NATIONAL SCIENCE AND TECHNOLOGY FORUM

DISCUSSION FORUM
ON
CREATIVE ECONOMY, SCIENCE AND THE 4th INDUSTRIAL REVOLUTION

2 & 3 MARCH 2022

TABLE OF CONTENTS

DAY 1

WELCOME AND INTRODUCTIONS, PROGRAMME, OUTPUTS, AND INTENDED OUTCOMES (MS JANSIE NIEHAUS, EXECUTIVE DIRECTOR, NATIONAL SCIENCE AND TECHNOLOGY FORUM (NSTF))

Ms Niehaus welcomed everyone to the NSTF discussion forum. Although it had been difficult to conceptualise and define the scope of the topic of discussion, the programme for the forum promised to be interesting and unusual.

The context of today's artists was very different from that of the recent past and this influenced art and the way that art was consumed by the public, as well as the perception of the way artists worked. The new way of working presented a variety of new opportunities and possibilities for making art, marketing and selling artworks, and delivering artworks by electronic means. There were also new possibilities of securing the Intellectual Property (IP) of artists.

The 2021 International Year of Creative Economy for Sustainable Development presented an opportunity to look at creative industries from a new perspective, that of science and technology, and to notice the interesting touch points. It also presented an opportunity to look at Science and Technology from the perspective of creativity and raise questions about whether the Arts had any use for Science and Technology and whether Science and Technology had any use for the Arts. In 2021, the NSTF made a special award for an outstanding contribution to Science, Engineering, Technology and Innovation towards the creative economy for sustainable development.

Some of the interesting and tricky questions for consideration during the two days' discussions and beyond were:

- What do the 4IR mean for the creative industries?
- Are 4IR technologies useful for or not of real relevance to creatives?
- What does it mean to be an artist in the 4IR?
- What does it mean to be human in the 4IR?
- Where does art stop and technology begin, particularly given the challenges presented by Artificial Intelligence (AI) that force art and technology to have boundaries?

THE IMPORTANCE OF INNOVATIVE THINKING IN THE FOURTH INDUSTRIAL REVOLUTION (4IR) (DR TEGAN BRISTOW, UNIVERSITY OF THE WITWATERSRAND (WITS) SCHOOL OF ARTS (WSOA) AND FORMER DIRECTOR, FAK'UGESI AFRICAN DIGITAL INNOVATION FESTIVAL)

The intersection between art and science was a very interesting location and was often about translation and perception and understanding from a scientific perspective, what happened in the artistic or creative process and understanding what happened in the scientific process from the creative perspective. Those conversations had to go both ways in order for them to be valuable and well considered.

Overview of Fak'ugesi African Digital Innovation Festival and its award winning work

The Fak'ugesi African Digital Innovation Festival was very much about bringing culture, specifically African culture, forward in the digital creative sector. Participants at the 2019 event commented that the festival was about digital innovation, looking at really cool projects and displaying them and showcasing all the talents that South Africa and other African countries had. It was a meeting place for content creators, technologists, virtual reality (VR) enthusiasts, and a springboard for revival in Africa. The festival provided opportunities to meet people, network, see amazing work, be inspired, plot and scheme, learn basic technical principles, and for poets and digital artists to come together to create auto-correlated poetry. Participants found the festival to be inspirational as it encouraged people to start looking at the creative arts and technology as a business and was an opportunity to expose children to the animation industry. On another level, the festival was a market place where connections were made, especially in terms of owning, selling and trading in a way that is meaningful to Africans.

Until recently, creativity was thought of from the perspective of painting, drawing, theatre, music and poetry.

The festival focused specifically on digital creativity with a focus on animation, gaming, immersive media as well as the intersections of creativity and technology. The festival slogan, 'Own Your Force', was chosen because critical questions were being asked about how creatives could own what they produced from a content perspective, what the copyright issues might be and how to contract as creators within the digital space.

One of the festival's most important achievements over the years was the partnership between the WSOA and the Tshimologong Innovation Precinct, a public facing innovation precinct founded in 2014/2015, which served as a link between the creative industries and the research and learning aspects of academia. The partnership provided an opportunity to create visibility for the digital creative sector and allowed for critical engagement as the link between research and learning and the industry. It also supported many young digital creatives to grow in that space and an industry ecosystem to grow a vision for the future. The festival has evolved beyond its development focused orientation to being a marketplace for digital creativity in Africa.

More information is available from www.fak'ugesi.co.za.

Cultural and Creative Industries (CCIs) and 4IR in South Africa

The Presidential Commission on 4IR brought different leaders together in a process of engaging with industry, university and government to look at the country's needs in terms of 4IR followed by a strategy development process. CCIs had the opportunity to respond to the initial strategic interventions that came out of the 4IR Commission and the Commission was interested to find out more from the CCIs in order to include their perspective in the strategy.

The response looked at how the CCIs were represented in the strategic interventions and one of the main findings was that there was an issue regarding the perception of 4IR and the CCIs. The CCIs were very broadly and not specifically included in the strategy and there was very little understanding of how the CCIs engaged with AI technologies and of the technical needs in that space. The CCIs were not understood as a beneficiary in the strategy, because it was unclear how they would need 4IR related infrastructure and resources or related commercial strategies, financing, digital future proofing policy or legislation. It was very important for the CCIs response to bring these matters to the table.

