RESEARCH BULLETIN ON POST-SCHOOL EDUCATION AND TRAINING

NUMBER 8

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& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

Message from Director-General

It is my pleasure to present this special edition of the annual Department of Higher Education and Training (DHET) *Research Bulletin on Post-School Education and Training* (PSET). This year marks the eighth edition of the Research Bulletin, an achievement of which the Department is most proud. The purpose of the annual Research Bulletin is to share examples of the latest research on PSET, which covers Universities, Technical and Vocational Education and Training (TVET) Colleges, Community Education and Training (CET) Colleges, Sector Education and Training Authorities (SETAs), and Qualifications and Quality Assurance Bodies. The Research Bulletin serves to draw the creators and users of post-school research closer to one another to inform policy and practice. The previous seven editions of the Research Bulletin can be found on the Department's website at www.dhet.gov.za.

This edition of the Bulletin focuses on the Fourth Industrial Revolution (4IR), which is an extension of the dialogue, debate and research shared at the 2019 DHET Research Colloquium on the implications of the 4IR on PSET. This theme was selected given its significance in the current landscape, with technology increasingly taking over many core functions in the labour market, and in society at large. In addition, given the recent union of the DHET with that of the Department of Science and Innovation (DSI), where the 4IR is a critical component to the work of the DSI, and one that is radically changing the education and training landscape, the theme of the 4IR was a fitting choice to focus our attention on, in our first year as a dual Ministry.
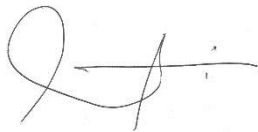
The use of the term 4IR is highly contested both nationally, as well as internationally. There is considerable debate as to whether we are indeed in an era of 4IR when many parts of the world still struggle with access to basic services and technology. Some might argue that we are still in the 2nd or 3rd industrial revolution. The Department views the notion of 4IR as a concept that reflects rapid changes in technology that affect the paradigm of how we work and live. The Department strives to leverage the opportunities provided by 4IR to achieve our goals of access, quality and success in the PSET system. It also aims to provide our stakeholders and beneficiaries with information and insights that will assist them to keep abreast of the changing landscape.

Each contribution made to this edition of the Bulletin demonstrates the considerable influence of the 4IR on the sector. Research has now become our biggest ally in trying to create understanding and awareness of the impact of the 4IR, whilst also affording us with the

opportunity to uncover how best to use the 4IR as a tool for our success, one that will allow citizens to not only survive, but thrive in this ever-changing economy.

As technology brings change to our environment, we must adapt, learn and relearn as is required. It is only through research that we will be afforded sight of the possible changes to come. I encourage us all to embrace the research, interrogate it, debate it, and use the evidence to inform the way forward. Research should be used to our advantage to guide our steps in decisions, policies and strategy.

I extend my thanks and appreciation to each and every contributor of this year's Research Bulletin. It is only through your support that we have something of value to share with the research community. And it is through your efforts in the sector, that we are able to gain insights into underlying challenges in the PSET sector, as well as opportunities that can be taken forward, to improve the sector for the current and future citizens of the country. Thank you for making a difference and for being part of the change for a transformed PSET system.

Mr G F Qonde
Director-General: Department of Higher Education and Training

Editorial Statement

The *Research Bulletin on Post-School Education and Training* (PSET) is published annually by the Department of Higher Education and Training (DHET) as a service to the education research community and all stakeholders and participants in lifelong learning. It is a browser-based application, comprising abstracts, summaries, and excerpts of completed/current research and evaluations; book reviews; summaries of event proceedings; reflections on research practice; and statistics on post-school learning, most of which have web links to full research articles and reports. The Research Bulletin promotes good quality research. It is therefore not primarily a journal of opinion but is open to all well-argued and substantiated views, for which the authors alone will have responsibility. Contributions are expected to be brief and plain language is encouraged so that excessive use of jargon can be avoided. Contributions to the Research Bulletin are welcome from all researchers engaged in key research on PSET. The Department's Editorial Committee reviews all contributions made towards the Research Bulletin and assesses their relevance to research on PSET, before finalising which contributions should be included. The final decision to accept a contribution rests with the Editorial Committee. Research contributions can be sent to dhetresearch@dhet.gov.za.

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RESEARCH ARTICLES

AND

REPORTS

1. ***Navigating the Fourth Industrial Revolution (4IR) Rapids of Skills Supply and Demands: Implications for Research and Practice*** **(Jennifer Chishamiso Nzonzo, Geena Vimbayi Maingehema, and Francisca Nyasha Maingehema)**

Technological advancements have brought about dramatic changes to skills demands and supply for developed and developing economies since the emergence of the industrial revolution. Although South Africa has made critical strides in skills development, challenges have been experienced in terms of aligning skills supply and demand with the drivers of the Fourth Industrial Revolution (4IR) and economic growth. Key strategic documents such as the Human Resource Development Strategy and the National Skills Development Strategy all draw attention to the risks associated with the poor supply of skills from the education and training system. It is against this construct that this paper provides a conceptual analysis on navigating the 4IR rapids of skills supply and demands. From the analysis, a skills supply and demand competency framework is developed, which is inextricably linked with the drivers of the 4IR. By conceptualising and assessing the different drivers of skills demands and supply, an explicit account of how the drivers influence the development of technical, psychosocial, managerial, professional and personal competencies is provided. In addition, specific and concrete theoretical and practical implications are outlined for professionals, policy makers, academics and various stakeholders involved in assessing the impact of skills demands and supply in organisations.

The full paper is available on the following link:

https://www.dropbox.com/s/gj1fnummjm0421c/Navigating%20The%204th%20Industrial%20Revolution%20Rapids%20of%20Skills%20Supply%20and%20Demands_Implications%20for%20Research%20and%20Practice.pdf?dl=0

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2. *Preparing for the Impending Revolution: An Outline of the Critical Skills of the Future and Concomitant Roles of Government, Private Sector and the Third Sector* (Blessing Mabuto)

The Fourth Industrial Revolution (4IR) will bring about sweeping changes to the way in which people live and the global labour market, in particular where skills supply and demand is concerned. Using authoritative reports and academic literature on 4IR, the paper highlights the crucial skills which the era currently demands and will demand in the not so distant future. The emerging findings reveal that not only technological skills will matter in the future but a whole range of skills. Preparedness for an effective response to the skill demands brought about by 4IR will require a coordinated response from the public, private and third sectors with each bringing to the table unique capabilities for the benefit of society as a whole.

The full paper is available on the following link:

https://www.dropbox.com/s/wysiokam2537k1w/Preparing%20for%20the%20Impending%20Revolution_An%20Outline%20of%20the%20Critical%20Skills%20of%20the%20Future%20and%20Concomitant%20Roles%20of%20Government%2C%20Private%20Sector%20and%20the%20Third%20Sector.pdf?dl=0

Author: Mr Blessing Mabuto is a Youth Development Specialist and the Founder of the Organisation for Youth Advancement (OYA) (mabutoh@yahoo.com).

3. *Harnessing the Fourth Industrial Revolution (4IR) to Advance Quality Education in Africa to Meet Aspirations as Articulated in the Continental Education Strategy for Africa* (Donald Kubayi)

The rapid spread of Information and Communications Technologies (ICTs) and convergence of innovative technologies is arguably one of the most promising developments that is driving the Fourth Industrial Revolution (known as 4IR or Industry 4.0). In the area of education, ICT has become increasingly influential in opening new doors for universal access to education for communities in remote rural villages. The paper evaluates the impact and effectiveness of the ICT based educational innovations, and where possible, assess the extent to which these ICT tools have improved universal access, quality provision and delivery of educational services to advance the Sustainable Development Goals (SDGs), in particular goal 4 (quality education) in Africa. As examples of practical innovations in education, experimental evidence from two case studies are highlighted, that demonstrate the effectiveness of interactive distance instruction using ICT tools as part of the design, development and delivery of education in rural villages.

The full paper will be made available in the African Union's (AU's) Africa Education Innovations Handbook, 2019. In the interim, it can be accessed on the following link: https://www.dropbox.com/s/52zk0s5r8h20rey/Harnessing%20the%204IR%20to%20 advance%20Quality%20Education%20in%20Africa.pdf?dl=0

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4. *The Impact of the Fourth Industrial Revolution (4IR) in Higher Education* (Ephodia M. Mokwala and Kelebogile Paadi)

The world is adapting to a new era of technologies, use of digital gadgets and cyber systems commonly referred to as the Fourth Industrial Revolution (4IR) or 4.0. Most organisations today in the workplaces use technology devices and machineries which are fast to conduct their daily work, employers are in the process of adapting to this change. The question is, are graduates coming into the organisation ready for the changes. Higher education prepare and equip individuals with knowledge for employment. This means that higher education needs to respond to the demands in the work environment as a result of the 4IR.The paper is aimed at exploring how higher education is adapting to these changes in terms of their curriculum to adequately prepare graduates for the changing labour market. The paper follows a qualitative research approach with a sample of academics purposively selected to respond to in-depth interview questions. Preliminary findings show that higher education provides a platform for individuals to explore digitalisation and it uses digitalisation to enhance learning, however academics feel that the curriculum needs to be responsive to these changes, but university procedures and systems sometimes delay the change process. It is recommended that discipline specific technological systems modules be incorporated into the curriculum.

