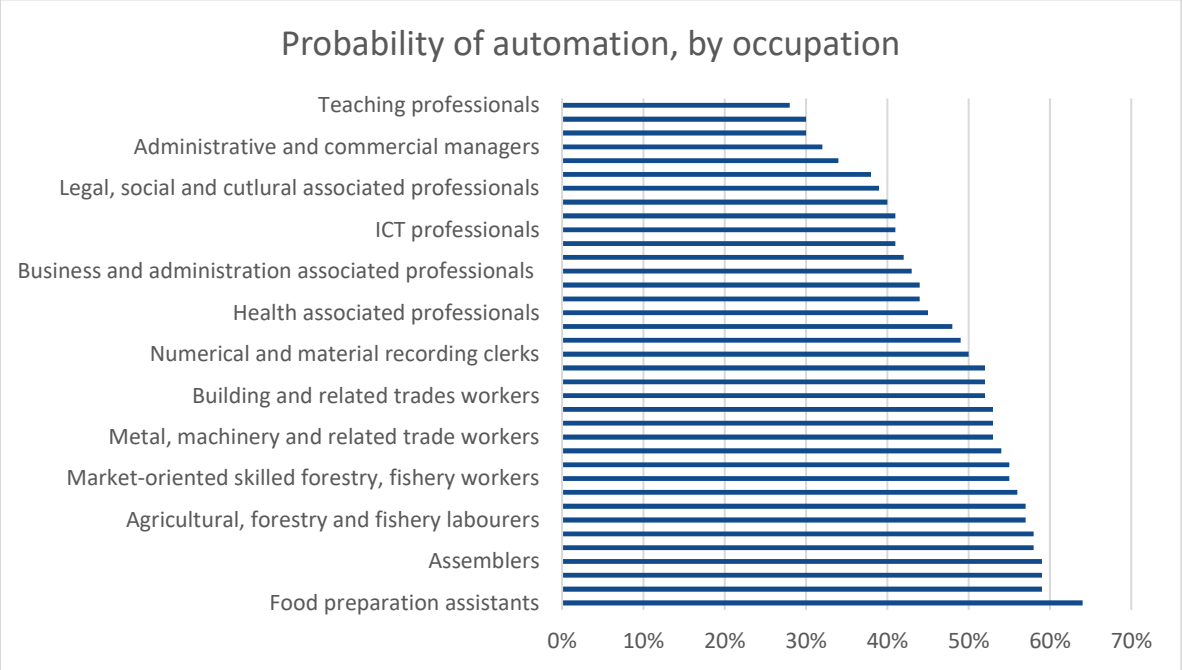
3.3. Implications of the 4th Industrial Revolution

The world of work remains one of the components of our lives that will be most heavily impacted by the 4IR, especially with regards to skills development. Due to technological advances, the labour markets are most likely to be affected. This is since technological advances and automation will ultimately substitute the human element across a wide range of functions within a company. With this automation comes the displacement of jobs, resulting in talent, more than capital, representing the critical factor of production. This, in turn, is likely to give rise to the job market segregating

into low-skill/low-pay and high-skill/high-pay job segments and this may result in increased social tension[61].

In 2018, the OECD[62] conducted a study to investigate the impact of 4IR technologies on jobs. Figure 2 shows the results of this study, presenting the risk of automation for different occupations.

Figure 2: Probability of automation, by occupation



The study further considered the characteristics of jobs that were at a higher risk of automation. The primary finding from this analysis was that the risk of automation is primarily driven by job type and industry, rather than socio-demographic characteristics. There were three exceptions: higher education and income levels were negatively correlated with the risk of being automated, and women were more likely to have jobs that are automated than men are[63].

The implications from this research are that low-skilled jobs are the most likely to be automated and that technical skills are becoming increasingly important in this new world. While age and work experience were not significantly correlated with the risk of

[61] Schwab.
[62] Nedelkoska and Quintini.
[63] Nedelkoska and Quintini.

automation, the additional risk posed to women suggests that this should be a targeted group when considering skills development.

Of course, jobs and skills are not the only requirements for succeeding in the 4IR. Ndung'u and Signe[64] examine the requirements for Africa to succeed in this new world and identify technology access, technology use and technological preparedness as the foundational requirements for success.

Table 8: South Africa's preparedness for the 4th Industrial Revolution

Component	2018	2019	2020
Technology access			
Broadband coverage[65]	19,1%	22,4%	24%
Technology usage (score from 0 to 10, with 10 being the highest)			
Big data and analytics	4.66	5.52	4.76
Digital transformation in companies	5.61	5.19	4.76
Technology preparedness (rank out of 63 countries)			
Technological knowledge	52	54	60
Technological infrastructure	52	51	55
Future readiness	43	44	57

This table suggests that South Africa has many significant challenges to overcome in preparing for the 4IR, especially given that our rankings in terms of technological preparedness have decreased over the past three years. Technical knowledge – which is comprised of talent; education and skills; and research and development – remains the weakest area for the country, giving a clear starting point from which to begin with improvements.

[64] Njuguna Ndung'u and Landry Signe, 'Capturing the Fourth Industrial Revolution: A Regional and National Agenda', *Foresight Africa*, 2019, 60–73 <https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017/methodology.aspx>.
[65] Measured as active mobile 4G and 5G subscriptions as a percentage of the total mobile market

3.3.1. Sub-sector implications

Based on the above, along with additional research, Table 9 summarises the occupations that are most likely to be automated in each sub-sector. Industries, whose employees are predominantly low-skilled workers, are the most likely to suffer from the 4IR, unless these workers are trained in the new skills and technologies that will help them in the 4IR.

Table 9: Occupations that are likely to be automated, by sub-sector

Sub-sector	Occupations that are likely to be automated
Arts, Culture and Heritage	• Labourers in manufacturing, e.g., textile manufacturing • Assemblers • Trade workers • Handicraft and printing workers
Conservation	• Drivers • Agricultural, forestry and fishery labourers • Skilled agricultural, forestry and fishery labourers
Gaming and Lotteries	• ICT professionals
Hospitality	• Food preparation assistants • Serving staff • Drivers • Cleaners and helpers • Sales workers • Safety inspector
Sports, Recreation and Fitness	• Sports coach • Sports referee • Personal service workers
Travel and Tourism	• Travel agent • Safety inspector • Driver • Cleaners and helpers • Sales workers

Based on the occupations listed in Table 9, the Conservation and Hospitality sub-sectors are the most likely to be negatively impacted in terms of employment. While there are several occupations in the Arts, Culture and Heritage sub-sector that are likely to be automated, the creative element of this work, along with the large portion of workers who are self-employed, reduce the impact of automation on the sub-sector overall.

Table 10 summarises the strengths, challenges and opportunities that were identified for each sub-sector through the qualitative research. The summary indicates that the Arts, Culture and Heritage sub-sector, as well as the Sports, Recreation and Fitness sub-sectors are the weakest in terms of their readiness to adopt 4IR technologies. Table 6 indicates that these sub-sectors were also two of the least familiar with 4IR technologies.

Table 10: Strengths, Challenges and Opportunities, by sub-sector

Sub-sector	Strengths	Challenges	Opportunities
Arts, Culture and Heritage		Lack of skills and knowledge to be able to identify places where 4IR technologies can be applied.	Use of 4IR technologies for prototyping of new equipment, ideas etc.
Conservation	Technology allows for faster access to information, allowing for faster response times.	Knowing what is available and what the challenges are to be able to find the right innovations to apply to it.	Biological innovations and 3D printing uses for restoration and recreation.
Gaming and Lotteries	Digital payments and data analytics have been heavily embraced by the sector.	Regulation and legalisation remain challenges, although these have been improved.	
Hospitality	The use of 4IR to increase	Reduced workforce; COVID-19.	Using VR to create new types of

Sub-sector	Strengths	Challenges	Opportunities
	automation, making processes and payments more seamless.		experiences in the phase of COVID-19.
Sports, Recreation and Fitness		Access to WiFi and the costs associated with data and technology.	Use of VR tools to train sportspeople and improve sporting abilities.
Travel and Tourism	Mobile money and similar innovations reduce the risks for tourists.	Managing personal data and balancing the use thereof with privacy.	VR could be used to bolster tourism in the context of COVID-19.

One of the most consistent findings across the qualitative research was the observation that all sub-sectors struggled to identify potential areas for using 4IR technologies in their work. From Table 7, it is apparent that there are multiple applications of most of these technologies in each sub-sector. This lack of knowledge on the potential application of these technologies, then, is the result of unfamiliarity, rather than the simple inability to apply these technologies to their work.

Table 11: Impact of 4IR technologies

Technology	Positive impact	Negative impact	Not in use
Artificial Intelligence (AI)	35.2%	6.0%	58.8%
Internet of Things (IoT)	61.7%	3.5%	34.8%
Blockchain	15.5%	3.1%	81.4%
Cloud Computing	62.1%	2.0%	35.9%
Robotics	13.2%	6.6%	80.2%
Virtual Reality (VR)	40.3%	2.5%	57.2%
Augmented Reality	21.3%	4.6%	74.1%
3D Printing	24.7%	1.5%	73.7%
Nanotechnology	12.4%	2.1%	85.6%
Big data	37.8%	2.1%	60.1%
Machine learning	29.7%	3.6%	66.7%

Quantum Computing	18.7%	2.6%	78.8%
Cyber Security	56.6%	3.5%	39.9%
Simulation	39.2%	2.5%	58.3%

Table 11 shows the responses from the survey to various 4IR technologies. The overwhelming majority of responses indicated that these technologies are not in use at all. Closer inspection of the data indicated that the driving force behind these responses was familiarity with the technologies: participants stated that technologies were not in use when they were not familiar with them and then either selected a positive or negative impact when they were familiar with them. The Sports, Recreation and Fitness sub-sector reported a negative impact for all technologies with which the sector was familiar, as did the Travel and Tourism sub-sector. The Hospitality and Gaming and Lotteries sub-sectors both reported variable answers for the technologies that they were familiar with[66].

4. WHAT'S MISSING IN THE CURRENT SOUTH AFRICAN WORKFORCE?

4.1. Skills required to thrive in the 4th Industrial Revolution

Given the fact that the 4IR is changing how we work, live and socialise, it is expected that a number of skills are mandatory to thrive in this new technological era, deliver high expectations and use technology to serve employees and their companies. A comparison was made by the World Economic Forum[67], where they compared the top 10 skills needed by a workforce in 2015 and the top 10 skills that will be needed by the workforce in 2020 for them to thrive in the 4IR.

Table 12: Skills required to thrive in the 4th Industrial Revolution, 2016[68]

	Top 10 skills needed in 2015	**Top 10 skills needed in 2020**
1	Complex problem solving	Complex problem solving

[66] These differences are statistically significant at the 10% level
[67] World Economic Forum, *The Future of Jobs 2016*, *Global Challenge Insights Report*, 2017 <https://doi.org/10.23943/princeton/9780691172811.003.0009>.
[68] World Economic Forum, *The Future of Jobs 2016*.

	Top 10 skills needed in 2015	Top 10 skills needed in 2020
2	Coordinating with others	Critical thinking
3	People management	Creativity
4	Critical thinking	People management
5	Negotiation	Coordinating with other
6	Quality control	Emotional intelligence
7	Service orientation	Judgement and decision making
8	Judgement and decision making	Service orientation
9	Active listening	Negotiation
10	Creativity	Cognitive flexibility

Table 12 lists these skills in the order of importance that they were given in the 2016 study. The relative importance of critical thinking and creativity increased between 2015 and 2020, and the need for coordinating with others decreased from the 2nd most important skill to the 5th. In 2020, the World Economic Forum repeated the study[69] and identified 15 of the most important skills for the workforce to develop between now and 2025, as identified by employees.

While the prevalence of soft skills in this list is an important observation, it is less helpful when considering the development of training and qualifications that are relevant in the context of the 4IR. To develop a set of concrete skills to consider, the 4IR technologies listed in Table 4 were taken and tangible degrees, qualifications and skills were identified that would enable an individual to work with these technologies. There was significant overlap in skills across technologies, so the skills and qualifications were collapsed into a single list, presented in Table 13 below.

Table 13: Skills and qualifications required for working with 4IR technologies

Skills and qualifications	
Physics	Edge computing
Bayesian networking	Engineering
Biochemistry	Genetics
Biology	Mathematics
Biomedicine	Microbiology

[69] World Economic Forum, *The Future of Jobs Report 2020*, 2020 <https://www.weforum.org/reports/the-future-of-jobs-report-2020/digest>.

Skills and qualifications	
Cognitive science theory	Network splicing
Computer programming	Pharmacology
Computer science	Physics
Cryptography	Radio Frequency principles
Data science	Robotics
Design	Software engineering
Economics	Statistics

It is immediately apparent that the bulk of these skills and qualifications require tertiary education, as well as strong foundations in mathematics, science and technology. The reliance on these foundational skills is a concern for South Africa. The 2019 Trends in International Mathematics and Science Study (TIMSS) showed that South African learners scored second lowest for mathematics and lowest for science for the 14-to-15-year-old age bracket[70]. Only 41% of Grade 9 learners displayed basic competency in mathematics and only 36% showed basic competency in science[71].

While there have been improvements in South Africa's TIMMS scores between 2015 and 2019, analysis showed that these were not statistically significant and that the disparities in outcomes were predominantly explained by socio-economic status[72]. These results are mirrored in the educational attainment of the country, with only 30,7% of the population aged 25 and above having completed secondary school.

4.1.1. Sub-sector skills

In the survey analysis conducted for this research, participants were asked to identify the skills from the WEF[73] *Future of Jobs* report that were relevant to their work. Variability in answers was low, with most jobs being identified as relevant across all sectors. The skills were analysed as the percentage of respondents who stated that the skill is relevant to their work. Table 14 shows the most and least relevant skills in each sub-sector. Because of the low variability in the data, skills that were one

[70] C van der Merwe, 'South African Science and Maths Literacy Remains Poor', *Research Professional News*, 2020 <https://www.researchprofessionalnews.com/rr-news-africa-south-2020-12-south-african-science-and-maths-competency-remains-poor/>.
[71] van der Merwe.
[72] van der Merwe.
[73] World Economic Forum, *The Future of Jobs Report 2020*.

standard deviation or more above the mean score were taken as the most relevant, while skills that were one standard deviation or less below the mean score were taken as the least relevant. Actual relevance was established through the research presented in Section 1.2 of the report.