Part of that process was an exercise to position the history of the different industrial revolutions and look at how the CCIs engaged in those from an international perspective, and to look at the CCIs influence and impact across different areas. The first industrial revolution was about mechanisation and the next phase brought electricity and communication processes, and the development of phone and time based audio and visual recording. It fundamentally changed how the world could be perceived and processed. The link from photography to film and audio was not often considered a creative encounter that influenced how the world was processed and perceived. Then came information technology and the internet, the graphical user interface and the graphical input and output systems that were used on a daily basis and fundamental to how personal computing evolved. The 4IR was data and software driven, and data and AI, digital networks and cyber systems were very important in terms of how different kinds of content were administered, produced and monetised. Audio visuals, music streaming, digital design from web to architecture to the metaverse engaged CCIs in some or other way. This continued trajectory was important in terms of how human cultures, specifically African human cultures, were thought about from language to diversity to creativity, and how that impacted AI, for instance. Developments from the digital arts sector included significant contributions in computer vision, haptic and body sensitive systems, non-text based processing (visual audio and language processing), additive manufacturing (3D printing), the future of screens and immersive interfaces and audio visual media in virtual, augmented and mixed reality environments. Digital arts were very much embedded in these spaces and it was important to understand that these industries also required the same amount of critical engagement, technical engagement and resource development.

The 4IR strategic plan for South Africa was developed around the strategic 4IR pillars, which were based on the technologies and the resources, contributions and needs relating to the different technologies.

The CCIs response showed how the CCIs played a significant role in some of the strategic 4IR pillars,

how the CCIs engaged different technologies and the kinds of resources that they needed for development, and highlighted aspects that needed to be a fundamental part of policy development in South Africa:

- AI: In order to become intelligent, AI had to have a lot of information. This meant that data sovereignty and the ability to hold own data and monetise it, or to choose who and how it was used were of utmost importance. Africa was one of the most diverse spaces in the world and generated an abundance of diverse data, which AI depended on. This raised questions about how to protect the data and control what happened with it. It was important that culture engaged in the AI spaces, not just from a technical perspective.
- 3D printing and additive manufacturing; These technologies were significant to heritage preservation and to architectural design and structural design, raising the question about what needed to be done in terms of rapid additive manufacturing that was context responsive, and in the general rapid and sustainable manufacturing.
- VR and AI immersion: VR was huge resolution work and fully immersive. The CCIs in South Africa could manage that level of resolution for audio visual content as they had high processing capabilities and looked at content distribution, but additional support and engagement was needed.
- Cloud computing was significant in terms of streaming media and video on demand, and fundamental to audience access. This raised questions about how audiences accessed the content that CCIs made, how they dealt with new digital distribution models that were held within the Cloud space, and how to engage management and digital trade within the Cloud space.
- Digital asset management was fundamental within the blockchain space, as were smart contracts, digital distribution, crypto led monetisation and financing of non-fungible tokens (NFTs).

The policy agenda related to 4IR presented interesting opportunities for the South African creative economy to position itself as a driver of innovation and digital adaptation, a source of new value creation and a contributor to human capital needs of the economy by addressing the value of emotional intelligence, creative intelligence and innovative thinking that comes from creative engagements, and the inclusion of the Arts as part of the Science, Technology, Engineering and Mathematics engagement in terms of education and development. The CCIs' response also highlighted the following challenges in the sector with respect to 4IR:

- The lack of a strong digital and future proof policy orientation, financing instruments or institutional frameworks
- Significantly undeveloped infrastructure resources and limited access to consistent digital education and training
- Nonresponsive rights policy and legislation review processes.

Interventions to address these challenges were put forward and the CCIs advocated for:

- Attention to research on and development for the creative industries within the 4IR pillars.
- Inclusion of social science and creative sector expertise within core competencies for 4IR strategy in the presidency and the Department of Telecommunications and Postal Services
- Agile governance and anticipatory policy and regulation that responds to gaps, challenges and needs
- Shifting the orientation of existing innovation spend by private sector and government
- Designing and testing better social, economic and cultural measurement tools to establish the full impact of innovation and entrepreneurship activities (including the CCIs).

The CCIs' response was taken extremely well and they looked forward to the Commission's response and to future work in this space.

A sneak-peak into new research at the Digital Arts Department, WSOA,

Dr Bristow was currently engaged in the following projects:

- A collaboration between the WSOA and the Fak'ugesi Festival, which specifically looked at an Inter-Regional focus to understand and develop 'intermediary roles' in the digital creative sector (a space that is often overlooked).
- A collaboration between WSOA, Google Arts and Culture and the Wits Computer Science Department, to look at AI and Arts in Africa – a supported residency to develop a series of proposals with artists on the continent for Art and AI interactions with a focus on natural language processing and heritage

focused proposals. (There was very little understanding of what it took for creative and cultural practitioners to engage in AI technologies and concepts.)
- Her personal research that looked at Vernacular Algorithms, engaging ethnomathematics and vernacular design principles as an algorithmic philosophy.

Dr Bristow could be contacted at Tegan.Bristow@wits.ac.za or www.wits.ac.za/WSOA.