The full paper is available on the following link:

https://www.dropbox.com/s/nfr7e056vpyn5uh/The%20Impact%20of%20the%204IR%20in%20Higher%20Education.pdf?dl=0

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5. *Innovation for the Public Good in a Deeply Unequal Society* (Laura Czerniewicz)

Like universities all over the world, South African universities are grappling with the implications of living in the era of the Fourth Industrial Revolution (4IR), where there is a blurring of boundaries between the physical, digital, and biological domains. They are asking themselves what the accelerating combination of machine automation, the changing nature of work, and the ubiquitous digital mediation of daily life, means for the core function of a university i.e. that of knowledge production and dissemination. At the same time, South African universities are also asking what these profound social and technological changes mean for their role in a deeply unequal society and whether they will hinder or enhance the democratisation of knowledge creation and access.

The challenges posed by the 4IR are closely linked to other challenges facing the universities in general, especially the persistent state of underfunding public universities and the rapid marketisation of the sector in most places in the world. It has been convincingly argued during this era that capitalism itself has been restructured into a new form, platform capitalism, whereby the big digital platforms (Google, Amazon, Apple, Microsoft, Facebook) are reshaping the nature of the economy. Higher education scholars are warning that this in turn is leading to the emergence of the "platform university" underpinned by a data-driven business model designed to extract profits from higher education and its market opportunities.

It is in this situation, that public universities everywhere must ask themselves how they can continue to fulfil their missions of civic responsibility and inclusivity for democratic ends. In the light of its history, South African universities also ask how they can contribute to redressing the wrongs of the past to address the stark social and economic divisions resulting from hard to shift structural inequalities in the country. Unlike many other public universities elsewhere in the world, South African universities are especially cognate of this imperative and express an overt commitment to a social justice agenda. They are less entangled in marketised discourses than higher education sectors elsewhere (like England and the United States of America) and are

in a stronger position to confront the new digital era with the will to leverage the emerging models and digital affordances for the public good.

This requires a concentrated focus of building on their core strengths including research, policy engagement, innovation, curriculum review, professional development and enabling students with appropriate graduate attributes. Encouragingly, there is already evidence of original initiatives which are framing and exploring elements of the 4IR with a public good agenda.

The full article is available on the following link:
https://www.universityworldnews.com/post.php?story=20190516104646131

Author: Prof Laura Czerniewicz is the Director of the Centre for Innovation in Learning and Teaching (CILT) at the University of Cape Town (UCT) (laura.czerniewicz@uct.ac.za).

6. *Reconfiguring Skills Supply in the Fourth Industrial Revolution (4IR)* (Elvis Munyaradzi Ganyaupfu)

The observed impacts of the Fourth Industrial Revolution (4IR) on occupations are increasingly dominating the centre stage in labour market discourses relating to education, skills, jobs and employment. The probability of several jobs becoming vulnerable to the risk of computerisation is progressively rising. Some economic predictions begin to show that structural unemployment is likely to be on the rise due to the mounting substitution of capital for labour production methods. The 4IR is predicted to have substantial consequences for both low-skilled and high-skilled workers. Workers in certain industrial sectors, such as high-tech sectors, have begun to find themselves threatened by digital technologies demonstrating technical capabilities to perform sophisticated decision-making in current environments characterised by strenuous pursuit of a balance between outcomes from the educational system and the 4IR.

The primary aim of this paper was to explore how Higher Education Institutions (HEIs) can restructure their *teaching*, *research* and *service* functions in pursuit of reconfiguration of the nature of skills produced and supplied to the dynamic labour market. A desktop qualitative research approach was used in which a thematic analysis was applied to conduct synthesis of literature obtained from online published research studies conducted by academic, research and corporate institutions. Major findings reveal that, in order for the higher education and training system to appropriately reconfigure the nature of the skills produced and supplied to the labour market, HEIs need to design and implement comprehensive strategies that respond to diverse economy-wide market channels in which interaction of the demand for and supply of labour occur.

The full draft paper is available on the following link:

https://www.dropbox.com/s/hp6zy292krjmq7a/Reconfiguring%20Skills%20Supply%20in%20the%20Fourth%20Industrial%20Revolution.pdf?dl=0

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7. *Private Sector Education and Training in the Fourth Industrial Revolution (4IR) Era: A South African Overview* (Gezani Mazibuko)

Education and training has long been critical to human welfare, but it is even more so in time of rapid economic and social change. The questions to be asked are: Does our current private education and training system address issues surrounding technological innovation and the new knowledge-based economy? Secondly, how can more private sector participation in providing education and training skills be encouraged? Under what conditions can private sector businesses provide more on the job training? Investigating these questions will help government leverage scarce national resources for public investments, and to support, vulnerable groups, while enabling the private sector to take on the bulk of education, training and skills provision. In the Fourth Industrial Revolution (4IR), the private sector is becoming a force for public education and training. In this context, it is vital to share on how the private education and training sector is adapting to new and emerging skills needs and requirements, and workforce training needs to ensure that everyone can find a place in the 4IR era. Improving educational outcomes at scale requires unorthodox approaches. One optimising, yet largely neglected approach, is to systematically leverage the private sector's education and training agenda. Specifically, what can private education and training contribute to the 4IR? This paper uses a qualitative research methodology to collect secondary data for public, private education and training, nationally and internationally.

The full paper is available on the following link:

https://www.dropbox.com/s/nnoxcbfhs8djr3u/Private%20Sector%20Education%20and%20Training%20in%20the%204IR%20Era-A%20South%20African%20Overview.pdf?dl=0

Author: Dr Gezani Mazibuko is the Group Executive of Thumeka Strategy and Project Management Consulting (PTY) Ltd (Hlohlo@lantic.net).

8. *Higher Education and the Fourth Industrial Revolution (4IR)* (Thabang Mafokoane)

Education has the power to improve lives. According to the United Nations' Sustainable Development Goal 4 (2018), a good educational system should "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". A quality education is one that responds to societal needs, as well as local and global trends. The Fourth Industrial Revolution (4IR) is a global phenomenon that is rapidly gathering pace. A report by the World Economic Forum (2016) described how the 4IR will "shape the future of education, gender and work". Technologies such as virtual reality, robotics, augmented reality, big data, the internet of things (IoT), Artificial Intelligence (AI) and digitalisation are becoming more accessible. The speed of technological transformation is exponential and offers seemingly endless possibilities. The impact of the 4IR on the education system cannot be ignored. There is a need to learn new things in different ways. Schools and universities must foster innovation and creativity. This paper discusses the impact of the 4IR on education. The implications for teaching, learning, research and service delivery are explored from basic education to higher education. The paper starts by reflecting on South African society and the history of education. Global teaching and research trends and innovations are examined. The paper concludes with opportunities and challenges for education with regards to the 4IR.

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9. *The Future of Jobs in the Services Sector – Long-Term View* **(Tsiliso Tamasane and Sibusiso Dhladhla)**

As part of the planning for skills development for the service sector, the Services Sector Education and Training Authority (SETA) commissioned a research on the future of jobs in the sector, in light of the rapid advancements in technology and the implications of the Fourth Industrial Revolution (4IR).

The purpose of this project was to identify occupations that may become obsolete in the next ten years and new ones that might emerge. The study sought to understand the key drivers of change for the South African services sector; the future emerging jobs in the South African services sector; the future endangered jobs in the South African services sector, and the status of skills provisioning in the services sector.

A mixed methods approach was used including expert engagement, and scenario development workshops with business owners and associations across services industries to identify plausible futures to map out the implications of social, economic, technological, environmental and political trends on future jobs and skills. The report also presents findings from a digital survey that was conducted with 300 youth, aged between 18 and 30, to garner their views about the future world of work, jobs and skills. The study was conducted between October 2017 and March 2019.

Findings from this research indicated that the following occupations are likely to be adversely affected by technology:

- Cleaning and laundry services
- Marketing services
- Postal services
- Business consulting services
- Project management services
- Real estate services

In the case of menial labour occupations, the impact is severe at the local elementary occupational level. However, in the case of complex occupations, the impact is felt mostly at management, professional and technical occupational categories.

The impact of technology on the future of jobs in South Africa varies from subsector to subsector and occupational categories. Less menial and complex occupations are likely to be severely impacted upon by technology. The upper-echelons of occupational levels are more likely to be affected by technology.

A key recommendation is that the Services SETA should foster closer collaboration with and between employers, universities of technology and Technical and Vocational Education and Training (TVET) Colleges to better understand future skills needs and devise timely interventions in the form of curriculum designs and training programmes.