Table 14: Relevance of skills, by sub-sector

Key:	Actual relevance		Perceived most relevant		Perceived least relevant	
	Arts, Culture & Heritage	Conser-vation	Gaming & Lotteries	Hospitality	Sports, Recreation & Fitness	Travel & Tourism
Persuasion and negotiation						
Systems analysis and evaluation						
Service orientation						
Troubleshooting and user experience						
Emotional intelligence						
Reasoning, problem solving and ideation						
Resilience, stress tolerance and flexibility						
Technology design and programming						
Technology use, monitoring and control						
Leadership and social influence						

Creativity, originality and initiative						
Critical thinking and analysis						
Analytical thinking and innovation						
Complex problem solving						

A few insights stand out from this analysis. First, in all subsectors, except Gambling and Lotteries, technology design and programming are viewed as the least relevant skill. This is, of course, concerning as the design and programming of technology will become increasingly important as the 4IR continues to expand.

Second, there are some important gaps between the perception of skill relevance and the actual relevance of skills. There are several sub-sectors where the least relevant skills, as perceived by survey participants, are also some of the skills that experts identified as being important for the sub-sector. These disparities are troubling for the sub-sectors, as the perceived irrelevance of the skills will likely result in decreased willingness to learn them.

Figure 3: Perceived competence of workforce in 4IR skills

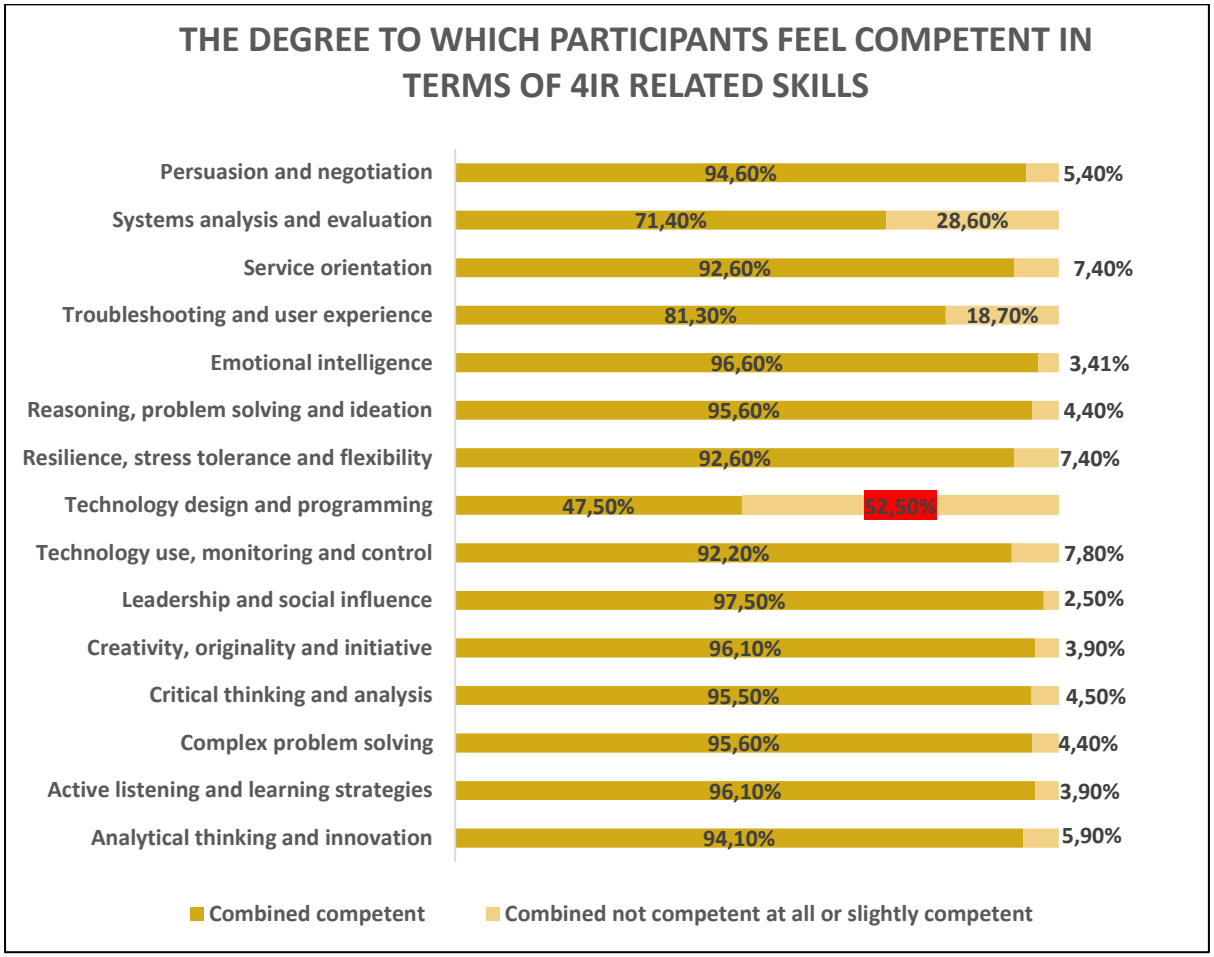


Figure 3 shows the perceived competence of survey participants in the 4IR skills. Once more, the responses had low levels of variability and most respondents stated feeling confident in all skills presented to them. The exception to this is in technology design and programming, in which 52,5% of participants stated that they were not competent or slightly competent. Note the similarities between Figure 3 and Table 14: those skills which are perceived to be least relevant to the work that participants do were also the ones where they were less likely to report a high degree of competence.

There are three factors that one should take into consideration when interpreting these results. First, the sample survey respondents are predominantly highly educated (see Figure 11 in Appendix L). This may very well mean that they are more competent than the average workforce in the country. Second, most of the respondents were CEOs, managers, or directors at their respective enterprises. These positions would likely result in a sample selection bias for individuals who have higher competency in skills such as negotiation and persuasion and leadership and social influence. Third,

respondents may not entirely understand the skills as they are being presented to them. The skills where participants reported the lowest levels of competence are also those that are easily identified as being technical skills that need to be learned. In contrast, “user experience” and “technology usage” seem quite straightforward but are, in fact, highly technical skills that require expert knowledge.

The conclusion, then, is that participants perceived themselves to be competent in these skills, but that perception may not be an accurate reflection of the real competence of the workforce. It is important to note that there were no differences in the findings for both perceived competence and perceived relevance of skills when decomposed by age and by province.

4.2. Obstacles and opportunities for success

When considering the expansion of the 4IR, there are some characteristics that form the foundation for success within a country in adopting the 4IR technologies. These are largely summarised by the variables presented in Table 8, which encapsulates South Africa’s preparedness for the 4IR.

The foundational requirements for success, then, are sufficient education, sufficient infrastructure for technology usage and an agile mindset among the workforces. There are also significant challenges in adopting and integrating 4IR technologies, although these challenges are often worse for developing countries than the developed world. Perhaps most apparent in these challenges is the cost of development and adoption, especially when the infrastructure still needs to be developed.

Inequalities in income and development can deepen with the expansion of the 4IR, as the developing world plays catch up to the developed countries in terms of technology[74]. While there is much discussion – and optimism – about the developing worlds’ ability to “leapfrog” technologies, there is little evidence that this optimism is well-founded.

The term “leapfrogging” refers to the ability of less developed countries to adopt technologies developed in more advanced countries, without having to spend the time

[74] Olha Kuzmenko and Victoria Roienko, ‘Nowcasting Income Inequality in the Context of the Fourth Industrial Revolution’, *SocioEconomic Challenges*, 1.1 (2017), 5–12 <https://doi.org/10.21272/sec.2017.1-01>.

or resources to develop these technologies themselves[75]. Although a good idea in theory, experience has shown us that leapfrogging rarely works as smoothly as this and developing countries are often left behind, spending all their resources in adopting technologies that will become obsolete within a few years[76].

4.2.1. How ready are our sub-sectors to face the 4th Industrial Revolution?

Table 15, below, summarises the enablers and obstacles to the adoption of 4IR technologies that were mentioned in the qualitative interviews and focus group discussions for this research. A common theme among the sub-sectors is a lack of exposure to 4IR technologies and a lack of awareness of what the technologies are and how they can be implemented. This lack of awareness prevents the sub-sectors from knowing how they can integrate these technologies into their own work and industries.

Table 15: Enablers and Obstacles to 4IR adoption, by sub-sector

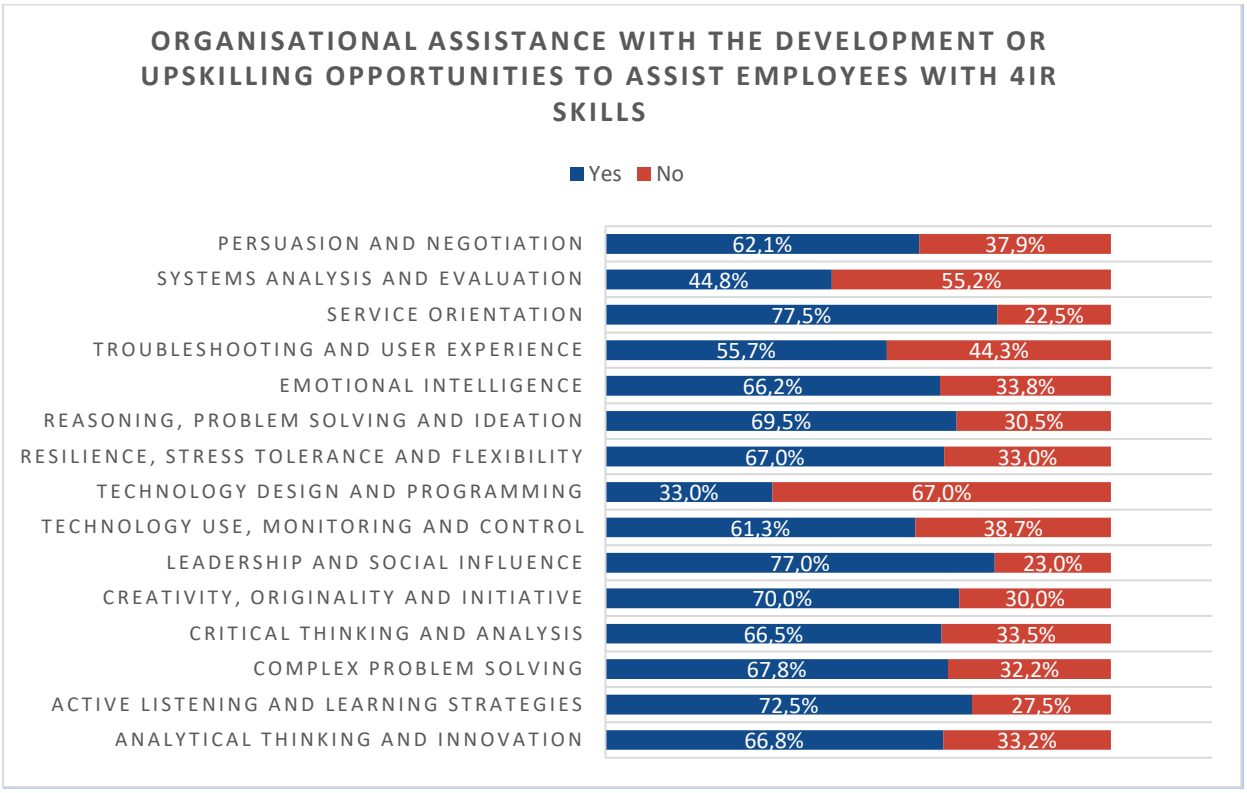
Sub-sector	Enablers	Obstacles
Arts, Culture and Heritage	Exposure to technology to increase the ability to incorporate it into their work.	The cost of technology and data. Lack of innovative and cutting-edge technologies in the country.
Conservation	Collaboration between the public and private sector. Education of children in rural areas, who are likely to work in conservation.	Connectivity and WiFi. Lack of cohesive strategy. Lack of knowledge and skills.
Gaming and Lotteries	Generating an understanding of processes and technologies.	Unclear regulation and legalities surrounding 4IR implementation in the sub-sector.

[75] United Nations Conference on Trade and Development, *Leapfrogging: Look before You Leap*, 2018.
[76] Barney Tan, Evelyn Ng, and Junhui Jiang, 'The Process of Technology Leapfrogging: Case Analysis of the National ICT Infrastructure Development Journey of Azerbaijan', *International Journal of Information Management*, 38.1 (2018), 311–16 <https://doi.org/10.1016/j.ijinfomgt.2017.10.008>.

Sub-sector	Enablers	Obstacles
	Identifying individuals who are able to train others in these skills.	
Hospitality	Clear information on the technologies and predictions of future behaviour and technological trends.	Lack of awareness of 4IR technologies, which prevents the implementation of these. Cost of adopting technologies.
Sports, Recreation and Fitness		Lack of knowledge on the potential applications of 4IR technologies. Lack of skills in implementing and using these technologies. Poor WiFi access.
Travel and Tourism	An innovative culture will enable the adoption of new. Exposure and training on the technologies to enable creativity in how these can be used.	Lack of collaboration between academia and industry. Small businesses being left behind. Lack of cohesive strategy, with clear action plans for implementing 4IR.

Figure 4 shows the results from the quantitative survey where participants were asked whether they received any assistance with skills development with regards to the top 4IR skills. While organisational assistance is common among participants, it is lowest for technology design and programming, and for systems analysis and evaluation – both of which are the skills in which participants noted low competence.

Figure 4: Organisational assistance with the development of 4IR skills among employees



When considering this assistance by sub-sector, the Conservation sub-sector showed the least support among all sub-sectors, followed by Sports, Recreation and Fitness, and Arts, Culture and Heritage[77]. Younger participants were also less likely to receive assistance; and provinces with economic hubs (Kwa-Zulu Natal, Western Cape, and Gauteng) were more likely to receive assistance[78].

Given that the competence of participants in these skills was not significantly different across age and province, these findings suggest that training should focus on rural areas and provinces, as well as young people and those working in Conservation; Sports, Recreation and Fitness; and Arts, Culture and Heritage.

Participants in the qualitative research were asked about their perceptions of the readiness of their organisations and of their employees for the changes that the 4IR will bring. This readiness was framed in terms of the skills, infrastructure and adaptability of their organisation and employees. Table 16 shows the results of this

[77] Differences statistically significant at the 5% level.
[78] Differences statistically significant at the 1% level

analysis. While most participants believed their organisations and employees to be well-prepared, there does appear to be sample selection bias in these results: Human Resources managers and CEOs were most likely to reply that their organisations were prepared, while managers were more likely to report that they were insufficiently prepared[79]. There were no statistically significant differences across sub-sectors, but younger respondents and participants from rural and agricultural provinces were more likely to believe that their organisations were not well enough prepared[80].