Q & A SESSION

Ms Deirdre Batchelor mentioned that many of the WSOA projects were related to fields of work that the Embassy of the Kingdom of the Netherlands was interested in and asked if there were opportunities for collaboration particularly in work related to AI and art in Africa. Dr Bristow responded that the WSOA would welcome collaboration with The Netherlands. The WSOA was building a research group made up of Honours and Masters students that produced a lot of work and would be glad to share this work with collaborators.

In response to a question by Mr Shaun Earl Harris, Dr Bristow indicated that the WSOA's Department of Digital Arts focused predominantly on gaming, animation and interactive media in different kinds of ways. As yet, the department did not have a programme that looked NFTs specifically but it had research projects that were engaging in that topic. The department had not yet decided whether to teach or how it would teach about this very new and complicated subject. Digital arts aspects were very well covered within the department. She explained that there were different opportunities for collaboration in public, inter-faculty and inter-institutional engagement through the digital arts department. The department did a lot of intersectional and cross-sectional work.

Mr Harris was looking for collaborators to bring NFTs into the public arena and trying to find ways to channel the proceeds back into society. He had put together a team to look at how to promote NFTs and artwork and wanted to develop a basic standard operating procedure to guide those who were entering the NFT space. Dr Bristow pointed out that a lot of people were interested in opportunities for profit from cryptocurrencies to be channeled back to people in those spaces. A fair amount of projects were charity orientated, although in very different ways. The department did not have students actively working in that space, but there was alignment between the work being done around intermediaries and the gap relating to intermediaries within that space. The department would be able to collaborate with Mr Harris in this regard.

Ms Niehaus asked Dr Bristow for her view on the suggestion that there was a growing tendency in the arts to intellectualise the work that artists made, while in the past, art was regarded as an intuitive practice. Dr Bristow commented that the sciences did not grasp this interesting space, which was often one of the topics of discussion between scientists and technical people. There was a mystery around the process of being creative and letting creativity flow to create knowledge in ways that were not common to the kind of empirical ways of making knowledge that scientists were used to. Dr Brett Pyper had helped to lead a lot of work in the WSOA around creative practice as a methodology and a knowledge forming location. The creative processes and cultural processes were often largely communal, specifically within African culture. Knowledge was deeply embedded within those practices. Work was done to unpack where knowledge was formed, how it was formed without becoming empirical but rather to be spoken about and to evoke the knowledge and the outputs as they were in their own location. Creative led and practice led research had found that this was happening a lot in the arts.

Dr Dimakatso Masideni-Ndau enquired about the marketing of the Fak'ugesi Festival. Dr Bristow explained that the marketing aspect was out-sourced to a specialist. A lot of marketing was done through to promote the work of artists through social media and by using different strategies such as videos and engaging certain communities. One of the most important things about marketing was to put across the right message. The festival had to be marketed as an African focused, cultural and technology encounter.

Dr Bristow was asked whether the Presidential Commission on 4IR had contributed enough towards the advancement of the creative economy up to this point and given its earlier responses. She indicated that

the CCIs response was in respect of the early strategic interventions from the Commission and happened post the Commission. It focused on informing the Commission's strategic committee of the CCIs perspective and the roles it could play in the 4IR, which had previously not been understood by the Commission.

Ms Niehaus remarked that 3D printing technology had great potential for use in the artistic, creative space, but that there were barriers to entry. Dr Bristow indicated that the barrier to entry on 3D printing at a really low level was quite low. 3D printing itself was not difficult to do and a myriad of maker spaces offered support in this regard, but tended to be located in urban spaces and rather expensive. Large scale, production orientated, commercially orientated, 3D printing was not well developed in the country, but the entry level understanding, code block aspect of it is quite accessible. A number of artists in South Africa worked in this media, and many were very excited about its prospects.

Prof. Deshen Moodley asked whether Wits offered a degree with majors in digital art and computer science and whether an undergraduate student could major in digital art. Dr Bristow responded that the digital art undergraduate programme was a collaborative progamme with the School of Engineering and the Built Environment. A game design degree could be taken either from Engineering or the Arts. Some of the courses were shared and some were specific to Engineering or the Arts. This was one of the only cross-faculty degrees in the country that looked at engineering practice and creative practice together. Postgraduate degrees were offered at Honours, Masters and PhD levels.

Mr Harris wanted to look at ways to work in a collaborative team within the South Africa, continentally, globally and through Blockchain to disseminate information about the technology of the 4IR and work together to create better lives for all, instead of keeping the knowledge within the intellectual institutions. NFTs were used in many facets of society in other parts of the world. Some countries were introducing their own cryptocurrency, NFTs and smart contracts that will become dominant in the future. He invited individuals who wanted to collaborate with him, beginning with one or two major projects to bring these issues to the attention of the media and the public, to make contact with him.

Dr Bristow suggested that Mr Harris's invitation to collaborate was one way for those in the creative industries who felt that they were not being met by the technology of the 4IR to be helped to engage with it.