The full draft report paper is available on the following link:

https://www.dropbox.com/s/9l2goubk3nfundd/Future%20Jobs%20Report_March2019.pdf?dl=0

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10. ***Demystifying the Perceived Advantage of the Fourth Industrial Revolution (4IR) and the Role it will Play in Higher Education Pedagogy on the African Continent*** **(Larry E. Jowah)**

If the Fourth Industrial Revolution (4IR) is about automation and the over-hyped notion of radical change in everything we do, it is important to indicate otherwise. The 4IR may be touted as scary because of the uncertainties of the future, but the human being, at the heart of all this, remains as a social animal. Pedagogy is one element that can be tempered with to the detriment of the society, and the perceived advancement. Based on the current situation in the South African education context, supported by the natural instincts of pedagogy – the human learning systems remain static. Human beings are social animals and learn through interaction. The status quo on the continent is gloomy with 63% -71% of the inhabitants classified as chronically poor on a continent with the youngest population. The use of technology for learning cannot take place amongst 71% of the people because of ever-increasing poverty. Replacing the classroom with technology simply means less people schooling, further making the poor poorer. The current failure and dropout rate in institutions is scary, even though these students are aided by lecturers and friends. What will the rate be if classrooms are reduced, and assistance reduced when they struggle now with a teacher? The robbery of the gadgets (as it is now) is a direct negative for the South African situation, as evidenced by the rate of robberies of cell phones, tablets and laptops. Besides, research has shown that students use less than 11% of their data on education related issues with 67% on romance and jokes, and 22% spent on family and friends. In the study, the history of the other revolutions has also been chronicled with clear evidence that the learning system and processes have remained the same. What has changed has been the material and facilities, but the human mind has one way of learning – the 4IR should not be dreaded as a revolution on pedagogy.

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11. *Technical and Vocational Education and Training (TVET) for Sustainable Skills for the Fourth Industrial Revolution (4IR): Snapshot at Some TVET Colleges in South Africa* (Moses Makgato)

Technological advancement is a major driver of the economic growth and has raised living standards enormously (though unevenly) across the globe. Digital technologies radically transform the structure of organisations and employment models, including teaching and learning. Youth and people who lack high level technological and interpersonal skills, are becoming vulnerable due to digital automated jobs. There is a need for targeted and strategic skills and Technical and Vocational Education and Training (TVET), which responds to the changing technological world. The digital revolution and an increasing demand for designing and manufacturing are driving the growth of the creative sector, which extends from arts to science and technology, and involves cultural creativity and innovation.

Science, Technology, Engineering and Mathematics (STEM) students should be equipped with designing and making skills for the 21st century jobs. There is growing polarisation of labour-market opportunities between high- and low-skill jobs, unemployment and underemployment especially among young people. Globally, almost 75 million youth are officially unemployed.

This paper presents the driving forces for new jobs and skills for the future. The paper also outlines the contribution of TVET knowledge and skills for digital literacy from basics to an advance level. The implication of digital literacy for the Fourth Industrial Revolution (4IR) is highlighted. The empirical part of this paper present results, based on the investigation done on the vocational educational and training practices at three TVET Colleges in one province in South Africa. The study focused on vocational pedagogic and didactic practices; workshop material and equipment for practical training; Work Integrated Learning (WIL); and integration of theory and practice in vocational subjects. This investigation is a case study to gauge the extent of readiness of some TVET Colleges for the 4IR. The methodology for collecting data included questionnaires, interviews and observation. The participants for the study were students and lecturers. On the basis of the data, the paper determines the extent of readiness of TVET as well as Community Education and Training (CET) Colleges in

the country for 4IR. The paper recommends measures to position the TVET and CET Colleges for the 4IR.

The full paper is available on the following link:

http://cdn.lgseta.co.za/resources/research_and_reports/4IR%20Resources/TVET%20for%20sustainable%20skills%20for%20the%204IR_Snapshot%20at%20some%20TVET%20Colleges%20in%20SA_Moses%20Makgato_TUT.pdf

Author: Prof Moses Makgato is a full Professor at Tshwane University of Technology (TUT) (makgatom@tut.ac.za).

12. *South African Qualifications Authority (SAQA) and the National Qualifications Framework (NQF) in the Context of the Fourth Industrial Revolution (4IR): Realities and Implications* (Yuraisha Chetty)

The South African Qualifications Authority (SAQA) has been engaging with the discourse on the Fourth industrial Revolution (4IR), specifically within the education and training sector. SAQA initiated focused exploratory research to consider the positioning of SAQA and the National Qualifications Framework (NQF) within the context of the 4IR, with a particular lens on the implications of the 4IR for the roles and responsibilities of SAQA, both from a broad organisational perspective as well as in terms of specific functional areas.

This contribution draws from a small, exploratory qualitative research study undertaken amongst a sample of management staff at SAQA. It provides a bird's eye view of some of the key issues SAQA will need to consider as part of envisioning the future within the context of the 4IR. The study selected participants using purposive sampling, and participants represented directorates involved in various functions. The research sought to determine a) the key considerations, b) what would enable success, c) the potential barriers and addressing these barriers, and d) the implications of the 4IR on the roles and responsibilities of SAQA (and particular functions).

In terms of the key considerations, the main issues that emerged from responses pertained to the automation of SAQA's work and the role of SAQA in ensuring the relevance of qualifications. The main enablers of success were as follows: collaboration, being open to change, funding, ensuring relevant qualifications and skills, and ensuring an appropriate Information Technology (IT) infrastructure and updated skills. Some of the reported barriers were the corollary of the reported enablers. According to respondents, the main barriers would be a lack of funding and resistance to change, amongst other things.

The study provides insights into the issues SAQA will need to engage with and provides an initial basis from which further dialogue and engagement can take place.

The NQF Act as Amended, Act No.12 of 2019, and the requirements thereof, such as having separate registers for misrepresented and fraudulent qualifications and part qualifications, and professional designations, amongst other things, will require SAQA to seek technological solutions where necessary, to enhance efficiencies.

SAQA will continue to deepen and enrich its understanding of the implications of the 4IR on its roles and responsibilities, by participating in both external and internal discussions and debates, keeping abreast of developments internationally, and conducting further research as necessary.

The full paper is available on the following link:

https://www.dropbox.com/s/75zwwxmakolktjc/SAQA%20and%20the%20NQF%20in%20the%20context%20of%20the%204th%20Industrial%20Revolution_Realities%20and%20Implications.pdf?dl=0

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13. *Learning by Solving as a Pedagogical Approach to Inclusive Health Innovation* (Trust Saidi, Donné van der Westhuizen, Nailah Conrad, Tinashe Mutsvangwa and Tania S. Douglas)

If South Africa is to keep up with global scientific and technological advances that are converging in what is referred to as the Fourth Industrial Revolution (4IR), while also ensuring social and economic development, the country will require graduates with interdisciplinary skill sets. Such graduates would need to appreciate the imperatives for the creation of an inclusive society. Suitable academic programmes are required that embed students in their social context and equip them with skills that enable them to contribute to inclusive innovation, which focuses on developing goods and services both with and for marginalised communities.

Saidi et al. (2019) have published an article that shows how universities can promote inclusive innovation by creating a learning and innovation environment that enables students to find new ways of addressing societal challenges. The article proposes learning by solving as a means of developing skills for inclusive innovation. Learning by solving equips students with ways of applying knowledge towards achieving developmental goals. It entails students' active engagement with a problem while taking steps towards a solution. The proposed approach to learning by solving combines a platform of engaged scholarship with design thinking as a problem-solving methodology. Engaged scholarship bridges the gap between academic settings and communities by applying research and education towards community development. Design thinking emphasises interaction with end-users of potential solutions to gain an understanding of their particular needs, as part of problem-solving.

The article presents a case study of a class project in a master's level course which aimed to improve the experiences of Deaf patients in an ophthalmology clinic at a public hospital. Learning by solving combined with engaged scholarship and design thinking enabled experiential learning in a real-world setting, provided students with an opportunity to navigate complex challenges, and resulted in productive collaboration with a community of Deaf patients and their healthcare providers. Such an approach to learning develops in students an ability to exploit new forms of knowledge production outside the university and is pertinent in an era where complex

societal challenges necessitate collaborative, interdisciplinary solutions. The approach develops an understanding of social context that mitigates the risk of technology being applied in ways that perpetuate the marginalisation of certain groups.

The full paper is available on the following link:

https://doi.org/10.1080/0376835X.2019.1640662

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14. *Are South African Manufacturing Small, Medium and Micro Enterprise Businesses (SMMEs) Ready for the Fourth Industrial Revolution (4IR)?* (Lizzie L. Mabotja)

The Fourth Industrial Revolution (4IR) is unquestionably resulting in significant changes in the workforce landscape, technological advancements, industry relations and it affects all aspects of society and the economy. This research paper is based on results from an earlier study focused on the challenges faced by Small, Medium and Micro Enterprises (SMMEs), sharing results from survey data and in-depth interview analyses conducted. A sample of 66 SMMEs was selected purposefully from the Small Enterprise Development Agency (SEDA)'s database where manufacturing SMMEs alluded to some of the critical challenges they are facing. A key finding from the research was that technological advancement and digital manufacturing are significant challenges for manufacturing SMMEs in South Africa. Small businesses are critical to South Africa's ability to participate profitably in the 4IR. The research shows that there are significant challenges for manufacturing SMMEs and that should be urgently addressed if South Africa is to participate advantageously in the 4IR. This study recommends embedding technology into education and embracing new advancements and machinery within the education system. A change in the education system will help create a supply for future skills needed in the manufacturing sector. Manufacturing SMMEs contribute to a stronger economy and should embrace automation and Artificial Intelligence (AI); this requires determined and collaborative efforts from government, its agencies and private sector through broader information sharing, planning for future skills and a dedicated fund for technology and modern machinery funding across various industries, particularly manufacturing.