Table 16: Perceived readiness for 4IR

Perceived readiness and preparedness for change	Fully prepared or somewhat prepared	Not prepared enough or not prepared at all
Preparedness and readiness of organisations for the changes that the 4IR brings	63,4%	36,6%
Preparedness and readiness of employees for changes that the 4IR brings	73,1%	26,8%

5. RESPONDING TO THE 4TH INDUSTRIAL REVOLUTION

This chapter considers the preparation of the workforce to ensure their ability to adapt successfully to the 4IR and the technologies that it brings. The chapter focuses on qualifications, rather than soft skills and creates a skills framework according to which to assess and prioritise the skills and qualifications needed in the country. Thereafter, it considers the skills delivery methods that should be considered and concludes with the strategic priorities that should be taken by sub-sectors to ensure an agile workforce.

[79] Results statistically significant at the 1% level.
[80] Results statistically significant at the 10% level.

5.1. Preparing the workforce

This section aims to establish the skills that are needed to prepare the South African workforce for the 4IR, with particular focus on the sub-sectors identified.

5.1.1. Skills framework

Table 17, below, presents a skills development framework developed for this project. The framework is comprised of three factors, which are then used to calculate an overall score to assist with prioritising the development of skills. The goal of this framework is to balance the usefulness of the technology, in both breadth (i.e. across sectors) and depth (i.e. across technologies), and the ability of the South African education system to train and develop these skills. Table 18 shows how available human resources was measured.

Table 17: Skills Development framework

Skills and qualifications	Relevant technologies (#)	Relevant sectors (#)	Available human resources in South Africa	Score
List from Table 13	Number of 4IR technologies from Table 4 that the skill is applied to	Number of sub-sectors that the skill is relevant to	The capability of the South African education system to train and teach this skill.	The product of all scores

Table 18: Score for education levels

Tertiary education required	**1**
Well-covered in secondary school	2
Somewhat covered in secondary school	3
Well-covered in primary school	4
Somewhat covered in primary school	5

Table 19 shows the results of the analysis, indicating that computer science, computer programming, design, mathematics and statistics are the qualifications which the country is both best able to provide and which will best meet the needs of the sub-sectors under consideration.

Table 19: Skills Development Prioritization

Skills and qualifications	Relevant technologies (#)	Relevant sectors (#)	Available human resources in South Africa	Score
Bayesian networking	2	4	1	8
Biochemistry	1	2	1	2
Biology	1	2	3	6
Biomedicine	1	2	1	2
Cognitive science theory	3	5	1	15
Computer programming	6	5	1	30
Computer science	5	5	3	75
Cryptography	1	4	0	0
Data science	5	5	1	25
Design	2	5	3	30
Economics	1	5	3	15
Edge computing	2	2	0	0
Engineering	4	5	1	20
Genetics	2	2	1	4
Mathematics	4	5	3	60
Micro-biology	1	1	1	1
Network splicing	1	1	1	1
Pharmacology	1	2	1	2
Physics	3	2	3	18
Radio Frequency principles	1	3	1	3
Robotics	2	3	1	6
Software engineering	4	6	1	24
Statistics	3	5	3	45

As per the above framework (Table 19), the skills that are relevant across all sectors are statistics, mathematics and computer science. Indeed, these skills make up the foundation for almost all other skills needed for the 4IR. There are some differences across sub-sectors, where specialised skills are required. In Conservation and Sports, Recreation and Fitness, for example, there is a higher need for skills relating to genomics, resulting in a higher demand for skills in biology and medicine. In Hospitality and Travel and Tourism, there is a higher demand for skills in robotics, resulting in increased demand for skills like engineering, physics and computer programming. Finally, Gaming and Lotteries and Hospitality and Conservation all have a higher demand for blockchain technologies and require additional skills in physics, edge computing, cryptography and data science.

5.1.2. Skills delivery

When investigating the most appropriate skills delivery methods, survey participants were asked to specify which learning method would be most appropriate to adopt for upskilling their employees. Figures 5 to 7 show the results from this analysis by age group, province and sub-sector respectively.

Figure 5: Preferred learning method, by age group

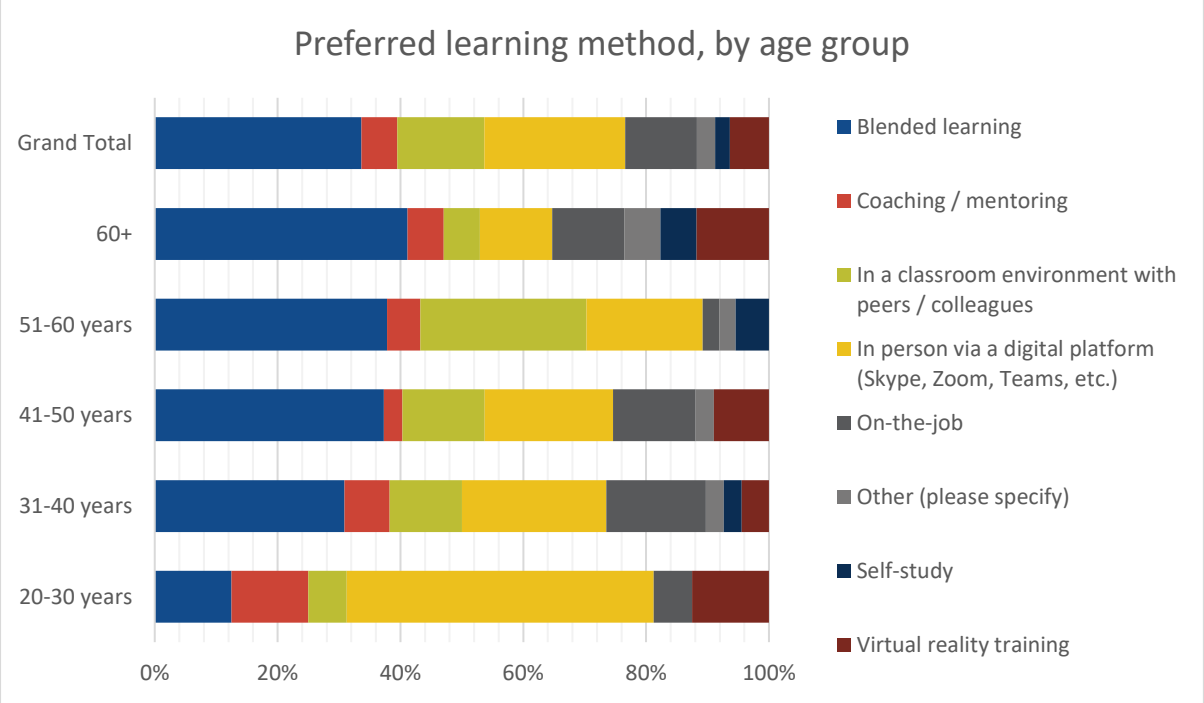


Figure 5 shows that younger participants prefer more modern learning methods, which rely more heavily on technology and internet access. Older participants are more likely

to prefer blended learning and on-the-job training than their younger counterparts, while self-study was the least preferred method across all age groups. This likely reflects the fact that younger generations are more comfortable with technology, while older generations are more likely to want assistance and practical training for learning new skills.

Figure 6: Preferred learning method, by province

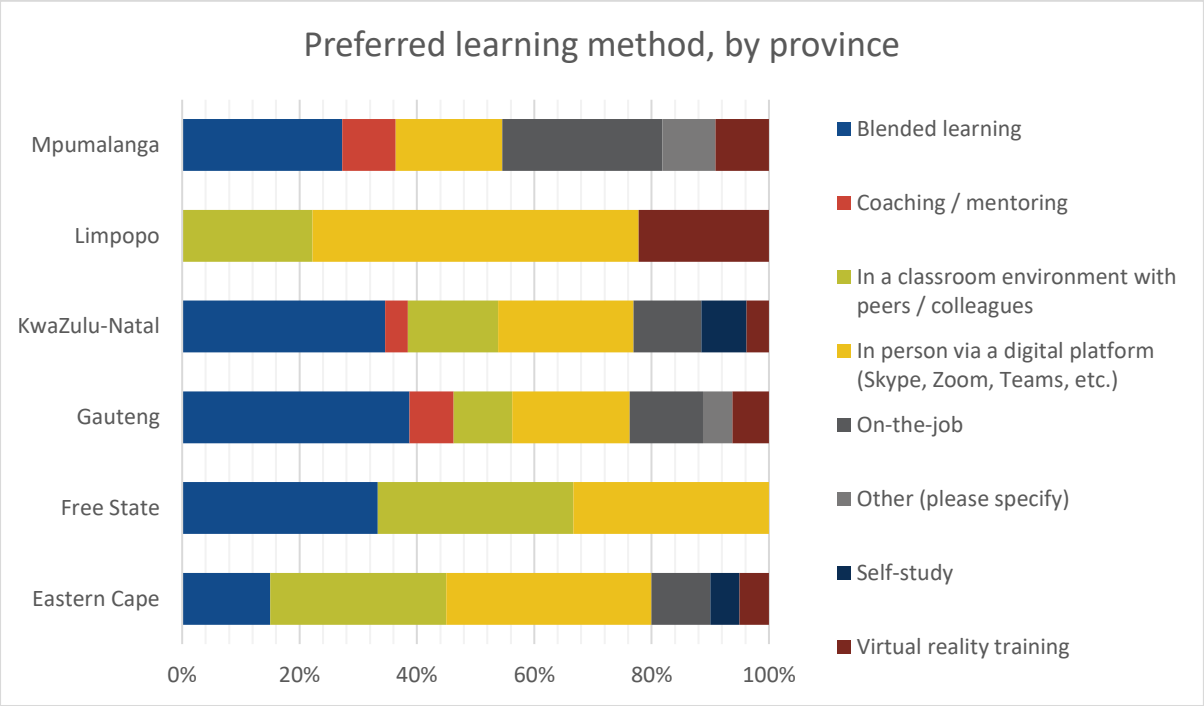
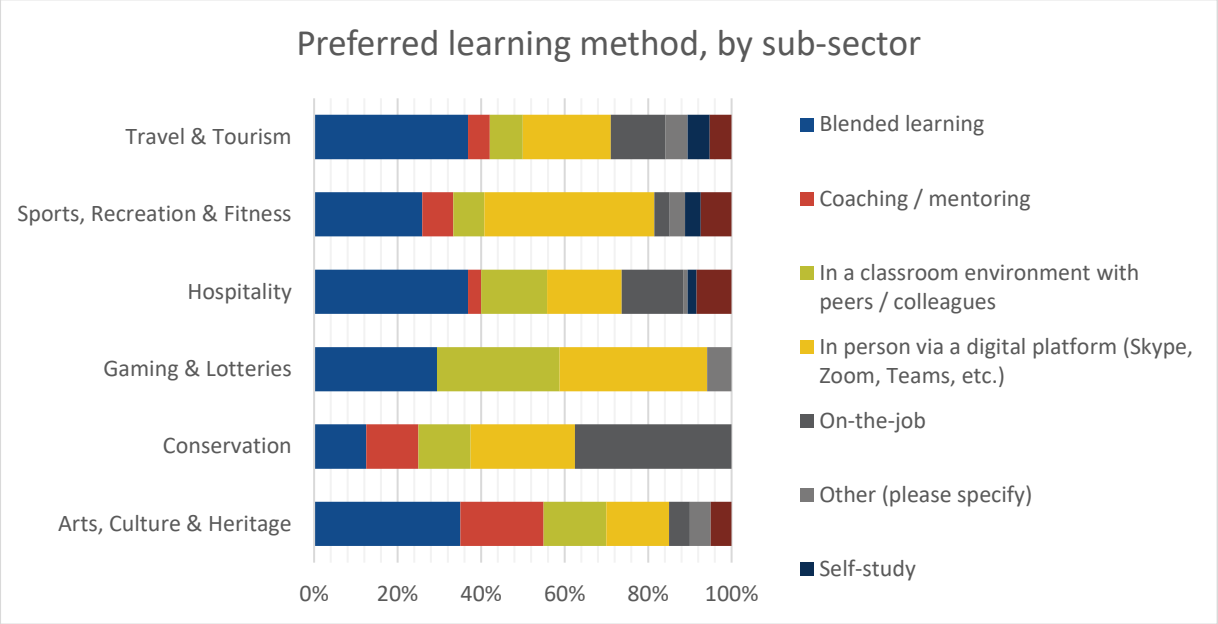


Figure 6 shows the differences in preferred learning method by province. Provinces that rely more on agricultural income and have larger rural areas are more likely to prefer blended learning to digital learning types. The exception here is Limpopo, where the majority of participants preferred in-person learning via digital platforms. This is likely to be reflective of the high transport costs for getting to education facilities in the province. Mpumalanga showed the highest preference for on-the-job training, reflecting he high proportion of jobs in the province that rely on physical skills and manual labour.

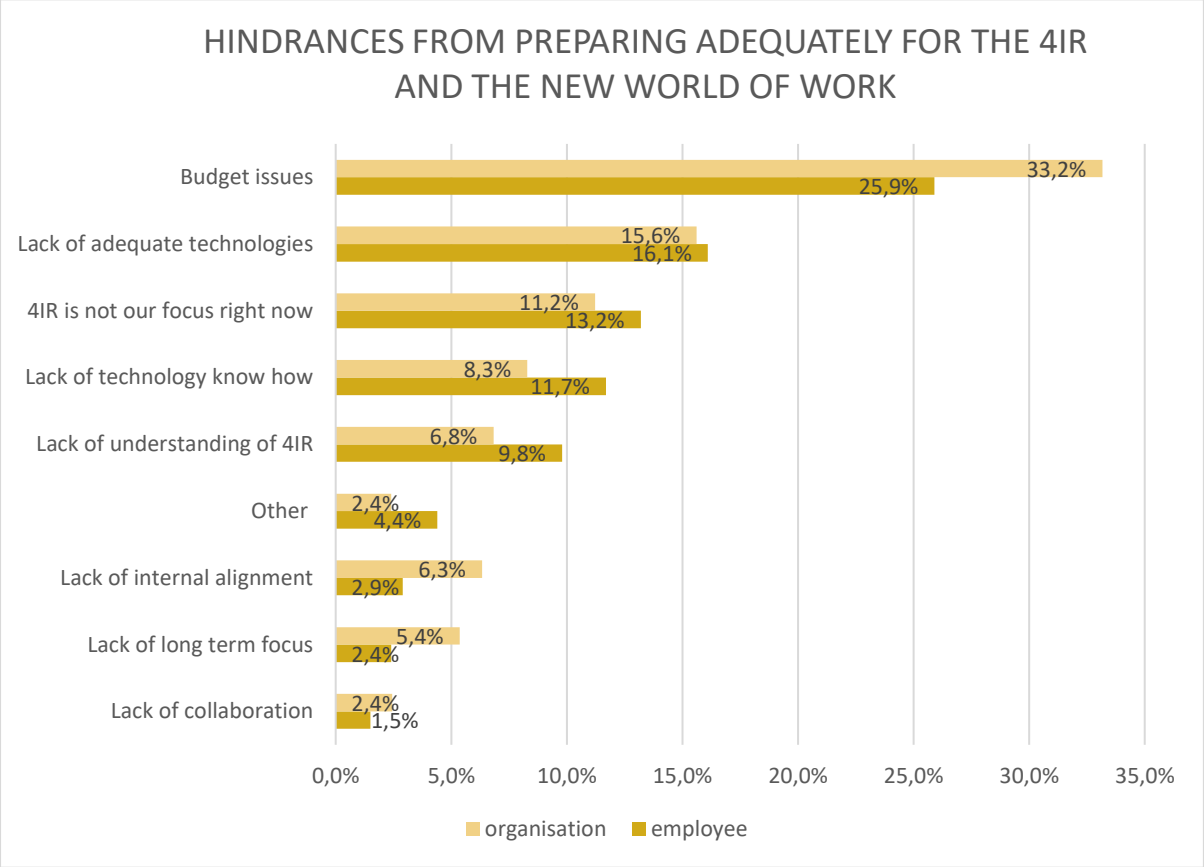
Figure 7: Preferred learning method, by sub-sector



Perhaps most interesting of the differences in skills delivery methods is that between sectors. Figure 7 shows that the Conservation sub-sector has a strong preference for on-the-job training, relative to other sectors, while Gaming and Lotteries has the highest preference for classroom environments, relative to the other sub-sectors. The latter of these results is surprising, given that the Gaming and Lotteries sub-sector has the highest level of technology adoption among the sub-sectors.