THE IMPORTANCE OF INNOVATIVE THINKING IN THE 4IR (PROF. TSHILIDZI MARWALA, VICE CHANCELLOR OF THE UNIVERSITY OF JOHANNESBURG (UJ))

Prof. Marwala's journey into the 4IR space could assist others to think about the Creative Economy, Science, and the 4IR. One aspect of this journey was multidisciplinary educational experience that he received in the United States, which meant that even though he was trained as an engineer, he had to take Human and Social Sciences (HSS). As a student, he transferred from the University of Cape Town (UCT) after six months to Cleveland, Ohio in the US. The curriculum included twelve HSS modules. He chose to take two classes in Psychology, three in Acting and two in History. The 4IR was about the merging of technology to humans to form a system. Many people today were not just a human biological system, but were also machines because they cannot live without their devices such as cell phones and artificial limbs. This was an era where men and machine were becoming a single system and where a person will not be able to exist without a machine.

Certain developments have happened over the last few years. People were trying to trying to create a system where information can be downloaded directly from the brain. This was quite important because the brain has been one of the most inaccessible aspects of human being. It was not thoroughly understood and could not be manipulated. People's minds cannot not be read technologically or in the way that other vital aspects of the body can be. The Coronavirus 2019 (COVID-19) pandemic thrust the world to the centre of the 4IR. Technology and AI were crucial to drug development and helped design better vaccines. China used drones to monitor people who are not complying with COVID-19 regulations.

The World Economic Forum (WEF) stated that 'the 4IR was about more than just technology driven change

– it was an opportunity to help everyone, including leaders, policymakers and people from all income groups and nations to harness converging technologies in order to create an inclusive, human centered future. The real opportunity was to look beyond technology, and find ways to give the greatest number of people the ability to positively impact their families, organisations and communities.' This had renewed the need for innovative thinking, which was how humans adapt with agility to their current context where business as usual would simply no longer exist.

Reimagining the concept of innovation was taking place in an era where things were moving fast. So the innovation that that was being reimagined today had to take into context that products would come to the market and disappear very, very fast. This was called hyper-capitalism.

Innovative thinking - the ability to come up with new ideas and intriguing solutions to problems - was a skill and differentiated humans from machines.

Prof. Marwala recommended Isaac Asimov's 1959 essay on creativity which interrogated the concept of coming up with new ideas for reading. The factors of innovation encompassed by new products, productive techniques or technologies were defined by economist Joseph Schumpeter in 1911, who coined the term 'creative destruction', which dismantled long standing practices of production. Innovation was in some ways transformational. The world will always be confronted with new that contends with supply and demand, and this is the key to the success of innovation. Schumpeter explained the concept as 'a process of industrial mutation that revolutionised the economic structure from within, destroying the old one and creating a new one'. A resurgence of this theory is being seen currently through disruption. In 1995, Clayton Christensen introduced the concept of denoting innovation that displaced systems that were already established. Disruption has accompanied every revolution. A toolkit had to keep pace with the technological tsunami that was faced every second. Business models and practices had transformed overnight from digital authentication for banks, 3D printing in healthcare and even more than the model of Uber. The root of the definition of disruption described a process whereby a smaller company with fewer resources was able to successfully challenge established incumbent businesses. As established businesses focussed on improving their products and services for their most demanding customers, they exceeded the needs of some segments and ignored the needs of others. Disruption began by targeting the overlooked segments with functionality and low prices, then moves up market delivering the same performance to the established businesses' mainstream customers. Innovations in products and services could increase the GDP by as much as 7%. According to a report by McKinsey Institute on the impact of AI on the world economy, it was appalling that innovation was believed likely to emerge from elsewhere with Africa and South Africa as receiving agents. In other words, South Africa was not innovating in the same way as the US, China and other countries, and Africa's projected trajectory has not been to 'punch higher and harder'. In 2014, the African Union Summit adopted a 10- Year Science, Technology and Innovation (STI) Strategy for Africa, but was Africa moving from strategies to implementation, were any of these strategies taken seriously by the private sector? Did lawmakers, politicians and parliamentarians understand STI enough to bring change to the continent? The same questions could be asked of the situation in the US, for example.

South Africa has produced a strategy for the 4IR that looked good, but seven of the eight recommendations addressed the need for investment in Human Capacity Development (HCD). The strategy would have no impact unless there was adequate HCD that was equal to task, in that education had to provide an understanding of the human, social and technological aspects of society. It had to prepare people to understand that technology was not only about interaction between technologies, but also about interaction with humans and societies. The people who created that technology had to understand the span of that knowledge in its entirety. They must have a multidisciplinary educational experience.

The next recommendation addressed the need to establish a national artificial intelligence institute that focussed on the implementation of AI technology in all areas of people's lives. AI was the engine of the 4IR. Simply put, AI was a technology that allowed machines to think and do the tasks that were done by human beings usually better than they are able to do them. Although this would have a variety of implications for the future of work, production would move away from South Africa leaving increased poverty, inequality and unemployment in its wake if AI was not implemented. It was therefore important to advance the country's productive forces through AI technology.

The next recommendation was about industrialisation. The country has been de-industrialised simply because it has not invested in technology and was therefore no longer efficient or as productive as it was supposed to be. A further recommendation was about data, which was the 'new oil'. Data companies were mining this 'new oil' from South Africa on a daily basis, which raised the need to investigate the mechanisms for data collection and storage, and ways to secure the data.