The full paper is available on the following link:
https://amhinternational.com/journal/index.php/jevr/issue/view/247/V%289%292

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15. *Enhancing Learning through Formative Assessment for First Year Education Students* (Lindiwe C. Mthethwa)

Handling formative assessment in previously disadvantaged universities' large classes, can be challenging especially among first year students. This is because adoption of technology is a challenge due to historical context of underdevelopment.

This paper focuses on enhancing learning through formative assessment by exploring how it is conducted to benefit students' confidence on what has been learnt. The problem identified was using formative assessment without any constructive alignment to promote deeper learning. The contextual imperatives have led to establishment of new policies relevant for National Qualifications Framework (NQF) level one, which are indeed needed to be implemented irrespective of contextual deficiencies. Initially formative assessment ought to be designed to equip students with knowledge, understanding and skills that will be used throughout their career rather than targeted at promoting students. Using formative assessment can be misled by concepts such as continuous assessment versus continual assessment, which enabled the students to focus on learning rather than grading.

Data was collected from six lecturers who taught level one education students using semi-structured questionnaires. The intention was to explore the dialogue and reflection involved in their modules and the availability of communal interaction.

The study realised the suitability of Learning Management Systems (LMS) as appropriate for enhancing learning through formative assessment in higher education. Research evidence confirmed the dragging of the adoption rate in using LMS but since usage of technology in this study was confirmed to widen spaces of insight acquisition, the study proposed monitoring of formative assessment at institutional level through consistent intervention of LMS. However, diverse support of interaction styles between lecturers and students using computers was recommended. This was the Human-Computer Interaction (HCI) which was promoted since instructional interaction was not only on creating interfaces but promoting interaction techniques relevant and aligning to the Fourth Industrial Revolution (4IR).

The full paper is available on the following link:

https://scholar.google.com/scholar?cluster=337664666553202578&hl=en&as_sdt=0,5

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16. *Repositioning the Future of the South African Clothing and Textile Industries (Rob Stewart)*

In the Fourth Industrial Revolution (4IR), enterprises will need to merge their virtual and real production domains as much as possible with the help of advanced software, automation and data integration. Production processes and automation should be designed and commissioned virtually in tight collaboration with suppliers and partners. Manufacturers that want to retain their competitive advantage will increase production flexibility, automate logistics and deploy smart machines and smart products along the manufacturing value chain.

The paper reflects on the implications of digitalisation and Industry 4.0 in a digital policy briefing document, "Repositioning the Future of the South African Clothing and Textile Industries". The paper examines this topic through five interconnected themes: increasing data availability through object linked sensors; object interconnectivity providing large data sets and associated powerful business analytics; the application of Artificial Intelligence (AI) to big data, to enable machine learning and responsiveness; new materials availability and capability; and finally the increasing use of additive technologies and robotics.

The paper alludes to four lessons that will have implications for the South African Clothing and Textile Industry:

- If South African retailers and manufacturers are to remain relevant, they will need to establish their own digital platforms for connecting with one-another and the consumer.
- The specific combinations of digital disruptions must be understood and responded to at a specific value chain level.
- The impact and role of disruptive technologies in changing the economics of production and the nature of Global Value Chains due to closer monitoring. Production locations unable to verify their sustainability may be locked out of leading global markets.
- In order to address Clothing and Textiles value chain digitalisation pressures, the paper calls on appropriate institutions to research, engage, interpret and

frame national policy framework. The paper also mentions the potentially very positive impact digital technologies could have on regulatory implementation.

The paper concludes by stating that the future of the South African Clothing and Textile industry will depend on how its stakeholders re-act to digitalisation and Industry 4.0 in the near future.

The full paper is available on the following link:
https://static1.squarespace.com/static/52246331e4b0a46e5f1b8ce5/t/5be4547389858365dbdf42ec/1541690506446/DIP+Brief+7.pdf

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17. *Teacher Education in the Face of the Fourth Industrial Revolution (4IR) in Zimbabwe: Challenges and Opportunities* (Dube Bekithemba)

In this paper, the researcher problematises initial teacher education in Zimbabwe in its failure to revamp its curriculum to cater for the Fourth Industrial Revolution (4IR). Teacher education has remained stagnant for the past decade making it difficult to produce educators that can comprehend and assist learners in teaching and learning in the context of the 4IR. Based on these trajectories, the paper is located in bricolage theory whose agenda is transformation based on local available resources. The two questions are: a) What are the challenges of teacher education in the face of the 4IR? and b) What opportunities can recurriculusation towards the 4IR promote effective teaching and learning? Participatory action research was used to generate data. The findings revealed that while the government is championing the need for the 4IR through policy and curriculum change in school, it overlooks the need to recurriculise teacher education to meet the needs of learners in the face of technology. The paper concludes by arguing that teacher preparedness is critical for adoption of the 4IR and its benefits. To this end, the government of Zimbabwe needs to move towards embracing technology through capacitating teacher education towards adoption of technology.

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18. *Predicting School Performance Using a Combination of Traditional and Non-Traditional Education Data from South Africa* (Henry Wandera, Vukosi Marivate, and David Moinina Sengeh)

The application of Big Data Analytics (BDA) in education is transforming learning, teaching and administration in schools. Current Education Data Mining (EDM) research focuses on teaching and personalised learning in higher institutions mostly in western countries with limited research conducted in African countries. Most research has been conducted using small datasets, simple learning analytics techniques and machine learning black box models to predict students' performance. Black box modelling approaches use complex structures which are difficult to be easily interpreted by stakeholders. EDM approaches and tree based machine learning techniques were synthesised to identify important features that can predict school performance across African countries such as South Africa. LightGBM a gradient boosting framework and interpretable tree based algorithms was applied on combined data sources from community surveys, school master lists and examination results to perform feature importance. The challenge faced in EDM research is limited education data sources; different existing datasets from government reports and archives were merged. Community survey data was used to determine the standards of living in secondary schools within those communities. Cell phone internet, toilets, security, usable water sources, number of teachers and students, school location, and family head were identified as control variables impacting the attainment of schools. LightGBM, underlies the developed prediction model. It empowered the model with high accuracy, stability and easy interpretation hence outperforming XGBoost, decision tree and random forest algorithms. Index Terms—performance prediction, school performance, national statistics.

The full paper is available on the following link:

https://www.k4all.org/wp-content/uploads/2019/07/Predicting-school-performance-using-a-combination-of-traditional-and-non-traditional-education-data-from-South-Africa.pdf

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19. *Augmented Leadership through Adaptive Intelligence* (Cliff Brunette)

The paper explores the notion that traditional learning architectures are too slow to keep up with the speed of learning required to match the rate of organisational adaptation.

The paper posits that the rate of organisational adaptation within the Fourth Industrial Revolution (4IR) requires a new learning architecture that should enable an innovative view of organisational learning itself. However, such a learning architecture would depend on augmented leadership who can harness the collective intelligence, and enable multi-frame thinking, within their organisational teams.

Such a view of organisational learning, however, requires leaders to challenge their own - and their teams' – very human moral dilemma of holding a single truth. The new learning architecture will have to compensate for, and enable, multi-truth intelligence, or rather adaptive intelligence, which could be obtained through the embedding of axioms within the learning architecture.

The full paper is available on the following link:

https://www.researchgate.net/publication/335835507_Augmented_leadership_through_adaptive_intelligence

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20. *Higher Education in the Fourth Industrial Revolution (4IR): Lessons and Trends for South African Higher Education Institutions (HEIs)* (Dawchund. B. Jarbandhan and Abiel Mahlatsi)

The world has undergone a quiet technological revolution that has impacted on every facet of human life. The introduction of smart technology such as three dimensional (3D) printing, autonomous vehicles, new forms of currency (for example, *Bitcoin*), robotic and drone technology and quantum computing, has changed the way in which societies live, work, communicate and operate. Higher Education Institutions (HEIs) themselves have not been isolated from these rapid changes. Online technology driven teaching and learning has become fashionable, and the use of data digital analytics to monitor student throughput and reporting has taken centre stage recently. A perusal of the literature indicates that limited research has been undertaken on the impact of the Fourth Industrial Revolution (4IR) and measuring its impact on HEIs. Consequently, this paper identifies the trends and international experiences that HEIs have adopted in placing themselves at the forefront of this revolution. HEIs cannot use antiquated methods of teaching and learning. Furthermore, HEIs would have to proactively retrain and recruit employees who could prepare students to be active participants in the 4IR. Preparing an adequately trained graduate who is capable of participating in, among other things aspects of social life in the 4IR, is a crucial mandate for HEIs. This paper used an exploratory research design to aggregate all existing evidence to address the following research question: *What are the best international practices that South African HEIs can build on to produce competitive graduates in the 4IR?*