Figure 8 shows the obstacles reported by survey participants that prevent them from preparing for the 4IR. Unsurprisingly, the largest obstacle noted was the cost of 4IR technologies or a lack of budget. In line with the earlier findings of this report, a lack of adequate technologies was listed as the second largest obstacle. There were no differences across sub-sectors, ages or provinces in this variable.

Figure 8: Obstacles to preparing for the 4IR



5.2. Strategies for success

CATHSSETA's *Strategic Plan for the fiscal year 2020/21 to 2024/25* (hereafter referred to as the *Strategic Plan*) highlights that the focus of the entity will be on medium-term goals aiming to address the following:

- The 4th Industrial Revolution
- Training provision
- Analysis of skills needed
- Increased partnerships to include worker-initiated interventions
- Sector transformation
- SMME interventions and green economy
- Monitoring and evaluation
- Addressing occupational shortages and skills gaps

The guiding principles for CATHSSETA's strategic plan derive predominantly from the National Development Plan and the National Skills Development Plan, where CATHSSETA's role is to support skills development, build partnerships between employers and education providers, support TVET colleges and establish credible assessment centres within the industry[81].

The strategic priorities for the sector include supporting the development of SMMEs; supporting women, Black Africans and the youth; future skills planning; and re-skilling the South African workforce for emerging skills, given the technological advancements in the present world.

According to CATHSSETA[82], the strategic skills priority and planned action state that the 4IR is a skills priority and that the planned action associated with this is 'Skills identification through Research Agenda'.

Six strategic imperatives should form the basis of CATHSSETA's strategy to meet the future needs of the 4IR. These imperatives form the foundation of a future-ready business strategy and are:

- Develop new leadership capabilities for the 4IR
- Manage the integration of technology in the workforce
- Enhance the employee experience
- Build an agile and personalised learning culture
- Establish metrics for valuing human capital
- Embedding diversity and inclusion

CATHSSETA identifies the need for the development of entrepreneurial, information and communication technology (ICT) and managerial skills. However, further than this, the *Strategic Plan* does not identify specific skills and qualifications that require

[81] CATHSSETA, *Strategic Plan 2020/21 - 2024/25*, 2020.
[82] CATHSSETA, *Strategic Plan 2020/21 - 2024/25*.

development, noting that these need to be identified through research. It is in this strategic imperative that this report is situated.

In order to align CATHSSETA's strategy to the 4th Industrial Revolution, the strategic priorities for the sub-sectors should first be identified.

Table 20: Strategic priorities, by sub-sector

Sub-sector	Observations from participants on existing strategy	Strategic Priorities
Arts, Culture and Heritage	Participants felt that there were no specific plans in place for adopting 4IR technologies but, rather, that this would be a natural process that eventually unfolds.	Building awareness of the upcoming technological changes and shifting culture to one that values innovation.
Conservation	Participants could not identify a clear strategy or focus, because the concept of the 4IR is complicated.	Contextualise the 4IR within the sub-sector so that they can understand its relevance to their work.
Gaming and Lotteries	No clear strategic plan has been identified but the sector has been implementing many 4IR technologies, especially with regards to payments and data analytics.	Focus on developing a comprehensive strategy that moves away from ad-hoc implementation and gives the sub-sector a roadmap for implementation.
Hospitality	Participants noted that the 4IR is being spoken about frequently in the sub-	Identifying new technologies for adoption within the sub-sector and focus on

	sector but that these conversations are broad and high-level.	developing these technologies locally.
Sports, Recreation and Fitness	No specific strategies have been identified, with the sector still trying to understand what the 4IR is and how it influences their work.	Focus on understanding and awareness so that they can identify the ways in which the 4IR can be implemented within the sub-sector.
Travel and Tourism	While there appear to be plans in place from government, the sub-sector itself does not have clear plans for adopting 4IR technologies.	Focus on identifying the potential technologies for the sector and ensure that conversations include practical components on the implementation of these technologies.

Given the above, it is clear that CATHSSETA's strategic plan should begin with building awareness of 4IR technologies and investigate the ways in which these can be implemented within the different sub-sectors. Each sub-sector should have a tailored strategic plan and efforts should be made to bring the sub-sectors to the same level of understanding of the 4IR, as there are currently large gaps in knowledge and understanding between the sub-sectors.

Having brought the sub-sectors to a general level of understanding of the 4IR and its technologies, CATHSSETA can turn its attention towards training existing staff in the technologies that are already being implemented and ensuring that these are being used in ways that maximise their effectiveness. In conjunction with this, CATHSSETA can identify the emerging technologies and the skills required to harness them within each sector and work with education institutions and employers to ensure that these skills are developed in the upcoming workforce.

5.3. Learning from others

This sub-section reviews some examples of the successful implementation of skills development programmes in other countries. It pays particular attention to the role of government and government policies to this implementation and aims to draw learnings on the development of a strategy for South Africa in preparing the workforce for the 4IR.

5.3.1. Private sector examples

In 2013, AT&T identified skills gaps withing their existing workforce which centred around cloud computing and data science. Their strategy for resolving this skills gap was to prioritise reskilling the existing workforce through changes in organisational structure and in performance incentives. Partnerships with Udacity and Georgia Tech University gave their employees the means to upskill themselves, while a mandatory 10 hours per week for training gave them the time and space to do so. The incentive for upskilling for employees was a shift in the company organisation, where hierarchy and pay-structures were changed to reflect the market value of the skills employees had gained, rather than their position in the company. The results of the programme have been astronomical, with 140 000 employees actively engaged in education for newly created roles in 2016. The company also reduced its product-development cycle by 40% and increased its time to revenue by 32% within the first three years of the programme. AT&T attributes this success to the changes in their organisational structure, rather than the monetary incentives. They argue that providing the opportunity for education and accurately acknowledging the value that skills bring to the organisation are the key drivers of their success.

Learning for South Africa: Incentivise education for existing workers through collaborations with education institutions and private companies to create the opportunity for upskilling.

Learning for South Africa: Create an awareness and appreciation for the value that skills bring to the country, economy and organisations to incentivise new workers and young people to focus their education on more difficult skills.

Saudi Aramco has placed learning and development as its key value proposition for employees. Over a third of their new hires are recruited directly out of high school, with the company actively developing their skills through formal learning opportunities after

recruitment. The most successful component of their education programme has been how they have approached unskilled workers. Instead of focusing their efforts on higher-skilled workers, the enterprise identifies illiterate individuals in the communities where they begin new projects and work with local NPOs to develop 6-month literacy courses for those in the community. 60% of these individuals went on to work in highly skilled occupations within 5 years of completing the literacy programme.

Learning for South Africa collaborates with local organisations who know the communities that are being targeted.

Learning for South Africa focuses on ensuring that those who lack the foundational knowledge are upskilled first, so that the workforce is on even footing to further improve their knowledge.

5.3.2. Public sector examples

The **Brazilian Fund for the Protection of Workers** allocates resources towards unemployment benefits and vocational training. The fund is overseen by a tripartite council, made up of representatives from the public sector, education and the private sector. The Fund builds out training programmes in a variety of sectors and establishes temporary "schools" throughout the country to leverage existing infrastructure when presenting training, while enabling a far reach across the country. These schools operate for several months in one location before moving to begin operation in another location. Impact analysis shows that 32% of participants find work in the field of the training within 12 months of completing it.

Learnings for South Africa ensure that there are representatives from industry and education, as well as government, when designing and implementing education programmes.

Learnings for South Africa consider innovative ways to solve the constraints of infrastructure within the country-context. In South Africa, as in Brazil, rolling out education and training through digital classes would exclude large portions of the population. Making use of existing structures to present short-term courses can reduce costs and increase reach, while maintaining the quality of the education.

UNESCO Global Network of Learning Cities is an initiative that takes a proactive approach to ensuring inclusive education. This approach has resulted in the creation

of Citizen Universities in several countries, including Japan, Brazil, Greece, Indonesia and Tunisia. These are institutions that are community-based and leverage peer learning on a voluntary basis to offer courses to community members. Overseen by the Global Network of Learning Cities, the qualifications supplied by these Citizen Universities are now recognised in 17 countries and have expanded educational access in suburbs and townships of large metropolitan areas.

Learning for South Africa leverage the skills and knowledge of the existing citizenry to develop the skills of others.

6. DISCUSSION AND RECOMMENDATIONS

The study sought to assess the impact of the 4IR on each of CATHSSETA's sub-sectors, using a mixed-methods research approach comprised of 204 employer surveys, 13 expert interviews and 6 expert focus groups, focussed at a strategic level. The discussion and recommendations chapter will be presented in line with the research objectives, as outlined in the ToR.

6.1. Understanding of the 4IR

The world we live in is changing at a pace never seen in history. While there have been three industrial revolutions preceding this, the 4IR is notably unprecedented. The 4IR represents an era of innovation in technology which is enhancing human-machine relationships and opening new opportunities for growth across the global economy (Naude, 2017). Quantitative survey results showed that 90% of surveyed respondents had some idea of what the 4IR as a phenomenon meant.

Respondents' understanding of the 4IR ranged from familiarity with various technologies related to the 4IR (such as AI, AR, VR and robotics), to describing the 4IR as a new way of improving businesses using digital advancements. It was further confirmed through qualitative findings that all participants had some understanding of what the 4IR was. Participants were able to describe what they understood the 4IR to be and described the 4IR technologies they were familiar with.

The most common understanding of the 4IR was with regards to technological advancements which could improve business. The most familiar 4IR technologies

across all sub-sectors were reported to be AI, VR and AR, while technologies such as blockchain were less familiar to respondents (both the term as well as the application thereof). While there seems to be a good general understanding of what the 4IR means, a report by KPMG (2020) reported that, even though there is an understanding of the 4IR amongst most organisations, the challenge comes in with regards to their lack of knowledge on how to implement 4IR to benefit them accordingly.

6.2. Employer and employee readiness for the 4IR

In terms of perceived readiness and preparation for change, 63.4% of survey respondents felt that the organisation for which they worked was prepared for the changes that the 4IR may bring, while 73% reported that they felt employees themselves within the business were ready for the change. This shows that the majority of individuals and businesses who participated in this research were willing to embrace the change that the 4IR may bring.

These results differ to those outlined by Deloitte (2018), where it was found that South African executives express doubt regarding their companies' readiness to embrace the changes associated with the 4IR. According to Deloitte (2018), most companies are in the early stages of preparing their organisations for the 4IR. Results from the current research, however, looked at the perceived readiness of the survey respondents (operational personal, i.e., human resource practitioners) and their perceived readiness of the organisation. To account for the difference in results, this may be due to the different level/job role of respondents.

6.3. Sub-sector/s planning for the 4IR

Across all sub-sectors (surveys and interviews), it was found that there was already some implementation of 4IR technologies. The Travel and Tourism sub-sector has seen the greatest implementation of 4IR technologies, particularly with regards to the introduction of automated bots, which are being used to manage their customer experience.

The bigger organisations within the sub-sector are, however, leading the pack, with smaller businesses in many instances being left behind for various reasons (funding, lack of information, etc). South Africa faces a range of technological issues from lack

of stable, fast speed internet connections to unstable sources of electricity in many parts of the country.

These factors all contribute to smaller businesses in the sub-sector being left behind. In the Sports, Recreation and Fitness sub-sector, while AR and VR technologies are currently being implemented slowly, particularly in the E-Sport Arena, there is much work to still be done before 4IR can be implemented successfully.

While there has been some implementation of 4IR technologies, there was consensus across sub-sectors that the plans going forward remain relatively unclear. There is no explicit strategy available to them and the main concern currently is with regards to no clear directive on how the different 4IR technologies apply within their sub-sectors. To plan for the implementation of the 4IR in their sub-sector over the next few years, it is pertinent to have a clear strategy developed at a higher level that provides them with a directive.

6.4. The impact of the 4IR on skills development

Despite the importance of upskilling and empowering employees, 67% of survey respondents indicated that no assistance was received with regards to skills development and training in relation to technology design and programming. Many organisations also receive little to no assistance with systems analysis and evaluation (55.2%); troubleshooting and user experience (44.3%); and technology use, monitoring and control (38.7%). This corresponds to a PWC study that found one-third of the employees who took part in the PWC global survey stated that training and upskilling of employees was their top priority to integrate 4IR into the workplace[83] effectively.

While literature points towards certain occupations being at risk with the advent of the 4IR, this was not the case for participants in this research study. Certain skills and the human element are unlikely to ever become redundant. Across all sub-sectors, there was no innate fear of drastic job losses over the next few years due to technologies.

[83] '4IR Survey: The Pros and Cons of Fourth Industrial Revolution Technology' <https://www.pwc.com.au/digitalpulse/4ir-survey-pros-and-cons.html>.

Participants alluded to the fact that, in certain instances, the human touch cannot be replaced and that technologies brought on by the 4IR are most likely to enhance and improve the work that they do, rather than replacing it. These findings differed from the global survey, conducted by PWC, where the majority of the employees were concerned about the security of their jobs and half of the executives admitted that there would most likely be some job losses[84].