The recommendation pertaining to infrastructure addressed the fact that South Africa lagged behind in terms of communication technology simply because a spectrum for 5G had not yet been awarded and this has led to the deterioration of connectivity. The shortage of connectivity in rural areas also needed to be corrected. Infrastructure of the 4IR was of utmost importance and required investment. Another recommendation addressed the need to review and update the legislation to incorporate issues relating to the 4IR, taking cognizance of the internet as a real time digital space. The last recommendation addressed implementation and the importance of focussing on the capacity to implement.

Creativity was of utmost importance. It required an open mind and an education system that encouraged inquiry. The idea that education is about one way communication, from lecturer to student, was outdated and had to end. Multidisciplinary education was another important factor. UJ required all students to take an introductory literacy course on AI and a course called 'Africa Insights' to enable them to understand the environment that they lived in, particularly to understand they would operate in when they become entrepreneurs. In addition, the UJ's Africa by Bus project took students to the rest of the African continent where they were expected to come up with ideas of how to solve the problems they encountered. Students' experiences were enriched by their exposure to the diversity of languages, lengthy queues at the border posts, the rich fauna and flora of South Africa and its neighbours. Prof. Marwala invited participants to register for UJ's AI course that was offered at no cost, and a certificate was given on completion of the course.

Q & A SESSION

Dr Bristow remarked that much of Prof. Marwala's thinking resonated with the work the WSOA was doing between the CCIs and 4IR, which faced the same hurdles as he had mentioned in his presentation, particularly with regard to legislation and inadequate engagement with technological resources and infrastructure. Although the CCIs had tried to respond to the 4IR strategy and engage policy development at different points, the process had been incredibly long and slow and crucial time had been lost. These technologies, their acquisition and use by other countries were incredibly rapid. She asked Prof. Marwala for his advice in this regard.

Prof. Marwala agreed that this was a difficult issue, adding that things were interconnected and specialisation was being challenged quite extensively. His advice was that it was necessary to learn to learn, and to learn quickly, which meant that people needed to read more (to this end, he has introduced a monthly reading club at UJ), think more, inform themselves more and be open minded. There was no stupid answer and no stupid idea. There was just an idea that did not work and an idea that did not work did not necessarily mean that it was not brilliant. It could be that the market forces were not ready for it. It was important to encourage discourse as this was the root of creativity.

Miss Jessica Glendinning commented on the necessity for a space of play and experimentation, especially at an early age, and that this was currently lacking in the education system, and asked about the possibility or potential and feasibility of bringing these spaces into the formal education system. Prof. Marwala emphasised the need for the formal education system to provide such spaces, but they would not need to be sophisticated. He had learnt many engineering concepts through play and experimentation as a child (described in his book, *Closing the Gap*).

Mr Harris mentioned that there were many different dynamics of how 4IR technologies could empower all communities. Government's recent announcement that each citizen would receive ten gigabytes of free data would propel technological innovation into the hands of those on the ground. It was likely that plans were underway to look at how the infrastructure could be put in place to allow those on the ground to access

this data. Nowadays games on the gaming system platform allowed players to earn cryptocurrency while learning, and people were earning a lot in cryptocurrencies. Many virtual platforms offered online 'universities' where people knowledgeable in a specific field offered virtual lectures in virtual rooms where students could meet virtually. This was a new way of educating the masses going forward. There were ideas of looking at ways to make this work in South Africa and globally at all levels of life through blockchain technology.

Prof. Marwala mentioned that lessons about innovation could be learnt from Russia in that it had failed to take its innovative and scientific culture to the commercial spaces. Many of the big names in machine learning and AI were born in Russia, yet that country was disproportionately represented in that creative space. With regard to the free data to be provided to all citizens, Prof. Marwala mentioned that he had recommended to the Minister that the ten gigabytes should be limited to educational websites and platforms. He undertook to send information about his reading club and the latest reading event to the NSTF.

CREATIVE INDUSTRY AND NFTs (MR JAMES MCCARTHY AND MR JAMES BOYERS, MCCARTHY LEGAL)

McCarthy Legal was a creative and entertainment law practice that specialised in guiding clients with IP related issues. The presentation addressed questions posed to McCarthy Legal by the NSTF.

Definitions
Non-fungible (unable to replicate or copy) token (something that is traded).

NFTs' authenticity could be guaranteed and this meant that their provenance was traceable (one was able to see who created the NFT and the price at which it was traded), which gave the NFT its value. A blockchain was a public ledger where every NFT transaction was recorded and hardcoded into the ledger. It was transparent - every transaction and its history could be seen – and a very trustworthy and reliable source of information.

IP referred to creations of the mind, such as inventions, literary and artistic works, designs and symbols, names and images used in commerce. IPs were broken up into four main areas: patents, trademarks, copyrights and trade secrets.

The role of NFT's in the art market
The most expensive digital image NFT sold $91.8m, raising a question about the sustainability of NFTs. Digital images of tangible assets are NFT in the form of sculptures, paintings, diamonds and so on. NFTs give value to physical artworks in terms of increased tradability, allowing one artwork to be traded hundreds of times in one day. Images of physical diamonds that were kept in a vault were able to be traded as NFTs numerous times a day.