The full paper is available on the following link:

https://www.dropbox.com/s/7cayf5juxsnyx64/Higher%20Education%20in%20the%204IR_Lessons%20and%20Trends%20ofr%20South%20African%20HEIs.pdf?dl=0

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PLANNED RESEARCH

1. *A Broad-Spectrum Overview and Survey of Available Fourth Industrial Revolution (4IR) Technology Being Applied in Agriculture* (JP van Deventer and Tania Prinsloo)

The World Resource Institute (WRI) estimates that by 2050 there will be a significant shortfall between the food being produced and the amount needed to feed an estimated 10 billion people. The WRI additionally estimates that there will be a 56% food gap between crops being produced and those required, if current agricultural techniques remain prevalent. Limited by the availability of arable land and essential agricultural resources such as water, we will be required to change current agricultural practices to feed the growing population, without necessitating an increase in land usage and resource consumption. A shift in the agricultural paradigm and innovative approaches to food production will be required to optimise agricultural practice. From robotics used for automated harvesting of food crops and pest management, up to bioengineering producing crops and livestock that are more resilient that can survive and flourish in harsh environmental conditions, the Fourth Industrial Revolution (4IR) has the potential to have a direct and beneficial impact on sustainable agriculture. The new and innovative technology applied in the establishment of the 4IR's cyber-physical systems has the potential to enhance food security and agricultural practices with the potential of optimising the food production value chain, by reducing waste of limited and valuable resources and speeding up the production of sources of edible calories.

The draft research plan for this paper is available on the following link:
https://www.dropbox.com/s/cdblgoonojtipp7/A%20broad-spectrum%20overview%20and%20survey%20of%20available%20Fourth%20Industrial%20Revolution%20%284IR%29%20technology%20being%20applied%20in%20agriculture.pdf?dl=0

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EVENTS AND REVIEWS

1. *2019 DHET Research Colloquium: The Fourth Industrial Revolution (4IR)*
    (Refiloe Mohlakoana and Rakal Govender)

On 18 and 19 September 2019, the Department of Higher Education and Training (DHET) hosted its fifth Annual Research Colloquium. The aim of the 2019 Research Colloquium was to provide a platform for researchers to share new and emerging research on the Fourth Industrial Revolution (4IR). The Colloquium showcased and shared new and cutting-edge research on key dimensions of the 4IR, thus providing an opportunity for stakeholders to reflect on policy and practice.

The two-day format featured international and continental presentations, as well as, panel discussions, and a set of parallel commissions on the following topics: (a) Skills Supply and Demand in the Context of 4IR; (b) Technologies to Improve PSET; and (c) Workplace Readiness in the Context of 4IR.

The international session featured presentations from Dr Marieke Vandeweyer from the Organisation for Economic Co-operation and Development (OECD); and Ms Kirsty Chadwick from the Training Room Online (TTRO).

Dr Vandeweyer gave an international view of the 4IR where she highlighted the importance of access in digitation. Sharing some research around access, she said it is estimated that by 2022, for each person there will be three connected devices; and noted that access to technology differs between households in rural areas and urban areas. In rural households only 56% of households have access to fast fixed broadband, compared to 85% in urban households. She noted progress in the use of technology, highlighting that a lot of people are using their smart phones mainly for personal use. With this in mind, there is a need to move beyond basic uses of technology and move towards the more sophisticated use.

She highlighted that the policy response to digitisation and automation should consider skills, training, adult learning and future readiness, and alignment.

Ms Chadwick spoke to *Leveraging Digital Platforms to Accelerate the Creation of Economic Opportunities* where she shared insights from Saudi Arabia, from which she noted the following recommendations:

- Education must work together with technology to build a skills pool within the 4IR framework.
- There is a need to break down silos.
- Get small-medium enterprises involved in innovative programmes.
- Provide the necessary support to small-medium enterprises as they are failing.
- Embrace the e-tech community in our ecosystem.
- Create an impact fund for e-tech entrepreneurs; as these businesses need that kind of ecosystem. They have great ideas, but they do not have access to capital and procuring from government is also difficult.
- Design something that looks different, something for a new sector.

The proceedings report of the 2019 Colloquium will be made available on the DHET website: www.dhet.gov.za, and the presentations are available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FlaQa?dl=0

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2. *Interrogating the Fourth Industrial Revolution (4IR) Discourse: Seminar Summary* (Nobakoena Ntoba, Nompumelelo Hlatshwayo, and Queen Mawela)

On the 17th October 2019, the Human Sciences Research Council (HSRC) hosted a seminar on "Interrogating the Fourth Industrial Revolution (4IR) Discourse". The presenter was Professor Mokong S. Mapadimeng who is the Director of Education and Skills Development Unit at the HSRC.

Prof Mapadimeng stated that the concept of the so-called 4IR has high contemporary currency and is marked by claims that it will fundamentally alter the world we live in. As such, it warrants strategic responses to optimise the opportunities it presents, while mitigating its likely undesirable consequences. Drawing from long wave theories that were previously used to account for major societal changes, notably main transitions such as from pre-industrial feudalism to industrial capitalism, a theoretical critique of the discourse is advanced. Identified as major weaknesses within the discourse, are: the absence of a theoretically anchored explanatory account of the changes said to be underway; contradictions and inconsistencies amongst proponents of the 4IR around its periodisation; and exaggerative claims made without supporting evidence about the progressive nature of the technologies that define the 4IR phenomenon. It was noted that the discourse is also riddled with uncertainties.

The seminar offered a theoretical critique and outlined a proposal for an in-depth qualitative analysis located within the long wave theories of change. Its key argument was that such an undertaking would allow for a much more subtle account and grasp of present day technological innovations, which in turn, should inform strategic responses by the less developed world.

Professor Mapadimeng argued that there are limits of the 4IR discourse in a sense that there is no consensus on where exactly we are. Some argue that we are in the 4IR while others debate that we are at advanced stages of the third Industrial Revolution or getting to the 4IR.

He also noted that the periodisation of the Industrial Revolution is characterised by long and short waves. The transition period from one Industrial Revolution to the next has gotten shorter by the decades.

He is unconvinced that we are in the 4IR because he questions whether the 4IR is based on internet and green energies, also is it moving from fossils to renewables?

In conclusion, he noted that the present discourse on the 4IR is misleading and confusing and the matter needs to be approached with caution, wisdom and open minds; we need to be aware of rushed actions.

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3. *Workshop: The Impact of the Fourth Industrial Revolution (4IR) on Skills (Rakal Govender and Renay Pillay)*

On 12 November 2019, the Banking Sector Education and Training Authority (BANKSETA) hosted a workshop on the Impact of the Fourth Industrial Revolution (4IR) on Skills. The workshop took place at the Mining Qualifications Authority (MQA) in Johannesburg.

Mr Vuyani Ntanjana, Head of Research at BANKSETA, welcomed attendees which included banks, stakeholders and the Department of Higher Education and Training (DHET), before providing a background of the BANKSETA Research Chairs. He noted that there were three chairs, as follows:

- Monitoring and Evaluation (M&E): Prof Eureta Rosenberg, Rhodes University.
- Occupations and Skills: Dr Presha Ramsarup, University of the Witwatersrand (Wits).
- Digitisation: Dr Colin Thakur, Durban University of Technology (DUT).

He noted that the purpose of the workshop was to share research from the Digitisation Research Chair.

Dr Thakur noted that there was a difference of about 100 years between the first and second revolutions and between the second and third; however there was only a difference of 30-40 years between the third industrial revolution and the 4IR. He then distinguished between the concepts of digitalisation (i.e. the conversion of text, pictures, or sound into a digital form that can be processed by a computer) and digitisation (i.e. the process of converting information from a physical format into a digital one), before providing examples of organisations that were in different stages of these processes; for example, he noted that the South African Revenue Service (SARS) was partly a mixture of both. His point was that the 4IR was taking place incrementally.

He also talked to the mass job loss owing to 4IR, particularly in the banking sector, where he listed multiple media examples of restructuring as a result of machines being able to do the tasks previously done by humans. For example, with the growing use of internet banking, there was less of a need for as many tellers with regards to deposits and transfers etc. He also gave the example of chatbots which replaced people at Multichoice. People take the queries to the chatbots, so there is less of a need for as many people answering queries on the phone. He noted that chatbots are going to be the next big thing in South Africa.

On the other hand, with the 4IR comes the requirement of new jobs and skills. He noted that 4IR-specific jobs available amounted to a total of 61155, which far outnumbers the number of retrenchments as a result of the 4IR. He gave specific examples of there being a need for 8500 data scientists (based on the number of job adverts published on PNET). He also noted that the country was only producing 3000 when there was a need for 60 000. He noted that the financial sector is highest contributor to Gross Domestic Product (GDP) and employs people across the widest spectrum of things, adding that the scope and span of opportunities in the country is wide.

The full report with the above research findings will be made available on the BANKSETA website: www.bankseta.org.za.