Across all sub-sectors, participants felt that the impact of the 4IR in the years to come will be substantive and that jobs are not necessarily at risk. Rather, companies within each of the sub-sectors need to focus on upskilling their employees to ensure that they stay on par with international organisations. Technology, given its vastness, is something that needs to be understood from a strategic perspective. Not every technology and technological advancement applies to all sub-sectors. While the common technologies, such as AR, AI and VR ,are known and slowly being implemented in all sub-sectors, other less known technologies, such as IoT, Blockchain and robotics amongst others, need to be researched in terms of their applicability to the sub-sector. It is recommended that this research, together with additional inputs from other key role players in each of the sub-sectors, be utilised to develop and inform a strategic plan for each of the sub-sectors. The focus of the strategic plan should not only focus on implementing all of the 4IR technologies within a sub-sector, but rather identify the technologies which will have the biggest impact within the sub-sectors. Those technologies can then be prioritised instead of a “one size fits all” approach.

Within the Travel and Tourism sub-sector, there were no concerns of major job losses due to 4IR. It was reported that there may be opportunities where client interactions with guests may decrease, since the use of AI, VR and bots will inevitably increase. However, the engagements that they have will be enhanced. Scaling a business is not going to happen through individuals but is only going to happen through the adoption of new technologies. Post COVID-19 technology is going to make things a lot easier and the ability to connect to other business markets will be easier. Thus, the

[84] ‘4IR Survey: The Pros and Cons of Fourth Industrial Revolution Technology’.

advantages of the 4IR for the Travel and Tourism sub-sector far outweigh the limitations.

In terms of the Sports, Recreation and Fitness sub-sector, from a business point of view, it is believed that massive changes are likely to take place, although 5 years may be an over-estimation. The pace at which 4IR is being implemented is slower than other sub-sectors, but even though it may take longer, the impact will be immense. There are many platforms which are enabled by the 4IR technologies that can be used to stream sport where the biggest change is going to be seen. There also seems to be an increase in performance, especially since the industry is changing so quickly. As people gain more access to information and are able to have better insight, so are they able to adapt. Technology will continue to be integrated and the analytics itself, and the ability to use data effectively, are going to grow.

In terms of the Conservation sub-sector, the 4IR is likely to bring improved service and products; job creation and having the ability to analyse data; using that data to derive intelligence; and use it to make informed decisions. Education and the ability to work and make decisions at a faster pace appear to be the main changes that will be seen. One of the biggest advantages, according to an interviewee, is information sharing, being able to have data present, analyse it and report on the information to benefit the environment.

There is the potential that the 4IR will bring with it the introduction of more exciting games from a virtual point of view to the Gaming and Lotteries sub-sector. This will attract a younger generation into the sub-sector, particularly through improved services with VR and AI. There also need to be substantial changes with regards to regulations. One of the key focuses pointed to during the interviews was that both the physical casinos and online gambling sites would need to be regulated. The regulations don’t seem to have been kept up to date and in-line with technological advancements.

It has been noted that there are going to be a lot of changes in the Arts, Culture and Heritage sub-sector that will take place and it is important to remember that, if individuals are not willing and able to adapt, they will ultimately get left behind. There

needs to be some type of understanding that change is inevitable and training needs to happen, in order for individuals to adapt to new technologies and 4IR as a whole. In-house training is also important and, in years to come, we need to see more micro-colleges pop up to assist in the training and re-training of individuals.

The Hospitality sub-sector is going to see a profound effect on booking processes and payment gateways, with the introduction of 4IR and this will be for the betterment of the consumer and customer. There will be both advantages and disadvantages to this, however, on the one hand, it will be more convenient and on the other hand, some customers still prefer the human element of the Hospitality industry. Things will be made easier since everything will be digitised. The fear will ultimately be around the use of new and different technologies, until individuals in the sub-sector become more comfortable using technology. However, even though technology is an important element, the human touch is just as important- and the pros and cons, therefore, need to weigh up within this sub-sector with regards to a balance or slow integration of technologies, which evolve as the consumer behaviour also begins changing.

6.5. Strengths, opportunities, challenges, and solutions that the 4IR will bring

As outlined in section 4.3, there are various strengths, opportunities, challenges and solutions that the 4IR will bring with it, as identified by each of the relevant sub-sectors.

The 4IR is more than likely to bring many benefits and opportunities for companies and employees alike. However, with these opportunities and benefits come many obstacles and challenges that need to be overcome to survive and thrive in the new world of work[85].

All sub-sectors had consensus that the 4IR is useful to their sub-sector and that changes and improvements, once fully implemented, would be immense. In terms of strengths, participants referred to a range of ways in which technology would be able to assist them within their sub-sectors. Within the Travel and Tourism sub-sector for

[85] Schwab.

example, 4IR technologies can make access to different places easier in terms of viewing and navigating. Technological advancements help streamline processes and procedures, cutting out redundant "middleman" work. One of the biggest opportunities the 4IR will bring, according to participants, is the increase in learning on-the-job opportunities. Upskilling in different areas of work/skills, due to the advances in technology and more on-the-job training (less formal education), is going to be a great opportunity for employees always to remain relevant. Similarly, literature from previous studies points towards greater efficiencies and better work experience overall, as well as long term gains inefficiency and productivity. It is believed that the 4IR will contribute to things such as the reduction in transport and communication costs, increases in productivity and more efficient logistics and supply chains[86]. Technological advances also bring with it the ability to improve lives of others, through easier access to information and education through devices and networks. While this is a reality for many people around the world, whether it could be a strength or advantage for South Africa would depend on overcoming some of the barriers and challenges such as unstable internet connections.

Challenges that the 4IR will bring, particularly in the South African context, was explored during this research. Respondents believed that South Africa was lagging, since digitisation was occurring much faster than legislation is challenging. Many businesses, across all sub-sectors, are also not sure which technologies are best suited to them and how to apply these to assist them with their requirements, which means that they do not know how to proceed. This was again consistent with the report by KPMG[87], where it was reported that, despite having knowledge or understanding of what the 4IR was, many organisations still struggle to implement this according to their requirements. As a result of not knowing which technologies to implement, many companies don't know which skills are required to thrive fully[88]. Solutions, which could be looked at, include moving from a rigid regulatory framework to one that is more

[86] '4IR Survey: The Pros and Cons of Fourth Industrial Revolution Technology'.
[87] Piers Hogarth-Scott and Shane O'Sullivan, *The 2020 Fourth Industrial Revolution Benchmark*, 2020 <https://assets.kpmg/content/dam/kpmg/au/pdf/2020/fourth-industrial-revolution-benchmark.pdf>.
[88] Martyn Davies Valter Adao Mike Vincent, 'The Fourth Industrial Revolution Is Here - Are South African Executives Ready?', *Deloitte*, 2018, 17 <https://www2.deloitte.com/content/dam/Deloitte/za/Documents/Consumer_Industrial_Products/Industry 40 - SA Findings.pdf - 15 June 2018.pdf>.

agile, as well focussing on the upskilling of individuals before investing in technologies.

6.6. What should we be teaching and how can we re-conceptualise training?

Although there is a risk that some occupations may disappear or change drastically soon, some skills will not become redundant. For training to remain relevant, it needs to adapt to the changing times, whether this is in terms of the content or the delivery method of the training.

The content of training should focus on skills that are relevant to thrive in the 4IR. According to the WEF[89], there are 15 top skills which individuals need to thrive in the 4IR. In evaluating competency of these, over 90% of respondents also believed that they were competent (to some extent) in almost all the main skills needed to thrive under the 4IR, as recognised by the 2020 Future of Jobs survey.

Skills in technology design & programming showed the least competence (52.5%) as reported in the survey results. A further two skills, which reflected 28.6% and 18.7% not being competent in, respectively, were systems analysis and evaluation, as well as troubleshooting and user experience. These skills which indicate survey respondents not having any competence in are skills areas which CATHSSETA can consider as focus areas. It is important to note that, overall, respondents felt technology design and programming was the skill most irrelevant to the jobs that they do (57.84%). This was particularly reflected by respondents in the Conservation sub-sector, where 37.5% of respondents believed that technology design and programme had little to no relevance for the work they do.

The Conservation sub-sector had the lowest response rate overall (3.9%), which could account for the difference in their responses in comparison with other sub-sectors. It may be worth noting that survey respondents were all operational staff, particularly HR personnel. The views reflected in the survey are from their perspective. Other skills which reflected lower relevance included systems analysis in the Conservation sub-

[89] World Economic Forum, *The Future of Jobs Report 2020*.

sector (50%); and technology design and programming (51.6%) in the Hospitality sub-sector.

Given that these skills are in the top 15 skills required to thrive in the 4IR, they are skills which need to be re-evaluated in terms of competence and relevance to CATHSSETA's sub-sectors.

With continual learning and upskilling of employees, organisations will be able to leverage the power of the 4IR technologies and assist them in thriving in the years to come[90]. There was consensus among research participants that technologies which underpin the 4IR are not yet being incorporated into the delivery of skills development interventions. In the Travel and Tourism sub-sector, for example, it was reported that technology is always seen as a supporting capability and, therefore, never gains full attention. Further research on the applicability of certain 4IR technologies in each sub-sector is needed.

Participants alluded to the need of having this information easily accessible to them, so that upskilling employees and training opportunities are clearer and can be made a priority. In terms of delivery methods in the space of learning, participants felt that formal institutions and face-to-face learning is becoming "a thing of the past". Covid-19 saw many institutions move towards digital platforms and online learning and this has given everyone a good head start.

Easy access to information and online platforms, where employees can be upskilling at any time, is crucial. The Sports, Recreation and Fitness and Conservation sub-sectors have reported that skills development programmes were being delivered virtually over the past few months, but this was in response to Covid-19 and not due to the 4IR. Based on experience over the past few months, Sports, Recreation and Fitness reported challenges in adapting the syllabus to meet the needs and requirements, as the current syllabus was not producing adaptable and flexible students - a key skill for embracing the 4IR.

[90] M Jaffe, 'What Does the Future of Work Look Like?', *The 360 Blog*, 2020 <https://www.salesforce.com/blog/make-change-future-of-work/>.

In terms of incorporating technology into skills development interventions, bigger brands in the Hospitality and Travel and Tourism sub-sectors are once again leading the pack. Across sub-sectors, there is a need for a) getting the syllabus 4IR ready and b) getting learning and training platforms up to scratch.

There is also a lack of skilled facilitators who can deliver the training and learning interventions, so this is an area which needs attention. Although few, the Conservation sub-sector was able to identify a module taught by the Wildlife college which addresses the use of technology/4IR in relation to conservation. Combining different learning methods and technology to enhance the learning experience is pertinent.

The South African education system, as a whole, is not geared towards this kind of training and the entire education system, therefore, needs to be re-evaluated and updated to produce open-minded, adaptable, technological-savvy graduates, who then go on to join the workforce. Training methods need to be adapted to match the role of the organisation and the role of the employee within it. Learning materials and training needs to be customised, personalised and adapted to the pace of the employee[91].

Training methods need to be less focused on regurgitation of information and theories and rather geared towards the practical application of skills within their field. According to the Boston City Campus[92] review, future proofing one's career requires developing soft skills, team building exercises, team leader workshops and learning how to mentor graduates.

Over and above these, participants from this research pointed to a range of skills which they believed would be important to be teaching, to "future proof" people's careers. This included: IT skills, flexibility, willingness to go over and above one's role, problem solving skills, critical thinking skills, business skills (with reference made to business writing skills), web design and strategic marketing.

[91] A Harve, 'Reskilling the Workforce for the Fourth Industrial Revolution', *Training Industry*, 2019 <https://trainingindustry.com/articles/workforce-development/reskilling-the-workforce-for-the-fourth-industrial-revolution/>.
[92] 'Preparing for the 4th Industrial Revolution', *Boston City Campus & Business College*, 2019 <https://www.skillsportal.co.za/content/preparing-4th-industrial-revolution>.

In addition to these skills, the Gaming and Lotteries sub-sector wished to see more skilled individuals in cyber law and data protection, while the Hospitality sub-sector made mention of coding, engineering skills, systems design, software design and application design. Some of the skills outlined through this primary research were in line with those reported by the WEF required to thrive during the 4IR (Creativity, critical thinking and problem solving).

Employers need to invest in training and upskilling employees and the education system, as mentioned earlier, would need to be adapted to focus on producing adaptable graduates. Employees need to be upskilled and taken along on the journey of the 4IR. Survey results indicated that blended learning and in-person learning (33.7%) via a digital platform (22.9%) were the most appropriate and applicable methods of upskilling employees in line with the 4IR.

6.7. Recommendations

Recommendation 1: Companies within each sub-sector need to focus on upskilling their existing employees to ensure that they remain on par with international organisations.

Although some companies are adopting new technologies and automation, these cannot be done at the expense of keeping the staff educated and trained on the use of these. The high costs associated with adopting these technologies often mean that the education of staff is not prioritised, due to lack of funding.

CATHSSETA, then, can work with employers to implement training programs on existing and upcoming technologies with their existing staff.

Recommendation 2: The first step in strategic planning for the sub-sectors needs to be based on exposure to the 4IR technologies.

One of the most consistent findings in this research is that those in the sub-sectors cannot identify the technologies that are relevant to their subsectors, due to a lack of awareness of the technologies that exist. Therefore, the focus should be on exposing

sub-sectors to existing technologies and bringing all sub-sectors to the same base level of understanding of the 4IR.

Recommendation 3: Strategic planning needs to be clear and detailed with explicit steps, goals and outcomes identified.

Experts within the sub-sectors were not certain about what 4IR is, nor what the impact of it will be on their work. Strategic planning needs to move from the high-level to the specific, to have a real impact and should ensure that it contextualises the 4IR within the sub-sectors, to show the relevance thereof.

Recommendation 4: Each sub-sector should have a tailored strategic plan to meet its individual needs.

The experiences of the sub-sectors are vastly different, resulting in different needs and strategies for effectively bringing the 4IR into the sectors. In order to accomplish this, sub-sectors first need to be brought to an equal level of understanding on the 4IR, so that they can be involved in the development of a strategy that is relevant and applicable to their contexts.

Recommendation 5: Training methods should focus on blended learning and should still include a Skills Development Facilitator to ensure cohesive and complimentary education and training.

Respondents are positive about their ability to learn and develop within the context of the 4IR, but feel that more support needs to be given. Learning needs to be adapted for the new times, but there should remain the human element, in the form of a facilitator.

Recommendation 6: As an immediate step, training should focus on improving the country's skills in mathematics and statistics and introducing early interventions for teaching computer programming and data analytics.

These are the skills that were either perceived to be the weakest skills in our sample, or the skills most used across the sub-sectors. Data analytics was used by almost all

sub-sectors and it is clear that this skill will soon become a requirement of the workforce, rather than an elite skill.

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8. APPENDIX A: SURVEY

Introduction:

CATHSEETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on behalf of CATHSSETA. The purpose of this survey is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

We would therefore like to ask you some questions which relate to the 4IR. This information will assist CATHSSETA to identify the impact that the 4IR will have across the six sub-sectors.