NFTs should not be spoken about exclusively in the context of art. It was important to understand that NFTs had nothing to do with art and meant that there were no duplicates of a certain physical object. There were many use cases for NFTs outside of the art realm. Utility NFTs were set to become exclusively NFTs in the future and included university degrees, drivers' licenses and branded products (in order to discourage counterfeits). Art-specific NFTs created a whole new creative field where creators were coming up with NFT concepts. It was up to them to decide what kind of utility was derived with each NFT.

Numerous weird and wonderful forms of utility were being associated with the NFTs that were purchased. For example, one NFT gave exclusive rights to a business club and could be sold in order to transfer that right to someone else. It was up to the individual to decide how a utility would be associated to an NFT, and a smart contract that allowed any utility to be associated with the NFT could be created. In essence, it was about coming up with one's own concept, something that spoke to the community and created content or art, and making that known so that it would sell.

Were NFTs a bubble? The vast majority of art projects on any of the online markets were going to zero.

However the utility and the technology were extremely powerful and a handful of art projects would continue to increase in value, as was the case with physical pieces of art.

An overview of the legal framework for IP in artworks and images
Copyright is inherent in a work and does not have to be registered. It is attracted by way of a work being copyrightable. The Companies, Co-operatives and Intellectual Property Rights (CIPC) defined copyright as an exclusive right granted by law for a limited period to an author, designer etc. for his/her original work. Examples included paintings, computer programs and sound recordings.

In terms of the legal framework governing NFTs, they are regarded as copyrightable as digital images.
The Copyright Act 98 of 1978 referred to derivative works and the ability to make a derivative work (a digital image that not able to be substantially differentiated form the original work) was only given to the holder of the copyright, that is the artist or the estate of the artists if the artist had passed away.

Legislation that governs the creation, valuation and monetisation of NFTs
This was unchartered territory, where no-one knew very much about what NFTs were and what the creation process was, but copyright governed the ownership of the image and it could be traded.
The creation of a NFT was known as minting and was governed by the specific rules of the market place.
The valuation of a NFT depended on whether it was digital or tangible. If it was tangible, the value of the artwork would be based on the provenance of the artist and previous sales. It was digital, the value would be based on other digital sales, which predefined the existing value.

The process used by McCarthy Legal in creating an NFT was as follows:
- Consultation between the client, attorney and NFT specialist
- Assessment of conceptual and legal/copyright issues
- Identification of the market (the most appropriate and cost effective platform for display)
- Minting on a specific blockchain (intake desired content to be minted for sale NFT)
- Collection of funds from sales and receiving royalties from secondary sales
- Payment in Rands, Pounds or cryptocurrency

Smart contracts could be created with whatever terms were desired. A common exercise within the NFT art gang was for artists to take a cut of secondary sales, which makes this an attractive option for artists as they earned revenue into perpetuity.

Is it beneficial to use NFTs to secure creative IP?
The IP is inherent in the work or image and that is where the ownership of the IP was. The copyright in the work was attracted to the work and was given to the author or the artist. With the trading a NFT, the IP could be given to a recipient of the NFT where it could be used for commercial purposes. Recipients were also able to make derivative works (more NFTs of that work).

THE IMPORTANCE OF SUPPORTING CREATIVITY AND INNOVATION (MR SIPHO DIKWENI, COMMERCIALISATION MANAGER AT THE TECHNOLOGY INNOVATION AGENCY (TIA))

Introduction
TIA was a state agency and an entity of the Department of Science and Innovation (DSI) that supported technological innovation. TIA ensured that technologies were developed in South Africa for exploitation locally so that technologies do not have to be imported, thereby increasing economic growth in the country.

Technological innovation has led to the digital world, which was characterised by new ways of doing things and a complete change in terms of how production is done and how human beings communicate and interact. Trade, distribution and consumption have also become very different from what they were in the previous industrial revolution. The changes have been substantial and the disruption widespread, impacting on all areas of the economy and industry, not only the creative industries, and have brought new forms of art, marketing strategies, management tools, business models, stakeholder relations as well as virtual communities with digital assets. The creative economies have not been left behind and can still transact in the digital economies. Humans can be immersed in the metaverse via augmented realities and VR

technologies while demonstrating innovations and showcasing products without being in physical contact with customers. It was very important for creators to rethink their strategies and learn about their new environment and navigate this new world in order to continue contributing and competing in the digital world.

Emerging Technologies 2021/22
Emerging technologies had a direct influence on the creative economies, particularly in terms of distributed infrastructure and Cloud computing, which directly affected the creative industries and how they transacted amongst themselves and interacted with customers because sales could take place without being in contact with anyone, and technologies, products, services or artworks could be showcased virtually.

Creatives in South Africa should be prepared to participate meaningfully in the digital world, but would not be able to do so without connectivity, which was essential in order to make transactions, participate in digital marketplaces and showcase products and creativity.

The gaming industry was the first industry to adopt 3D technologies and visualisation to ensure that the experience would be close to reality but in different locations. There are a myriad of possibilities with regard to technological innovations, which also include natural language processes and speech technology. Security was important, particularly given the developments around blockchain and NFTs, in order to ensure that the originality and authenticity of artworks was maintained, and the necessary verification can be done to secure transactions. It was essential for creatives to have a basic understanding of how the technology worked and how it influenced the work they produced.