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PAPERS FROM EVENTS

1. *Labour Market Imbalances by Occupations, Industries and Skills* (Marieke Vandeweyer)

The Fourth Industrial Revolution (4IR) is changing the skills needed in labour markets across the world. Using the Organisation for Economic Co-operation and Development (OECD) Skills for Jobs methodology, this paper documents the skills imbalances found in the South African labour market. It describes the methodology to calculate shortages and surpluses in detail, and presents the results at the Organising Framework for Occupations (OFO) occupation level, the Sector Education and Training Authority (SETA) industry level and the O*NET skills, abilities and knowledge level.

The analysis shows that shortages are found in occupations at all education levels. While the majority of occupations found to be in shortage are high-skill occupations, some of technical and crafts occupations are among the occupations with the most severe shortages. At the industry level, the SETA sectors facing the largest shortage-intensity are the safety and security industry, the mining industry and the energy and water industry.

When translating these shortages into skills and knowledge imbalances, the results point to significant shortages in the knowledge areas of computers and electronics, clerical, and administration and management, but also for some more transversal skills such as reading comprehension, writing, active learning and active listening. The paper concludes with some international good practices examples on how to use this type of skill needs information to prepare students and adults for a changing world of work.

The full paper is available on the following link:

https://www.dropbox.com/s/li222kd0wkpmrvu/Skills%20for%20Jobs%20in%20South%20Africa_Labour%20Market%20Imbalances%20by%20Occupations_Industries%20and%20Skills.pdf?dl=0

The above ideas were presented by the author at the 2019 Department of Higher Education and Training Research Colloquium on the 4IR and its implications for Post-School Education and Training (PSET). The presentation is available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FlaQa?dl=0

Author: Dr Marieke Vandeweyer is a Labour Market Economist at the (Organisation for Economic Co-operation and Development) OECD in Paris (Marieke.VANDEWEYER@oecd.org).

2. *Industry 4.0: Implications for Qualification Design, Accreditation and Certification* (Vidmantas Tūtlys and Georg Spöttl)

The Fourth Industrial Revolution (4IR) brings development of innovations based on combinations of technologies, such as Internet of Things (IoT), Artificial Intelligence (AI), cybernetical – physical systems. These innovations are radically changing the nature and contents of the human work, skills, and qualifications. The advent of the 4IR changes the demand of skills, structures of labour market and employment conditions (Schwab, 2016; Frey, Osborne, 2013; Spöttl, Windelband, 2017). Digitalisation, automation and robotisation change the work organisation (digital taylorism), what threatens not only traditional routine jobs, but also those jobs, that so far have been considered as high skilled (Schwab, 2016; Brown et al, 2011). Development of the 4IR could increase the segregation between the low skill and high skill segments of the labour market by reducing the employment and career opportunities for the first segment and significantly increasing them for the second one, thus increasing the social discontent, insecurity and tensions (Schwab, 2016). The study executed by the Steinbeis Foundation on the implications of the Industry 4.0 for the metalworking and electronics industry in Bavaria disclosed, that the vocational skills and qualifications of industrial workers and specialists will not lose their importance and applicability in the changed industrial work processes (Bayemevbm. 2017).

There are proposed different scenarios of future development of technologies and work organisation with rather contrasting views on the implications of the 4IR for skills and jobs: from the elimination of the routine jobs and operations that are easily susceptible to algorythmisation (including even high skilled jobs), to the increasing complexity and enrichment of skilled and high skilled jobs and related work processes with the new tasks and operations related to digitalisation, increasing networking of work processes and informatisation of work (Hirsch-Kreinsen, Itterman, 2017; Lee, Pfeiffer, 2017).

The adaptations of qualifications to the requirements of the Industry 4.0 is focused improvement of their responsiveness to the changes of the world of work. However,

there is a lack of research and expert discussion on the implications of the Industry 4.0 for qualifications and their systems. This research seeks to fill in this gap and to initiate more profound discussion about the change of vocational and professional qualifications created by the advent of the 4IR. To attain this goal, the following questions for research and discussion, can be proposed:

- Would Industry 4.0 challenge the existence of vocational and professional qualifications in the current form leading to their fragmentation and dissipation into more flexible and easier adjustable elements?
- Is there any place for a qualification as we understand it now in the dynamically changing world of business and work depicted in the visions of the Industry 4.0?
- What are the possible implications of the Industry 4.0 for the processes of design of qualifications, assessment of competence and awarding of qualifications?

This paper will seek to answer these questions by executing meta-analysis of the different studies and analytic materials on the implications of the Industry 4.0 for the skills, training and qualifications.

The above ideas were presented by the a Prof Vidmantas at the 2019 Department of Higher Education and Training Research Colloquium on the 4IR and its implications for Post-School Education and Training (PSET). The presentation is available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FIaQa?dl=0

The full article will be published in 2019.

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3. *Post-School Education and Training (PSET) as a Digital Ecosystem* **(James Keevy, Rooksana Rajab, Sebolelo Nomvete, and More Manda)**

While several role players in the Post-School Education and Training (PSET) system are moving towards the development of Information Communication Technology (ICT)-enabled solutions and platforms in South Africa to improve operational efficiency and governance, these developments are largely uncoordinated. The interface between these different developments lack interoperability and stands to benefit from improved coordination, which will enhance efficiencies within the PSET system. This is in line with the decision for shared services to be developed across the Sector Education and Training Authorities (SETAs) in particular, but also in relation to the interface between SETAs, the Department of Higher Education and Training (DHET) and other systems, including universities. We now have the technology to develop self-sustaining electronic platforms for collaboration and learning opportunities, including the utilisation of data. These new digital ecosystems can provide us with limitless opportunities to rethink academic integrity, standards and qualifications in a new world based on the principles of interoperability. The paper shares the emerging experiences and insights that are part of a collaborative project in the PSET system in South Africa. In particular, two concepts central to the undertaking, namely interoperability and a digital ecosystem are explored.

The full paper is available on the following link:
https://www.dropbox.com/s/3t2sygb5qfg5syx/Digital%20interoperability_the%20new%20frontier%20for%20academic%20integrity%20in%20the%20post-school%20education%20and%20training%20system.pdf?dl=0

The above ideas were presented by the Dr Keevy and Dr Manda at the 2019 DHET Research Colloquium on the 4IR and its implications for PSET. The presentation is available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FIaQa?dl=0

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4. *Exploring How Work Integrated Learning (WIL) Can Be Used as a Catalyst to Prepare Bachelor of Commerce (B Com) Degree Students for the Fourth Industrial Revolution (4IR): A Case Study at a University in the Western Cape* (Karen Dos Reis)

Universities are widely criticised by employers for inadequately preparing students for the world of work. Hagemann (2017) argues that if learning at universities 'does not translate into skills that individuals can use to advance themselves in life, what learning has really taken place'. While universities are using the right buzzwords when it comes to preparing students for the Fourth Industrial Revolution (4IR) , the reality is that the status quo of traditional way of offering degree programmes still remains (Effeilcorp, 2018).

With the rise of the #feesmustfall movement in 2015, it became evident that students are frustrated with the status quo of the higher education system. While their frustration was evident, it is notable that students are aware that change is inevitable but are unfortunately not in a position to drive change in the university curriculum.

The pertinent question is whether universities are preparing students to apply the 21st century skills that are key in the workplace, as well as equipping them with the digital skills needed for the future (Effeilcorp, 2018). An important role of a university in preparing students for the future is the importance of developing their emotional intelligence and shaping their minds to understand how to acquire new skills and to apply these skills, how to solve problems creatively and how to unlearn or relearn when they need to.

It is against this background that this study was motivated to explore how Work Integrated Learning (WIL) can be used as a catalyst to prepare students for the 4IR. This paper argues that learning must become more personalised, relevant and contextualised for students to be adequately prepared for the 4IR and it is vital for higher education to partner with multiple stakeholders to create this type of learning environment.

The full paper is available on the following link:

https://www.dropbox.com/s/ophmm09oi8vovvg/Exploring%20how%20work%20integrated%20Learning%20%28WIL%29%20can%20be%20used%20as%20a%20catalyst%20to%20prepare%20BCom%20degree%20students%20for%20the%20fourth%20industrial%20revolution%20%284IR%29_A%20case%20study%20at%20a%20university%20in%20the%20Western%20Cape.pdf?dl=0

The above ideas were presented by the author at the 2019 Department of Higher Education and Training Research Colloquium on the 4IR and its implications for Post-School Education and Training (PSET). The presentation is available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FIaQa?dl=0

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5. ***Balancing Skills Supply and Demand in the Context of the Fourth Industrial Revolution (4IR): A Perspective of the Five Media, Information and Communication Technologies Sector Education and Training Authority (MICT SETA) Sub-Sectors*** (Thabang Motsoeneng)

The topic of Supply and Demand in the context of the Fourth Industrial Revolution (4IR) is receiving greater attention where much emphasis is placed on how it will disrupt every industry in every country through large-scale automation, adoption of emergent technologies, big data and Artificial Intelligence (AI). While this sounds appalling, greater lenses are placed at how this change will or may redefine the workplace skills; however, it does not mean people will be out of their jobs; but one thing is certain, existing jobs will need new skills. The objective of this research paper is to explore both practical and theoretical lenses of skills demand and supply in the context of the 4IR, focusing on the five Media, Information and Communication Technologies Sector Education and Training Authority (MICT SETA) sub-sectors.