It must be stressed that all information received will be kept confidential and will only be summarised and reported on in an aggregated manner. The information you provide will not be shared with anyone outside the research team of Mthente. This is following the recognised industry standards, as set by SAMRA (the Southern African Marketing Research Association), of which Mthente is an organisational member.

The survey will take approximately 20 minutes to complete. By completing the survey, you consent to the collection and use of your data. At any stage of the research, you may choose to withdraw your consent without penalty. If you want to do so or if you have any questions, please contact:

[Insert Representative of CATHSSETA]

[Insert Representative of Mthente]

Do you agree to participate in this survey?	○ Yes	○ No
Participant name in print:		
Contact number:		

Stakeholder Information:

Name	
Age	
Province:	
Home language:	
Highest education level:	
Working experience (years):	
Type of business:	
Years in your current role:	
CATHSSETA sub-sector you work in:	
Position:	
Contact number:	
Email address:	

1. 4IR and the skills needed to thrive:

1.1 What is your understanding of the term “The Fourth Industrial Revolution”?

1.2 The following is a list of skills that have been identified as the top 15 skills which are needed to thrive in the 4IR. Please rate the degree to which you feel you are competent in terms of each of these skills?

1 (Not competent) – 5 (Highly competent)

	1 (Not competent)	2 (Slightly competent)	3 (Moderately competent)	4 (Very competent)	5 (Highly competent)
Analytical thinking and innovation					
Active listening and learning strategies					
Complex problem solving					
Critical thinking and analysis					
Creativity, originality, and initiative					
Leadership and social influence					
Technology use, monitoring and control					
Technology design and programming					
Resilience, stress tolerance and flexibility					
Reasoning, problem solving and ideation					
Emotional intelligence					
Troubleshooting and user experience					
Service orientation					
Systems analysis and evaluation					
Persuasion and negotiation					

1.3 Thinking about the organisation that you work in, which of these top 15 skills are relevant to the work that you do, and which are not relevant to the work that you do?

	Yes, this is relevant	No, this is not relevant
Analytical thinking and innovation		
Active listening and learning strategies		
Complex problem solving		
Critical thinking and analysis		
Creativity, originality and initiative		
Leadership and social influence		
Technology use, monitoring and control		
Technology design and programming		
Resilience, stress tolerance and flexibility		
Reasoning, problem solving and ideation		
Emotional intelligence		
Troubleshooting and user experience		
Service orientation		
Systems analysis and evaluation		
Persuasion and negotiation		

2. Development of the Top 15 4IR Skills:

2.1 With regards to the top 15 skills which are needed to thrive in the 4IR, does the organisation where you work offer any development or upskilling opportunities to assist its employees with these skills?

	Yes	No
Analytical thinking and innovation		
Active listening and learning strategies		
Complex problem solving		

Critical thinking and analysis		
Creativity, originality, and initiative		
Leadership and social influence		
Technology use, monitoring and control		
Technology design and programming		
Resilience, stress tolerance and flexibility		
Reasoning, problem solving and ideation		
Emotional intelligence		
Troubleshooting and user experience		
Service orientation		
Systems analysis and evaluation		
Persuasion and negotiation		

3. Readiness and Preparedness for Change:

3.1 How prepared and ready do you think the organisation where you work is for the new world of work, the changes that the 4IR brings with it and the technological advances the organisation will have to adopt?

•	Fully prepared for the new world of work
•	Somewhat prepared
•	Not prepared enough
•	Not prepared at all

3.2 How prepared and ready are you as an employee for the new world of work, the changes that the 4IR brings with it and the technological advances that you will have to adopt?

•	Fully prepared for the new world of work
•	Somewhat prepared
•	Not prepared enough

•	Not prepared at all

Fieldworkers note: Only answer 3.3, if question 3.1. is not “Fully prepared for the new world of work”

3.3 What, if anything, is holding the organisation where you work back from preparing adequately and making the organisation ready for the 4IR and the new world of work? (Please select)

Lack of internal alignment	
Lack of collaboration	
Lack of long-term focus	
Lack of adequate technologies	
Lack of technology know how	
Budget issues	
Lack of understanding of 4IR	
4IR is not our focus right now	
Other (Please Specify)	

Fieldworkers note: Only answer 3.4, if question 3.2. is not “Fully prepared for the new world of work”

3.4 What, if anything, is holding you as an employee back from preparing adequately and making yourself ready for the 4IR and the new world of work? (Please select)

Lack of internal alignment	
Lack of collaboration	
Lack of long-term focus	
Lack of adequate technologies	
Lack of technology know how	
Budget issues	
Lack of understanding of 4IR	
4IR is not our focus right now	
Other (Please Specify)	

4. Teaching Delivery Methods:

4.1 Which teaching delivery method would be the most appropriate and applicable for your organisation to adopt when it comes to up-skilling and further development of employees in the future?

In a classroom environment with peers / colleagues	
In person via a digital platform (Skype, Zoom, Teams, etc.)	
Self-study	
Blended learning	
On-the-job	
Coaching / mentoring	
Virtual reality training	
Other (Please specify)	

4.2 Taking into consideration the technological advances that the 4IR brings with it and thinking about up-skilling and further development in the future, would there be a role for a skills development facilitator in each of these teaching delivery methods? If no, please specify why?

In a classroom environment with peers / colleagues	
In person via a digital platform (Skype, Zoom, Teams, etc.)	
Self-study	
Blended learning	
On-the-job	
Coaching / mentoring	
Virtual reality training	
Other (Please specify)	

5. Obstacles of Workplace Development:

5.1 The below list are potential obstacles that employees may experience when it comes to workplace development opportunities. Do any of these obstacles ring true for limited or lack of workplace development opportunities within the organisation where you work? (Please select)

Lack of management support	
Lack of funding	
Lack of engagement from employees	
Lack of participation	
Dispersed workforce	
Lack of time	
Different learning habits	
Irrelevant opportunities	
Lack of commitment	
Other (Please specify)	

6. Change Management:

6.1 Has the organisation where you work offered any support and/or mechanisms to help prepare its employees for the 4IR?

•	Yes
•	No

If yes, what support and/or mechanisms have been offered to employees?

6.2 What would you like to see from the organisation where you work that will help mitigate and manage the impact of the changes the 4IR is likely to bring?

7. Impact on Work:

7.1 The below list is some of the technologies that are associated with the 4IR. What impact, if any, do these technologies have on the work that the organisation where you work is currently undertaking?

	Positive impact	Negative impact	Not in use
Artificial Intelligence (AI)			
Internet of Things (IoT)			
Blockchain			
Cloud Computing			
Robotics			
Virtual Reality (VR)			
Augmented Reality			
3D Printing			
Nanotechnology			
Big data			
Machine learning			
Quantum Computing			
Cyber Security			
Simulation			

7.2 Will the further developments and advances in 4IR impact or change the work that the organisation where you work is likely to do in the future?

•	Yes

•	No

If yes, please specify what impact or changes are likely to occur?

7.3 Have you, as an employee done anything personally to help mitigate and manage the impact of the changes the 4IR is likely to bring to the organisation where you work?

9. APPENDIX B: INTERVIEW GUIDE (SPORTS, RECREATION AND FITNESS)

Introduction:

CATHSEETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this interview is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

We would therefore like to ask you some questions which relate to the 4IR. This information will assist CATHSSETA to identify the impact that the 4IR will have across the six sub-sectors.

It must be stressed that all information received will be kept confidential and will only be summarised and reported on in an aggregated manner. The information you provide will not be shared with anyone outside the research team of Mthente. This is following the recognised industry standards, as set by SAMRA (the Southern African Marketing Research Association), of which Mthente is an organisational member.

The interview will take approximately 20 minutes to complete. By completing the interview, you consent to the collection and use of your data. At any stage of the research, you may choose to withdraw your consent without penalty. If you want to do so or if you have any questions, please contact:

[Insert Representative of CATHSSETA]

[Insert Representative of Mthente]

Do you agree to participate in this interview?	○ Yes	○ No
Participant name in print:		
Contact number:		

Stakeholder Information:

CATHSSETA sub-sector	Sport, Recreation and Fitness
Organisation name:	
Position within the organisation:	
Email address:	

1. Familiarity of the 4IR:

    a. What does the Fourth Industrial Revolution (4IR) phenomenon mean for the Sport, Recreation and Fitness sub-sector?

Probe:

1.1. What 4IR technologies (e.g., Artificial Intelligence, Blockchain, Internet of Things, Virtual Reality, Augmented Reality, etc.) do you think the Sport, Recreation and Fitness sub-sector are familiar with?

2. Adoption and Implementation of the 4IR Technologies:

2.1 What 4IR technologies are being implemented in the workplace across the Sport, Recreation and Fitness sub-sector?

Probe:

2.1.1. What are the challenges for implementing those technologies in the Sport, Recreation and Fitness sub-sector?

2.1.2. What are the successes or success stories for implementing those technologies in the Sport, Recreation and Fitness sub-sector?

2.2 In your opinion, what factors enable the adoption of new technologies within the Sport, Recreation and Fitness sub-sector?

2.3 What else can the Sport, Recreation and Fitness sub-sector do to remain relevant in the future and thrive in the 4IR?

3. Obstacles of Workplace Development:

a. What obstacles do you foresee when it comes to 4IR up-skilling and development within the Sport, Recreation and Fitness sub-sector?

4. Future and Strategic Focus:

4.1. What plans are in place to adopt 4IR technologies within your sub-sector?

5. Impact on Work:

5.1 In your opinion, what changes to the Sport, Recreation and Fitness sub-sector will the 4IR bring?

5.2 What type of impact are the 4IR technologies likely to have on the Sport, Recreation and Fitness sub-sector in the next 5 years?

6. Skills Development:

6.1 Do you think the technologies that underpin the 4IR are being incorporated into the delivery of skills development interventions within the Sport, Recreation and Fitness sub-sector?

10. APPENDIX C: INTERVIEW GUIDE (ARTS, CULTURE & HERITAGE)

Introduction:

CATHSEETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this interview is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

We would therefore like to ask you some questions which relate to the 4IR. This information will assist CATHSSETA to identify the impact that the 4IR will have across the six sub-sectors.

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The interview will take approximately 20 minutes to complete. By completing the interview, you consent to the collection and use of your data. At any stage of the research, you may choose to withdraw your consent without penalty. If you want to do so or if you have any questions, please contact:

[Insert Representative of CATHSSETA]

[Insert Representative of Mthente]

Do you agree to participate in this workshop?	○ Yes	○ No
Participant name in print:		
Contact number:		

Stakeholder Information:

CATHSSETA sub-sector	Arts, Culture and Heritage
Organisation name:	
Position within the organisation:	
Email address:	

1. Familiarity of the 4IR:

    a. What does the Fourth Industrial Revolution (4IR) phenomenon mean for the Arts, Culture and Heritage sub-sector?

Probe:

1.1. What 4IR technologies (e.g., Artificial Intelligence, Blockchain, Internet of Things, Virtual Reality, Augmented Reality, etc.) do you think the Arts, Culture and Heritage sub-sector are familiar with?

2. Adoption and Implementation of the 4IR Technologies:

2.4 What 4IR technologies are being implemented in the workplace across the Arts, Culture and Heritage sub-sector?

Probe:

2.1.1. What are the challenges for implementing those technologies in the Arts, Culture and Heritage sub-sector?

2.1.2. What are the successes or success stories for implementing those technologies in the Arts, Culture and Heritage sub-sector?

2.5 In your opinion, what factors enable the adoption of new technologies within the Arts, Culture and Heritage sub-sector?

2.6 What else can the Arts, Culture and Heritage sub-sector do in order to remain relevant in the future and thrive in the 4IR?

3. Obstacles of Workplace Development:

a. What obstacles do you foresee when it comes to 4IR up-skilling and development within the Arts, Culture and Heritage sub-sector?

4. Future and Strategic Focus:

6.1. What plans are in place to adopt 4IR technologies within your sub-sector?

7. Impact on Work:

5.3 In your opinion, what changes to the Arts, Culture and Heritage sub-sector will the 4IR bring?

5.4 What type of impact are the 4IR technologies likely to have on the Arts, Culture and Heritage sub-sector in the next 5 years?

8. Skills Development:

6.1 Do you think the technologies that underpin the 4IR are being incorporated into the delivery of skills development interventions within the Arts, Culture and Heritage sub-sector?

11. APPENDIX D: INTERVIEW GUIDE (TRAVEL & TOURISM)

Introduction:

CATHSEETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this interview is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

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[Insert Representative of CATHSSETA]

[Insert Representative of Mthente]

Do you agree to participate in this workshop?	○ Yes	○ No
Participant name in print:		
Contact number:		

Stakeholder Information:

CATHSSETA sub-sector	Travel and Tourism
Organisation name:	
Position within the organisation:	
Email address:	

1. Familiarity of the 4IR:

    a. What does the Fourth Industrial Revolution (4IR) phenomenon mean for the Travel and Tourism sub-sector?

Probe:

1.1.1. What 4IR technologies (e.g., Artificial Intelligence, Blockchain, Internet of Things, Virtual Reality, Augmented Reality, etc.) do you think the Travel and Tourism sub-sector are familiar with?

2. Adoption and Implementation of the 4IR Technologies:

2.7 What 4IR technologies are being implemented in the workplace across the Travel and Tourism sub-sector?

Probe:

2.1.1. What are the challenges for implementing those technologies in the Travel and Tourism sub-sector?

2.1.2. What are the successes or success stories for implementing those technologies in the Travel and Tourism sub-sector?

2.8 In your opinion, what factors enable the adoption of new technologies within the Travel and Tourism sub-sector?

2.9 What else can the Travel and Tourism sub-sector do to remain relevant in the future and thrive in the 4IR?

3. Obstacles of Workplace Development:

a. What obstacles do you foresee when it comes to 4IR up-skilling and development within the Travel and Tourism sub-sector?

4. Future and Strategic Focus:

8.1. What plans are in place to adopt 4IR technologies within your sub-sector?

9. Impact on Work:

5.5 In your opinion, what changes to the Travel and Tourism sub-sector will the 4IR bring?

5.6 What type of impact are the 4IR technologies likely to have on the Travel and Tourism sub-sector in the next 5 years?

10. Skills Development:

6.1 Do you think the technologies that underpin the 4IR are being incorporated into the delivery of skills development interventions within the Travel and Tourism sub-sector?