Requirements for Creative Economies
Broadband access, antipiracy and protection platforms, as well as production and distribution platforms were essential for the creative economies in order to mitigate the anticipated spike in piracy and security threat as the industry becomes digitalised.

TIA Supported Technological Innovations
TIA has been active in ensuring that South African creatives were prepared for the future and would be able to participate meaningfully in the digital world.

Examples of TIA-supported technologies relevant and helpful to the creative industry were:

- GLSDA: The technology was developed by the Council for Scientific and Industrial Research (CSIR). It is a dynamic spectrum management tool for efficient allocation, management and effective utilisation of national radio spectrum as well as full exploitation of TV White Space (TVWS) that would ensure connectivity for rural communities.
- FibrePoynt: An antenna-based high-speed fixed Internet/wireless communication system that can be an alternative or supplementary to fiber-to-the-home (FTTH) underground or overhead cable technology. This technology would solve signal strength problems and the huge costs typically found in existing “last mile” antenna wireless rollouts.
- RIOT: A wireless technology - hardware and software for crowdsourced last mile networks - that enabled households and small businesses to acquire and deploy network devices for serving their private internet access needs and contribute the same equipment to formation and operation of a public service infrastructure.
- Custos: A decentralised software platform tailored for detecting piracy for digital media content by identifying the initial infringer and unauthorised distribution. The media content can include videos, music, enterprise documentation, educational content software source codes and so on. Custos combined patented blockchain technology with forensic watermarking to keep media files secure and unshared both online and offline, and to detect content leaks when they happened.
- Contactable: A Digital Identity Orchestration Platform that enabled real time to verification and authentication of identity of people and consumers in the digital world. The federated identity enabled the creation or use of multiple digital identities to cater for different onboarding requirements across geography, industry or legislation within closed or open ecosystems, all managed through the platform. It reshaped digital customer journeys, reduced identity fraud, and simplified compliance across enterprise ecosystems.
- Cognitive Systems: The Artificial Mind Engine was a platform for in-stream cognitive computing, which

delivered real-time predictive analysis on constantly changing data including video and sensor streams, within the Internet of things (IoT) and Big data environments.

Conclusion
Mr Dikweni emphasised that there were more opportunities for growth in the digital world than threats and suggested that although it was not necessary to be an expert in order to participate in the digital and virtual economy, it would be important for creatives to learn about and become familiar with the new environment in which they functioned. In transitioning to a virtual world, it was important to pay close attention to the voice of the customer that would indicate preferences in terms of interaction and consumption of creative products and services. Understanding the foundational building blocks of the digital world would facilitate the contribution and participation of creatives and the competition between them.

Q & A SESSION

Ms Niehaus commented that a previous NSTF panel discussion addressed the IoT and the rollout of 5G, and that the allocation of spectrum had also came into play in those discussions. It was interesting to see TIA's presentation against that background and encouraging that there were possibilities to make connectivity possible for rural areas and the disadvantaged in society, but the lack of progress in this regard was frustrating.

Mr Dikweni mentioned that TIA ensured that communities were involved in these discussions because it would be difficult to rollout the technology without their involvement.

Dr Bristow (Zoom chat) said that she was familiar with the work of RIOT and inspired by long development process. She asked Mr Dikweni to give a timeframe for how long it took for technologies to go from idea to public use. Mr Dikweni indicated that technologies generally took about three years to full-scale commercialisation, partly due to the need to work with communities to demonstrate the viability of the new technology.

Mr Harris (Zoom chat) asked Mr Dikweni for information concerning the content detection system (Custos) from Stellenbosch University. Mr Dikweni explained that the Custos technology used blockchain technology with watermarks ensuring that there were embedded cryptocurrencies. In the value chain of transacting, there were technologies that ensured that the cryptocurrencies were embedded and that the work could be traced and the point of leaks and any infringement could be identified. The technology was being used by universities to protect their work in terms of educational content, enterprise documentation and films. Around 200 million copies had been protected by the technology to date.

Miss Glendinning asked whether TIA had community outreach programmes that addressed the rollout of technology in communities. Mr Dikweni indicated that TIA's progamme called Grassroots Innovation worked in communities to identify innovation and to stimulate innovation activity. The programme called for proposals from time to time. It was important to communicate with communities before technology was rolled out in order to inform the people, ensure the voice of the customer was heard and that networks rolled-out in communities were run by the people in those communities. In some cases, people in communities were trained by investees to manage and run the networks on their own.

Mr Harris explained that he had taken the photograph of Nelson Mandela that was used for his funeral and had been defending his copyright in the High Court for the last five years. This had been an outstanding learning curve, not only in copyrights, but also for creatives to understand and know the full copyright ambit. He was the spokesperson representing the creative community in the deliberation of the copyright amendment bill and the new mandates that the government was trying to bring in. In that sense, there were new technological advances that all creatives could take advantage of. Whole communities could benefit from the proceeds from NFTs. He was looking to collaborate with like-minded individuals
around projects where the proceeds of NFTs could be used for the benefit of the communities.

Ms Lindiwe Gama remarked on the interesting topic of discussion, expressed gratitude for the work done by the NSTF and thanked the NSTF for always bringing important matters (such as those under discussion)

to the attention of the relevant policymaker, namely the DSI.