The MICT SETA, as a skills development facilitator, aims to: a) shed some light on the demand for (skilled) labour in the MICT sector; b) highlight factors that impact on the volume of labour supply; c) describe the shifts in the economy, in trade, technology, and in policies, that are driving changes in the demand for skilled labour in the MICT sector; and d) assess the quantity and quality of skills intervention programmes, with specific emphasis placed on MICT-aligned National Qualifications Framework (NQF) programmes, in the context of the 4IR. In this paper the SETA shows that there is a need for talent more than capital, age old trust education systems need to be flexible, and the link between education and business need to be a two-way street.

The full summary is available on the following link:
https://www.dropbox.com/s/oz4fll94exchjlj/Supply%20and%20Demand%20in%20the%20%20Context%20of%204IR.pdf?dl=0

The above ideas were presented by the author at the 2019 Department of Higher Education and Training Research Colloquium on the 4IR and its implications for Post-

School Education and Training (PSET). The presentation is available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FIaQa?dl=0

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6. *Impact of the Fourth Industrial Revolution (4IR) on Tertiary Education* (Nelishia Pillay and Sunil Maharaj)

The Fourth Industrial Revolution (4IR) has brought with it an era of internet of things (IoT), Artificial Intelligence (AI) and robotics amongst others. The presentation focused on the fourth sustainable development goal posed by the United Nations, namely, to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" [1]. The presentation reflected on what this means for tertiary education in South Africa. The impact of the 4IR on education is twofold. On the one hand the 4IR will bring with it opportunities to improve teaching and learning. Secondly, there is a need to ensure that tertiary education programmes sufficiently prepare graduates and the current workforce to successful face the challenges posed by the 4IR. In the case of the latter training to support a skills shift to prevent unemployment timeously is necessary. The presentation examined both these aspects.

AI is and will continue to play an imperative role in improving teaching and learning. One of the areas that AI is contributing to is educational data mining and learning analytics to predict student failure and success [2]. At the University of Pretoria (UP) this is being used to detect student failure and to put mechanisms in place in response to this to prevent failure of the student. Such data analytics are also being used to identify those students that should attend additional tutorials. Another area in education in which AI is making a mark is automated teaching assistants and intelligent tutoring systems. Intelligent tutoring systems provide individualised tuition to assist learners overcome individual learning difficulties. At Georgia Tech University an automated teaching assistant attained a 97% accuracy in answering student queries [3]. Automated assessment is a further area in which AI is making a contribution. This has ranged from automatic marking of essays at schools in China to automatic marking of computer programs [3].

As we move into the 4IR, how do we prepare our graduates to meet the challenges posed by the 4IR in the various sectors of the South African economy? Should all students be required to complete courses on AI and programming as part of their degrees? How can Computer Science graduates be better equipped? Should South African universities offer degrees in AI and robotics as is done in Europe and the

United States? The presentation examined answers to these questions. A key aspect is to produce graduates that have sufficient skills and knowledge of foundational building blocks to adapt to ever-changing situations. A further aspect that the presentation explored is the need to cater for a skills shift to re-skill the current workforce. This needs to be planned and employed timeously to reduce the impact that it will have on employment. AI, IoT and robotics literacy is essential for the general public. The presentation examined mechanisms to facilitate this. One such initiative is the AI Student Society at UP which aims to promote AI literacy and community awareness.

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[3] Artificial intelligence for Africa: An opportunity for growth, development and decmocratisation," Microsoft White Paper on Artificial Intelligence, 2018.

The above ideas were presented by Prof Nelishia Pillay at the 2019 Department of Higher Education and Training Research Colloquium on the 4IR and its implications for Post-School Education and Training (PSET). The presentation is available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FlaQa?dl=0

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7. *The Impact of the Fourth Industrial Revolution (4IR) on Africanisation as One of the Emerging Global Trends in Higher Education* (Fabian N. Fon and Melusi Sibanda)

Africanisation as one of the global trends in higher education has been widely studied by different scholars, and they found it very difficult to trace the point of convergence with internationalisation until the study of Botha (2010) which demonstrates the compatibility of both trends. It defined Africanisation as all the dimensions of the process whereby University endeavour to retain its African character to achieve specific academic, economic, political, and cultural aims. Therefore, Africans must be the primary and principal communicator of the African experience. This was due to the fact that internationalisation as another global trend seemed to be dictating African experience which was not correct hence the conceptualisation of Africanisation where the primary objectives were for Africans to uphold African aspirations, descent, cultural heritage, own ideas, rights, interests and ideas, self-concept and own rationality in intercultural context. South Africa has one of the leading economies in Southern Africa if not in Africa, but its higher education continues to be under the spotlight as not being Africanised enough. However, there has been the recent wave or debate on decolonisation of curriculum that has been ongoing for a while now. If the Fourth Industrial Revolution (4IR) refers to the new wave of innovations that use several technologies that comprise three Dimensional (3D) printing, Internet of things (IoT), Artificial Intelligence (AI), smart cars, big data, and on-demand economy, what does this mean to Africanisation especially in higher education? Will it be promoting or make disappear Africanisation? Is Africa ready for the 4IR? What is the role of 4IR in terms of policies development and economic impact in African countries? This question seems simple but complex when it comes to unpacking them hence leaving gaps for research opportunities. Therefore, the paper sought to understand the role of 4IR in curriculum design, policies, execution (teaching and learning), assessments, evaluation and moderation. It interrogated the readiness of African higher education institutions (HEIs) as the majority may be very far from welcoming the 4IR as they lack affordability, resources, expertise and mere facilities and utilities to support such technologies. Lastly, it looked at why it is essential for Africa to be the creator of its 4IR than being a consumer because it is only then that a massive influence can be observed in higher education due to current miss match and a higher number of

redundant technologies seating in many HEIs. Africanising 4IR is currently a necessity and not a choice if Africa needs to move forward.

The above ideas were presented by the authors at the 2019 Department of Higher Education and Training Research Colloquium on the 4IR and its implications for Post-School Education and Training (PSET). The presentation is available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FlaQa?dl=0

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8. *The Fourth Industrial Revolution as a Driver of the South African Post-School Education and Training Applications Process* (Salamina. M. Dzingwa and Fayth. A. Ruffin)

Post School Education and Training (PSET) is commonly viewed as a major engine of economic development (Amoateng & Dufur, 2014:101; Câmpeanu, Dumitrescu, Costică & Boitan, 2017:749). This is evidenced by such South African policy documents such as the National Development Plan: Vision 2030 as well as the National Skills Development Plan (NPC 2011; NSDP 2019). Simultaneously, Mohamedbhai (2014:68) contends that "no country in the world has been challenged as much as South Africa in its attempt to overcome the overtly racial inequity in higher education after the end of apartheid in 1994". Application processing remains complex riddled with what appear to be inefficiencies. For example, in 2012, the tendency for applicants to appear in person at institutions led to the death of a mother who was accompanying her son to apply for late admission to the University of Johannesburg (UJ), 20 others were injured (Chetty, 2014; Jenvey, 2012). This incident subjected the South African Higher Education Institutions (HEIs) to scrutiny regarding the lack of efficiency and effectiveness of application processes. As a result a nation-wide PSET – Centralised Applications Service (PSET-CAS) was designed with 2019 as the targeted implementation date. Since 1998, a Centralised Applications System (CAS) has been operational only in the province of KwaZulu-Natal (KZN). The Central Applications Office (CAO), a non-profit organisation, processes applications for KZN PSET institutions.

This mixed methods study drawn from doctoral research, poses the research question: How can lessons learnt from a study on the KZN based CAS inform implementation of the national PSET-CAS in a fourth industrial age? We argue that, inasmuch as the Fourth Industrial Revolution (4IR) requires rethinking of teaching and learning, research, and overall post-school educational service delivery; attention must be directed to applications processes. We further argue that, provided certain actions are timeously undertaken, the 4IR offers opportunities for South African applications processing to advance decoloniality. The study employs a case study design underpinned by an integration of philosophical worldviews of post-positivist, pragmatist and, constructivist. Qualitative data regarding the CAS were collected from

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staff at the Durban University of Technology (DUT) and the University of KwaZulu Natal (UKZN) through interviews and focus groups. A group interview was conducted of officials at the CAO. Students from DUT and UKZN were survey respondents. There were 312 study participants. Non-probability sampling and purposive techniques were employed for the qualitative component and stratified random sampling for the quantitative component. Qualitative data were analysed through a combination of content, matrix and thematic analysis. Quantitative data were analysed through Stata 11.0. Based on the findings, 4IR lessons are drawn for the PSET-CAS and conclusions, policy implications and recommendations set forth to improve PSET applications processing in South Africa.