12. APPENDIX E: INTERVIEW GUIDE (CONSERVATION)

Introduction:

CATHSEETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this interview is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

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The interview will take approximately 20 minutes to complete. By completing the interview, you consent to the collection and use of your data. At any stage of the research, you may choose to withdraw your consent without penalty. If you want to do so or if you have any questions, please contact:

[Insert Representative of CATHSSETA]

[Insert Representative of Mthente]

Do you agree to participate in this workshop?	○ Yes	○ No
Participant name in print:		
Contact number:		

Stakeholder Information:

CATHSSETA sub-sector	Conservation
Organisation name:	
Position within the organisation:	
Email address:	

1. Familiarity of the 4IR:

    a. What does the Fourth Industrial Revolution (4IR) phenomenon mean for the Conservation sub-sector?

Probe:

1.1.2. What 4IR technologies (e.g., Artificial Intelligence, Blockchain, Internet of Things, Virtual Reality, Augmented Reality, etc.) do you think the Conservation sub-sector are familiar with?

2. Adoption and Implementation of the 4IR Technologies:

2.10 What 4IR technologies are being implemented in the workplace across the Conservation sub-sector?

Probe:

2.1.1. What are the challenges for implementing those technologies in the Conservation sub-sector?

2.1.2. What are the successes or success stories for implementing those technologies in the Conservation sub-sector?

2.11 In your opinion, what factors enable the adoption of new technologies within the Conservation sub-sector?

2.12 What else can the Conservation sub-sector do to remain relevant in the future and thrive in the 4IR?

3. Obstacles of Workplace Development:

a. What obstacles do you foresee when it comes to 4IR up-skilling and development within the Conservation sub-sector?

4. Future and Strategic Focus:

10.1. What plans are in place to adopt 4IR technologies within your sub-sector?

11. Impact on Work:

5.7 In your opinion, what changes to the Conservation sub-sector will the 4IR bring?

5.8 What type of impact are the 4IR technologies likely to have on the Conservation sub-sector in the next 5 years?

12. Skills Development:

6.1 Do you think the technologies that underpin the 4IR are being incorporated into the delivery of skills development interventions within the Conservation sub-sector?

13. APPENDIX F: INTERVIEW GUIDE (HOSPITALITY)

Introduction:

CATHSEETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this interview is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

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The interview will take approximately 20 minutes to complete. By completing the interview, you consent to the collection and use of your data. At any stage of the research, you may choose to withdraw your consent without penalty. If you want to do so or if you have any questions, please contact:

[Insert Representative of CATHSSETA]

[Insert Representative of Mthente]

Do you agree to participate in this workshop?	○ Yes	○ No
Participant name in print:		
Contact number:		

Stakeholder Information:

CATHSSETA sub-sector	Hospitality
Organisation name:	
Position within the organisation:	
Email address:	

1. Familiarity of the 4IR:

    a. What does the Fourth Industrial Revolution (4IR) phenomenon mean for the Hospitality sub-sector?

Probe:

1.1.3. What 4IR technologies (e.g. Artificial Intelligence, Blockchain, Internet of Things, Virtual Reality, Augmented Reality, etc.) do you think the Hospitality sub-sector are familiar with?

2. Adoption and Implementation of the 4IR Technologies:

2.13 What 4IR technologies are being implemented in the workplace across the Hospitality sub-sector?

Probe:

2.1.1. What are the challenges for implementing those technologies in the Hospitality sub-sector?

2.1.2. What are the successes or success stories for implementing those technologies in the Hospitality sub-sector?

2.14 In your opinion, what factors enable the adoption of new technologies within the Hospitality sub-sector?

2.15 What else can the Hospitality sub-sector do to remain relevant in the future and thrive in the 4IR?

3. Obstacles of Workplace Development:

a. What obstacles do you foresee when it comes to 4IR up-skilling and development within the Hospitality sub-sector?

4. Future and Strategic Focus:

12.1. What plans are in place to adopt 4IR technologies within your sub-sector?

5. Impact on Work:

5.9 In your opinion, what changes to the Hospitality sub-sector will the 4IR bring?

5.10 What type of impact are the 4IR technologies likely to have on the Hospitality sub-sector in the next 5 years?

6. Skills Development:

6.1 Do you think the technologies that underpin the 4IR are being incorporated into the delivery of skills development interventions within the Hospitality sub-sector?

14. APPENDIX G: INTERVIEW GUIDE- GAMING AND LOTTERIES

Introduction:

CATHSEETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this interview is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

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[Insert Representative of CATHSSETA]

[Insert Representative of Mthente]

Do you agree to participate in this workshop?	○ Yes	○ No
Participant name in print:		
Contact number:		

Stakeholder Information:

CATHSSETA sub-sector	Gaming and Lotteries
Organisation name:	
Position within the organisation:	
Email address:	

1. Familiarity of the 4IR:

    a. What does the Fourth Industrial Revolution (4IR) phenomenon mean for the Gaming and Lotteries sub-sector?

Probe:

1.1.4. What 4IR technologies (e.g. Artificial Intelligence, Blockchain, Internet of Things, Virtual Reality, Augmented Reality, etc.) do you think the Gaming and Lotteries sub-sector are familiar with?

2. Adoption and Implementation of the 4IR Technologies:

2.16 What 4IR technologies are being implemented in the workplace across the Gaming and Lotteries sub-sector?

Probe:

2.1.1. What are the challenges for implementing those technologies in the Gaming and Lotteries sub-sector?

2.1.2. What are the successes or success stories for implementing those technologies in the Gaming and Lotteries sub-sector?

2.17 In your opinion, what factors enable the adoption of new technologies within the Gaming and Lotteries sub-sector?

2.18 What else can the Gaming and Lotteries sub-sector do to remain relevant in the future and thrive in the 4IR?

3. Obstacles of Workplace Development:

a. What obstacles do you foresee when it comes to 4IR up-skilling and development within the Gaming and Lotteries sub-sector?

4. Future and Strategic Focus:

a. What plans are in place to adopt 4IR technologies within your sub-sector?

5. Impact on Work:

5.11 In your opinion, what changes to the Gaming and Lotteries sub-sector will the 4IR bring?

5.12 What type of impact are the 4IR technologies likely to have on the Gaming and Lotteries sub-sector in the next 5 years?

6. Skills Development:

6.1 Do you think the technologies that underpin the 4IR are being incorporated into the delivery of skills development interventions within the Gaming and Lotteries sub-sector?

15. APPENDIX H: FOCUS GROUP GUIDE (SPORTS, RECREATION & FITNESS)

Introduction:

CATHSSETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this focus group is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

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Ishreen Ismail, ishreen@mthente.co.za

(Research Director), Mthente Research and Consulting Services.

Do you agree to participate in this focus group?	○ Yes	○ No
Participant name in print:		
Contact number:		

Do you give consent for this focus group to be recorded?	○ Yes	○ No

Stakeholder Participation Roster:

CATHSSETA sub-sector	Organisation name:	Position within the organisation:	Email address:	Contact number:

Thematic areas (at a strategic level) to be covered during the Sport, Recreation and Fitness focus groups:

1. What is your understanding of the 4IR?
2. What is the impact of the 4IR on skills development for the Sports, Recreation and Fitness sub-sector?
3. In the Sports, Recreation and Fitness sub-sector, what are the strengths, opportunities, challenges, and solutions brought about by 4IR?
    a. what are the implications for the supply and demand of skills in the sub-sector?
    b. what would be the implications for qualification development?
4. In the context of the Sports, Recreation, and fitness sub-sector, what should we be teaching?
5. How can we re-conceptualise training? (e.g., delivery models, assessments, training providers).
6. What are the key developments and plans for the 4IR?
    a. How is the Sports, Recreation, and fitness sub-sector planning for the 4th industrial revolution?
    b. Which aspects are left behind, if any?
    c. What lessons can be learnt?
    d. Which employers are leading the pack?
7. What strategic measures should CATHSSETA consider aligning itself with the needs of the 4IR?

16. APPENDIX I: FOCUS GROUP GUIDE (ARTS, CULTURE & HERITAGE)

Introduction:

CATHSSETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf . The purpose of this focus group is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

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Ishreen Ismail, ishreen@mthente.co.za

(Research Director), Mthente Research and Consulting Services.

Do you agree to participate in this focus group?	○ Yes	○ No
Participant name in print:		
Contact number:		

Do you give consent for this focus group to be recorded?	○ Yes	○ No

Stakeholder Participation Roster:

CATHSSETA sub-sector	Organisation name:	Position within the organisation:	Email address:	Contact number:

Thematic areas (at a strategic level) to be covered during the Arts, Culture and Heritage focus groups:

1. What is your understanding of the 4IR?
2. What is the impact of the 4IR on skills development in the Arts, Culture and Heritage sub-sector?
3. In the Arts, Culture and Heritage sub-sector, what are the strengths, opportunities, challenges, and solutions brought about by 4IR?
    a. what are the implications for the supply and demand of skills in the sub-sector?
    b. what would be the implications for qualification development?
4. In the context of the Arts, Culture and Heritage sub-sector, what should we be teaching?
5. How can we re-conceptualise training? (e.g., delivery models, assessments, training providers).
6. What are the key developments and plans for the 4IR?
    a. How is the Arts, Culture and Heritage sub-sector planning for the 4th industrial revolution?
    b. Which aspects are being left behind, if any?
    c. What lessons can be learnt?
    d. Which employers are leading the pack?
7. What strategic measures should CATHSSETA consider aligning itself with the needs of the 4IR?

17. APPENDIX J: FOCUS GROUP GUIDE (TRAVEL & TOURISM)

Introduction:

CATHSSETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this focus group is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

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Ishreen Ismail, ishreen@mthente.co.za

(Research Director), Mthente Research and Consulting Services.

Do you agree to participate in this focus group?	○ Yes	○ No
Participant name in print:		
Contact number:		

Do you give consent for this focus group to be recorded?	○ Yes	○ No

Stakeholder Participation Roster:

CATHSSETA sub-sector	Organisation name:	Position within the organisation:	Email address:	Contact number:

Thematic areas (at a strategic level) to be covered during the Travel and Tourism focus groups:

1. What is the impact of the 4IR on skills development for the Travel and Tourism sub-sector?
2. In the Travel and Tourism sub-sector, what are the strengths, opportunities, challenges, and solutions brought about by 4IR?

   a. what are the implications for the supply and demand of skills in the sub-sector?
   b. what would be the implications for qualification development?
3. In the context of the Travel and Tourism sub-sector, what should we be teaching?
4. How can we re-conceptualise training? (e.g., delivery models, assessments, training providers).
5. What are the key developments and plans for the 4IR?
   a. How is the Travel and Tourism sub-sector planning for the 4th industrial revolution?
   b. Which aspects are left behind, if any?
   c. What lessons can be learnt?
   d. Which employers are leading the pack?
6. What strategic measures should CATHSSETA consider aligning itself with the needs of the 4IR?

18. APPENDIX K: FOCUS GROUP GUIDE (CONSERVATION)

Introduction:

CATHSSETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this focus group is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

We would therefore like to ask you to engage with us around questions which relate to the 4IR. This information will assist CATHSSETA to identify the impact that the 4IR will have across the six sub-sectors.

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Ishreen Ismail, ishreen@mthente.co.za

(Research Director), Mthente Research and Consulting Services.

Do you agree to participate in this focus group?	○ Yes	○ No
Participant name in print:		
Contact number:		

Do you give consent for this focus group to be recorded?	○ Yes	○ No

Stakeholder Participation Roster:

CATHSSETA sub-sector	Organisation name:	Position within the organisation:	Email address:	Contact number:

Thematic areas (at a strategic level) to be covered during the Conservation focus groups:

1. What is your understanding of the 4IR?
2. What is the impact of the 4IR on skills development for the Conservation sub-sector?
3. In the Conservation sub-sector, what are the strengths, opportunities, challenges, and solutions brought about by 4IR?

   a. what is the implication for the supply and demand of skills in the sub-sector?
   b. what would be the implications for qualification development?
4. In the context of the Conservation sub-sector, what should we be teaching?
5. How can we re-conceptualise training? (e.g., delivery models, assessments, training providers).
6. What are the key developments and plans for the 4IR?
   a. How is the Conservation sub-sector planning for the 4th industrial revolution?
   b. Which aspects are left behind, if any?
   c. What lessons can be learnt?
   d. Which employers are leading the pack?
7. What strategic measures should CATHSSETA consider aligning itself with the needs of the 4IR.

19. APPENDIX L: FOCUS GROUP GUIDE (HOSPITALITY)

Introduction:

CATHSSETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this focus group is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

We would therefore like to ask you to engage with us around questions which relate to the 4IR. This information will assist CATHSSETA to identify the impact that the 4IR will have across the six sub-sectors.

It must be stressed that all information received will be kept confidential and will only be summarised and reported on in an aggregated manner. The information you provide will not be shared with anyone outside the research team of Mthente. This is following the recognised industry standards, as set by SAMRA (the Southern African Marketing Research Association), of which Mthente is an organisational member.

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Ishreen Ismail, ishreen@mthente.co.za

(Research Director), Mthente Research and Consulting Services.

Do you agree to participate in this focus group?	○ Yes	○ No
Participant name in print:		
Contact number:		

Do you give consent for this focus group to be recorded?	○ Yes	○ No

Stakeholder Participation Roster:

CATHSSETA sub-sector	Organisation name:	Position within the organisation:	Email address:	Contact number:

Thematic areas (at a strategic level) to be covered during the Hospitality focus groups:

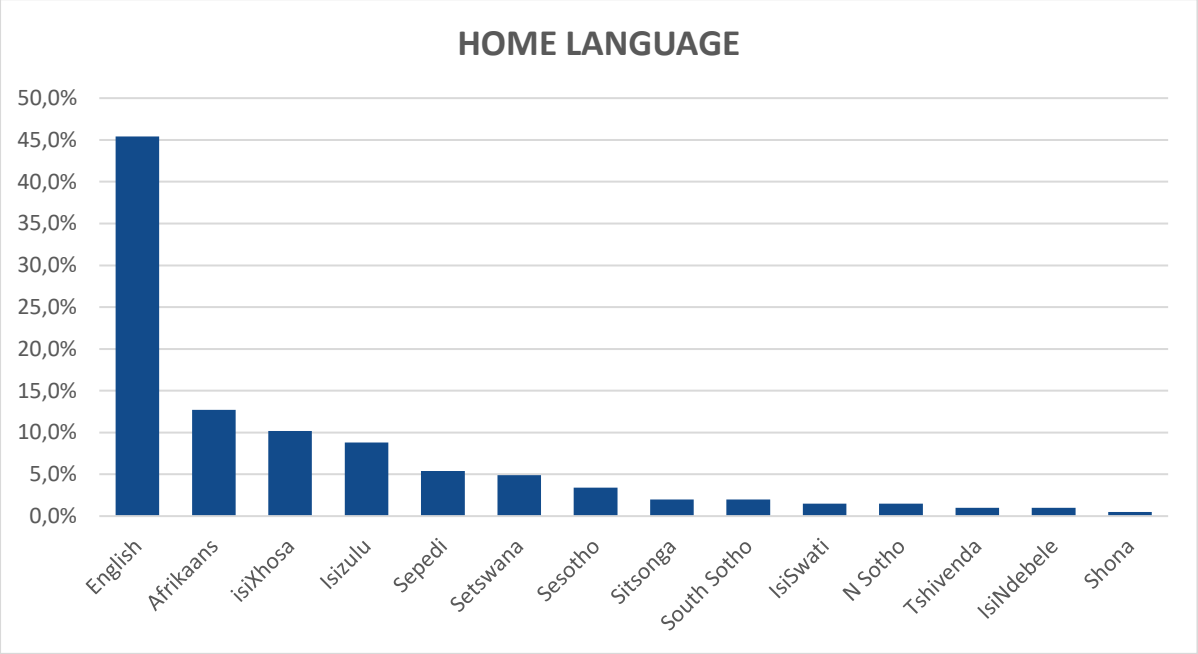
1. What is your understanding of the 4IR?
2. What is the impact of the 4IR on skills development in the Hospitality sub-sector?
3. In the Hospitality sub-sector, what are the strengths, opportunities, challenges, and solutions brought about by 4IR?
    a. What are the implications for the supply and demand of skills in the sub-sector?
    b. What is the implication on qualification development in the sub-sector?
4. In the context of the Hospitality sub-sector, what should we be teaching?
5. How can we re-conceptualise training? (e.g., delivery models, assessments, training providers).
6. What are the key developments and plans for the 4IR?
    a. How is the Hospitality sub-sector planning for the 4th industrial revolution?

   b. Which aspects are being left behind, if any?
   c. What lessons can be learnt?
   d. Which employers are leading the pack?