This research is under consideration for publication in: *The Electronic Journal of Information Systems in Developing Countries*

The above ideas were presented by the Dr Dzingwa at the 2019 Department of Higher Education and Training Research Colloquium on the 4IR and its implications for Post-School Education and Training (PSET). The presentation is available on the following link:

https://www.dropbox.com/sh/bis541d61xbatu1/AAACveW0WFoognBff4M-FIaQa?dl=0

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9. *Inspiring and Enhancing Academics as Teachers for Serving Diverse Students Using the Fourth Industrial Revolution (4IR)* (Sibongiseni Tunzelana Thotsejane)

Higher Education Institutions (HEIs) are finding themselves in an era where academics must be prepared to teach diverse students. There seems to be a multi-disciplinary approach and an increase in being inclusive at Post-School Education and Training (PSET) institutions globally. The Fourth Industrial Revolution (4IR) may be interpreted as a technological development that hazily converges physical, digital and biological systems. Industry 4.0 or the 4IR integrates cyber-physical systems and Internet of Things (IoT); big data and cloud computing; cyber-security; Artificial Intelligence (AI) and additive manufacturing; robotics; and genome editing.

As Graduates consider life after graduation, universities are facing questions about the Graduates' destiny especially employment. In the context of South Africa with an escalating unemployment rate for Graduates; there needs to be a strategy that prepares every single Graduate with a possible entrepreneurship opportunity that begins with being a Small Medium Enterprise (SME) using the knowledge and skills acquired from HEIs. The 4IR requires certain skills that are not exactly the same as skills that were required in the third industrial revolution (previous revolution) where information technology (IT) was the key driver. SMEs offer agility and significant value in addressing challenges of inequality, poverty and unemployment, stipulated in our national development plan 2030.

A value-based and sustainable strategy, unbiased by hype or fear, can improve e-learning practice with Big Data Analytics (BDA) and AI while producing commercial applications. There are at least five parts of the value-based strategy in the study: (1) create an institutional action plan while identifying time-consuming big data analytics tasks, (2) use AI to partially automate those tasks while directing lecturer attention to significant student issues, (3) collate all significant student data from the student, university, parents or guardians and social media for learner analytics purposes in order to serve each student as an individual (4) comply with Information and Communications Technology (ICT) laws such as General Data Protection Regulation (GDPR) and Protection of Personal Information Act (POPIA) and (5) continuously

evaluate the effects of BDA and AI while empowering students through coding commercial applications. The paper shares applications of inspiring academics must be prepared to teach diverse students enabled by 4IR technologies such as learner analytics, big data analytics and education technologies. The paper encourages simplicity of inspiration while advocating for a human-centred and technology centred approach to 4IR applications for the primary benefit of humanity. Stakeholders of PSET must be inspired and upskilled in the 4IR era.

The above topic was presented at the following event: Inspiring and enhancing academics as teachers for serving diverse Students, International Conference On "Enhancing Academics as Teachers" (Quality Enhancement Project Symposium). The slide presentation is available on the following link:

https://www.che.ac.za/sites/default/files/publications/Inspiring%20and%20Enhancing%20Academics%20as%20Teachers%20for%20Serving%20Diverse%20Students.pdf

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RESEARCH PRACTICE

1. *Using Analytics for Early Interventions in Student Success at the University of Pretoria (UP)* **(Alta van der Merwe, Dolf Jordaan, Jaun-Claude Lemmens and Sunil Maharaj)**

One of the main foci at universities is student success and throughput. This is especially of greater importance given the current financial situation we face and that in the Fourth Industrial Revolution (4IR) we need more engineers and scientists where the throughput is relatively lower than other disciplines. In the Faculty of Engineering, Built Environment and Information Technology (EBIT), we are constantly in the process of investigating new ways to support our students better. One of the exciting tools in the 4IR is the use of prediction through data analytics that enables universities to use previous data and do predictions for current students. At the University of Pretoria (UP) we have several projects that make use of historical data to assist us to create opportunities for interventions.

Our first project include the Student Academic Readiness Survey© (STARS) which measures students' academic attitudes and behaviours that enable readiness for university education. The purpose of the STARS is to identify areas, namely; academic, social or motivational, where UP could possibly support students. Readiness for university education can broadly be defined as the level of preparation of a student (cognitive and non-cognitive) in order to succeed at a Higher Education Institution (HEI). The STARS measures (a) academic attitude and needs, (b) motivational factors, (c) background factors, (d) test and exam skills, and (e) general well-being. During the welcome week almost all first-year students completed the STARS, which is used in combination with high school results to recommend interventions to empower students to meet their academic goals and graduate in minimum time (FLY@UP). If students agree, a copy of their report will also be available to a Faculty Student Advisor who will invite students in need of academic or course related support. First-generation and students from rural home environments will additionally be invited to become part of a mentorship programme. Students are also welcome to contact the Department of Student Affairs for health, psychological or counselling needs.

A second project is where we use prediction using the Learning Management Systems (LMS). The LMS supports not only the first strategic goal of the University to improve access and student learning but it also became a vital source of data to support student success. Through the integration of descriptive and predictive LMS data, academic staff have access to information to initiate subject related early interventions to support students either at risk or with the ability to improve their current grades.

The Faculty of EBIT uses both these sources of data and new Artificial Intelligence (AI) and analytic techniques to assist us with information to introduce interventions to enhance our student success.

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2. *What's needed to Prepare Youth for a Digitised World – Addressing Symptoms and Causes* (Rob Urquhart and Dianne Woodward)

Harambee's work with over 500 employers and in pathwaying youth to nearly 150,000 income generating opportunities has produced a deep evidence base for what is required to transition young people into work. Specifically, in preparing youth for a digitised world we understand that there are four attributes that need to be nurtured: foundational competencies (such as digital literacy and problem solving), the behavioural attributes needed for work (such as curiosity, positive mindset), resourcefulness (grit/agency) and then work readiness interventions relating to the specific roles. This all needs to be underpinned by a process of interactive and continuous learning. Harambee's insights are reinforced by the recent McKinsey report on 'The future of work in South Africa', which proposes a national plan of action in order for South Africa to leverage the employment opportunities of the fourth industrial revolution (Magwentshu, Rajagopaul, Chui, & Singh, 2019).

Whilst interventions that address these attributes are needed, if they take place without considering extraneous barriers that prevent young people taking up the opportunities on offer then the cause has been addressed but not the underlying symptom.

Instead it is argued that to prepare youth for a digitised world, the skills ecosystem needs to be repositioned in four ways. Firstly, there is a need for more agile and inclusive workforce development that can prepare youth coming out of the schooling system over the next 10 to 15 years and unemployed youth with no or limited work experience, for access and successful integration into not only digital opportunities but economic opportunities in general.

Secondly, there is a need to manage the pathways of young people. The days of getting one qualification and climbing the corporate ladder in one company are gone. In the Fourth Industrial Revolution (4IR), youth are required to be agile, flexible and responsive to ever-changing market needs. To do this they need help to navigate the skills landscape along non-linear career paths.

Thirdly, credentialing needs to be more demand-focused; on broad employability competencies that are sector-specific, modular and stackable, and don't follow traditional, linear, once-off career trajectories.

And finally, there is a need for performance-based financial solutions where funds are deployed against the achievement of pre-defined outcomes (e.g. placement into a job) that unlock barriers to employment and create quicker and more cost-effective pathways for youth (and especially excluded youth) into employment opportunities at scale.

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3. *The Fourth Industrial Revolution (4IR) Intervention on the Artisan Development for the Agricultural Sector Post Education System* (Nokuthula I. Sibia and Frikkie Fouche)

The Fourth Industrial Revolution (4IR) can be defined as science and technology advancement which brings drastic change worldwide (Liao, Yongxin et al, 2018). In the South African agricultural sector, the 4IR is at an infant stage. However, with the rapid technological growth in the country, training should be aligned to the skills demand thereof. One of the major drivers in addressing these changes is in supporting artisan development.

The artisan development programme at the Agricultural Sector Education and Training Authority (AgriSETA) aims to bring a paradigm shift that bridges the gap between emerging skills brought by the 4IR and those currently offered by the sector. Through this programme, trades are supported to address training needs in the sector, which are also aligned to the commitments set by the National Skills Development Plan 2030. Over the period of nine years from 2010-2019 AgriSETA has trained 36 trades which have an impact on the sector and moving towards advancement of technology through skills transformation.

The main occupations trained in the artisan development were electrician, tractor mechanic, millwright, diesel mechanic, fitter and turner and mechanical fitter/ fitter. Due to the 4IR, there is less demand in training of fitter-welder, industrial machinery mechanic, electrical equipment mechanic, diesel fitter, transportation electrician, forklift mechanic and heavy equipment mechanic. The reasons attributed to this shift are related to mechanisation and automation of the agriculture sector. Research has shown that most routine occupations such as those identified as currently less in demand will lead to job losses (Autor and David Dorn,2009; Aaronson, 2019) thus posing a threat to addressing the triple challenges, i.e. unemployment, poverty and inequality faced by South Africans.

AgriSETA is well aligned in responding to the skills needs and occupations in the artisan development which respond to the 4IR.

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