7. What strategic measures should CATHSSETA consider aligning itself with the needs of the 4IR?

20. APPENDIX M: SURVEY DISTRIBUTION

Figure 9: Home language of survey respondents

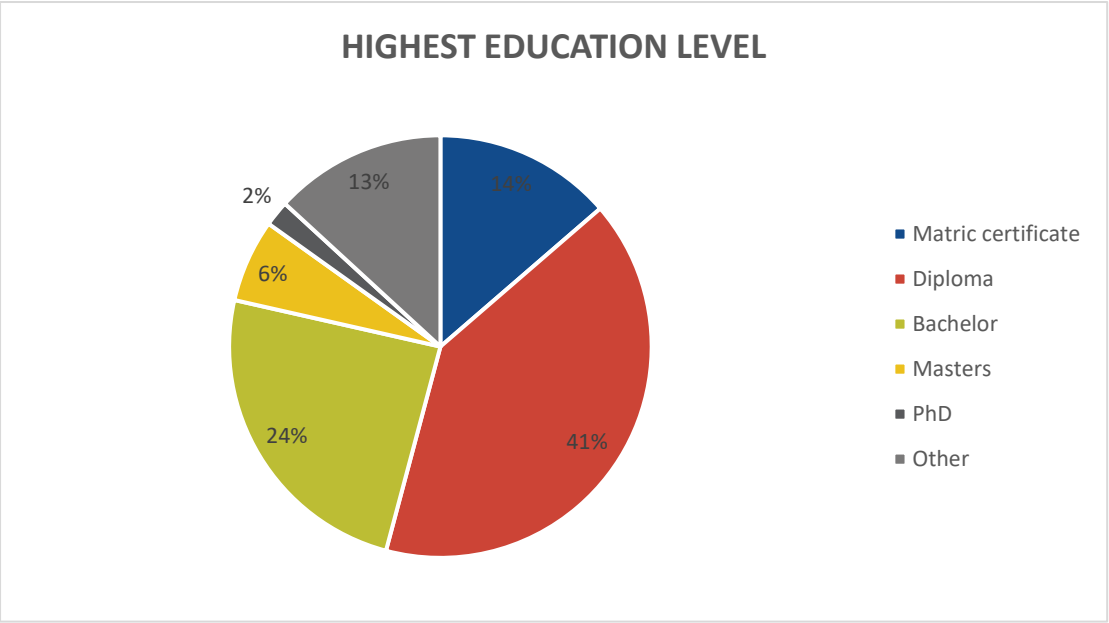


Error! Reference source not found. depicts the home languages spoken by the respondents. The majority of the participants indicated that they were English (45.5%), Afrikaans (12.7%), and Xhosa (10.2%) speaking. This is consistent with the findings of the provinces which participants were from, as English, Afrikaans and Xhosa are predominant languages spoken in both the Western Cape and Gauteng.

Figure 10: Work experience of survey respondents

Error! Reference source not found. and **Error! Reference source not found.** present findings on the amount of work experience and education level of survey respondents. Most participants had more than 20 years of experience working in their chosen field (28.3%) with the most common qualification amongst respondents being a Diploma (40.5%).

Figure 11: Education levels of survey respondents



21. APPENDIX N: SKILLS REQUIRED TO WORK IN 4IR TECHNOLOGIES

Technology	Skills and qualifications
Quantum computing	Physics
	Mathematics
	Computer science
Genomics	Computer science
	Biology,
	Microbiology
	Genetics
	Biochemistry
	Biomedicine
	Pharmacology
	Mathematics
	Data science
5G Network	Radio Frequency principles
	Edge computing
	Network splicing
	Computer programming
	Data analytics
	Engineering
Robotics	Computer programming
	Engineering
	Mathematics
	Physics
	Design
Cloud computing	Computer programming
	Software engineering
	Data science

	Computer science
Blockchain	Cryptography
	Software engineering
	Computer programming
Big Data	Data science
	Statistics
	Mathematics
	Economics
	Computer science
Artificial Intelligence	Mathematics
	Statistics
	Bayesian networking
	Physics
	Engineering
	Robotics
	Computer science
	Computer programming
	Cognitive science theory

Skills and qualifications	**Relevant technologies**	**Relevant sectors**	**Available human resources in South Africa**
Bayesian networking	Blockchains Artificial Intelligence	Gaming and Lotteries Conservation Hospitality Sport, Recreation and Fitness	**Limited**
Biochemistry	Genomics	Conservation Sport, Recreation and Fitness	**Somewhat**
Biology	Genomics	Conservation Sport, Recreation and Fitness	**Limited**
Bio-medicine	Genomics	Conservation Sport, Recreation and Fitness	**Limited**

Cognitive science theory	Genomics Robotics Artificial Intelligence	Conservation Gaming and Lotteries Hospitality Sport, Recreation and Fitness Travel and Tourism	**Limited**
Computer programming	Quantum computing 5G Network Robotics Cloud computing Blockchains Artificial Intelligence	Arts, Culture and Heritage Gaming and Lotteries Conservation Hospitality Sport, Recreation and Fitness Travel and Tourism	**Somewhat**
Computer science	5G Network Robotics Cloud computing Big Data Artificial Intelligence	Arts, Culture and Heritage Gaming and Lotteries Conservation Hospitality Sport, Recreation and Fitness Travel and Tourism	**Somewhat**
Cryptography	Blockchains	Gaming and Lotteries Conservation Hospitality Travel and Tourism	**No**
Data science	Quantum computing Genomics 5G Network Cloud computing Big Data	Conservation Gaming and Lotteries Hospitality Sport, Recreation and Fitness Travel and Tourism	**Somewhat**
Design	Genomics Robotics	Arts, Culture and Heritage Conservation Hospitality Sport, Recreation and Fitness Travel and Tourism	**Somewhat**
Economics	Big Data	Arts, Culture and Heritage Gaming and Lotteries Hospitality Sport, Recreation and Fitness Travel and Tourism	**Yes**
Edge computing	Quantum computing 5G Network	Gaming and Lotteries Conservation	**No**

Engineering	Quantum computing 5G Network Robotics Artificial Intelligence	Arts, Culture and Heritage Conservation Hospitality Sport, Recreation and Fitness Travel and Tourism	**Limited**
Genetics	Genomics	Conservation Sport, Recreation and Fitness	**Limited**
Mathematics	Quantum computing Genomics Robotics Artificial Intelligence	Conservation Gaming and Lotteries Hospitality Sport, Recreation and Fitness Travel and Tourism	**Somewhat**
Micro-biology	Genomics	Conservation	**Limited**
Network splicing	5G Network	Conservation	**No**
Pharmacology	Genomics	Conservation Sport, Recreation and Fitness	**Limited**
Physics	Quantum computing Robotics Artificial Intelligence	Gaming and Lotteries Conservation	**Somewhat**
Radio Frequency principles	5G Network	Conservation	**Limited**
Robotics	Robotics Artificial Intelligence	Arts, Culture and Heritage Conservation Hospitality	**Limited**
Software engineering	Quantum computing Cloud computing Blockchains	Arts, Culture and Heritage Conservation Gaming and Lotteries Hospitality Sport, Recreation and Fitness Travel and Tourism	**Limited**
Statistics	Genomics Big Data Artificial Intelligence	Conservation Gaming and Lotteries Hospitality Sport, Recreation and Fitness Travel and Tourism	**Yes**

22. APPENDIX O: FOCUS GROUP GUIDE (GAMING AND LOTTERIES)

Introduction:

CATHSSETA has commissioned Mthente Research & Consulting Services (Pty) Ltd, to conduct research on its behalf. The purpose of this focus group is to aid research being conducted on the impact of the Fourth Industrial Revolution (4IR) on CATHSSETA's sub-sectors.

We would therefore like to ask you to engage with us around questions which relate to the 4IR. This information will assist CATHSSETA to identify the impact that the 4IR will have across the six sub-sectors.

It must be stressed that all information received will be kept confidential and will only be summarised and reported on in an aggregated manner. The information you provide will not be shared with anyone outside the research team of Mthente. This is following the recognised industry standards, as set by SAMRA (the Southern African Marketing Research Association), of which Mthente is an organisational member.

The focus group will take approximately 60-90 minutes. By participating in this focus group, you consent to the collection and use of your data. At any stage of the research, you may choose to withdraw your consent. If you want to do so or if you have any questions, please contact:

Ishreen Ismail, ishreen@mthente.co.za

(Research Director), Mthente Research and Consulting Services.

Do you agree to participate in this focus group?	○ Yes	○ No
Participant name in print:		
Contact number:		

Do you give consent for this focus group to be recorded?	○ Yes	○ No

Stakeholder Participation Roster:

CATHSSETA sub-sector	Organisation name:	Position within the organisation:	Email address:	Contact number:

Thematic areas (at a strategic level) to be covered during the Gaming and Lotteries focus groups:

8. What is the impact of the 4IR on skills development for the Gaming and Lotteries sub-sector?
9. In the Gaming and Lotteries sub-sector, what are the strengths, opportunities, challenges, and solutions brought about by 4IR?
    a. what are the implications for the supply and demand of skills in the sub-sector?

   b. what would be the implications for qualification development?
10. In the context of the Gaming and Lotteries sub-sector, what should we be teaching?
11. How can we re-conceptualise training? (e.g., delivery models, assessments, training providers).
12. What are the key developments and plans for the 4IR?
    a. How is the Gaming and Lotteries sub-sector planning for the 4th industrial revolution?
    b. Which aspects are left behind, if any?
    c. What lessons can be learnt?
    d. Which employers are leading the pack?
13. What strategic measures should CATHSSETA consider aligning itself with the needs of the 4IR?

Country	Technology adaptation towards the 4IR	Sectors most likely to be affected by automation	Digital uptake	Internet access	Estimated share of jobs at risk of automation	Relative rankings from the World Economic Forum Global Competitive report		Lessons for South Africa
					Automation (%)	Skills level	Overall Impact	
Indonesia	Indonesia has a National Digital Vision that is supported by four structural anchors: 1. Digital Infrastructure (Healthy Industry, National Projects and Open Policy). 2. Consumer Awareness and Trust (Data Privacy, Cybersecurity and Consumer Education). 3. Future-Ready Workforce (Expanded National Curriculum, Private Sector Skill Building and Industry-University Engagement); and 4. Innovation Ecosystem (Intellectual Property Laws,	✓ Manufacturing (Garments, Computers and Electronics, Motor Vehicles); and ✓ Services (Retail Trade, Hotel, Banking)	-	47,69	-	65	70,8	✓ Understand Shifting Labor Markets ✓ Set a policy agenda for the future of work that is productive and rewarding for employees

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Country	Technology adaptation towards the 4IR	Sectors most likely to be affected by automation	Digital uptake	Internet access	Estimated share of jobs at risk of automation	Relative rankings from the World Economic Forum Global Competitive report		Lessons for South Africa
					Automation (%)	Skills level	Overall Impact	
	Funding and Exit Options and Ecosystem Facilitation)							
Brazil	The South African Centre for the Fourth Industrial Revolution and the World Economic Forum are piloting new policy tools on "facilitating technology capacity-building of small, medium and micro enterprises (SMMEs) in an increasingly digital world"	✓ Production Packers and Feeder ✓ Activities Artisan Workers Textiles, Clothing and Graphic Arts ✓ Professionals in Air, Maritime and River ✓ Library Service Assistants,	52,9	71,4	58,1	93	92,2	✓ Formalization of a national policy. ✓ Industries prone to automation are those that focus on manual dexterity tasks. Digital uptake could mitigate the number of job losses due to automation.

Country	Technology adaptation towards the 4IR	Sectors most likely to be affected by automation	Digital uptake	Internet access	Estimated share of jobs at risk of automation	Relative rankings from the World Economic Forum Global Competitive report		Lessons for South Africa
					Automation (%)	Skills level	Overall Impact	
		Documentation and Mail ✓ Clerks in general, agents, assistants and administrative assistants ✓ Officer secretaries and operators of office machines						
Greece	Digital Transformation for the years 2020-2025 1. Safe, fast, and reliable access to	✓ Manufacturing ✓ Construction ✓ Retail trade	60,1	80,4	22	43	67,6	✓ There is a relationship between the global ranking of

Country	Technology adaptation towards the 4IR	Sectors most likely to be affected by automation	Digital uptake	Internet access	Estimated share of jobs at risk of automation	Relative rankings from the World Economic Forum Global Competitive report		Lessons for South Africa
					Automation (%)	Skills level	Overall Impact	
	the Internet for all 2. A digital state offering better digital services to the citizens for all life events 3. Development of digital skills for all citizens 4. Facilitate the transformation to a digital enterprise 5. Support and strengthening digital innovation 6. Making productive use of public administration data	✓ Social protection and health industry.						local labor force skills and readiness for the 4IR.

Country	Technology adaptation towards the 4IR	Sectors most likely to be affected by automation	Digital uptake	Internet access	Estimated share of jobs at risk of automation	Relative rankings from the World Economic Forum Global Competitive report		Lessons for South Africa
					Automation (%)	Skills level	Overall Impact	
	7. Incorporating digital technologies to all economic sectors"							

Appendix 14: Summary of benchmark