Ms Niehaus invited the speakers to comment on the apparent extremely energy intensive nature of blockchain, cryptocurrencies and similar technology, and the resultant high carbon footprint they produced.

Mr Harris mentioned that according to the renewable energy sector, a number of projects were in process within the blockchain. He had been informed that a NFT could be attached to a process such as hydrogen power generation that would alleviate the country's energy problems. This needed to be considered. In addition, there were new ways of communicating images that were not through the normal frequencies. This would offset the energy and how people communicated into the future. The good thing about the blockchain was that everyone was putting their heads together to look at ways to overcome some of the problems it faced.

Ms Avril Joffe expressed her gratitude to the NSTF for initiating discussions around this topic and mentioned that the Cultural Policy and Management Department at the WSOA taught programmes and had students working in digital technologies in relation to the culture and creative economy. Students wanted to better understand the complex questions of science and technology in the creative sector, protect themselves in the digital world and be able to earn money in the digital realm.

Ms Niehaus indicated that it would be good to have follow-up discussions on the topic, possibly at the Fak'ugesi Festival, and invited participants to contribute to the NSTF newsletter concerning developments with regard to the interface of creative industry and science and technology.

Mr Whisper Maisiri commented that it was important for technology development to be contextual and focus on technologies that responded to the problems unique to South Africa and Africa. With regard to the recommendations of the Commission on 4IR concerning HCD, the fact that education focused on theory and not practice would impact on the country's competitiveness in the 4IR space, and the skills gap would become bigger and more serious in a few years' time. To be successful in the 4IR, there would have to be a balance of skills.

Ms Niehaus suggested that higher order skills were needed in order to get the most out of the 4IR and in order for the economy to leapfrog and become an advanced, developed economy while the practical skills remained extremely important and could not be negated. Both sets of skills came together in computer technicians for example, who worked not only with the software and the hardware, but the data as well. She agreed that the education system concentrated far too much on the academic and the theoretical, and not enough on the practical. Artists were also needed, not just in relation to the 4IR or in terms of technological advancement, but for other reasons such as the expression of human beings as emotional, cultural, and spiritual in relation to machines.

Mr Harris commented on the importance of balance in terms of theoretical and practical skills for the 4IR. Creatives had a different way of expression and propelling the community in positive ways. Digital assets could propel communities on the ground in a better way and the proceeds would go straight to the community. A lot of creatives were unable to exhibit their art, but digital methods provided a universal exhibition where unique pieces of art could be bought and sold, and smart contracts ensured that the creators of the art would receive royalties into perpetuity.

Dr Angela James suggested that it was necessary to recognise science, technology, engineering, art and mathematics (STEAM) and its place in education. There were many STEAM organisations and persons engaged in this, but a space was needed to collate all the initiatives and organisations with projects and programmes for children from grade 3 to tertiary level. There was much to work with to bring all these aspects together.

Ms Niehaus mentioned that the possibility of including STEAM in the programme of the NSTF discussion forum on STEM education, scheduled to take place later in the year.

Dr James added that she was part of group at the University of KwaZulu-Natal (UKZN) School of Education

called STEAMers that has shared ideas and programmes. However, this work seemed divorced from technology development and the 4IR. She suggested that there ought to be a recognised organisation in South Africa for everyone linked to STEAM.

Ms Niehaus mentioned that there had been talk about the value of modelling (making representations of something). This had huge potential and could be the same as STEAM depending on the form it was given in schools. STEAM was a brilliant idea, but teachers would need a lot of guidance with its implementation in the form of the curriculum.

In concluding the day's programme, Ms Niehaus remarked that the discussions had been valuable, thought-provoking and informative and that the potential of the topic had been thoroughly realised.

DAY 2

WELCOME TO PARTICIPANTS AND INTRODUCTIONS; PROGRAMME, OUTPUTS, AND INTENDED OUTCOMES (MS JANSIE NIEHAUS, EXECUTIVE DIRECTOR, NSTF)

Ms Niehaus welcomed everyone to the second day of the discussion forum and provided a brief synopsis of the presentations on the first day, which brought together innovation and creativity and explored the legal framework in which these happened. She also presented a brief introduction to the NSTF as a civil society forum registered as a non-profit company, and an independent, unique and neutral platform that facilitated and encouraged discussion on a variety of issues, whose activities were inclusive and collaborative.

COMMERCIALISATION OF IP (DR AUDREY VERHAEGHE, ANZA CAPITAL AND FORMER CEO, SOUTH AFRICAN INNOVATION SUMMIT (SAIS))

SAIS was a mechanism to accelerate the economy around technology startups, which were found in the places where people gathered, thought, came up with new ideas, experimented and made discoveries then wondered what to do next to take the innovation to commercialisation. SAIS aimed to showcase, connect and capacitate, and attracted 56 countries and 3600 participants from around the world. Future summits would be hybrid events with the options of online participation at no cost.

A fund was created to serve startups at the stage when the business had been proven and needed to scale-up in order to grow aggressively. Most of the private sector money supported this stage of startup development, but there was a massive gap in funding for the earlier stages of startups due to the private sector's perception of it being too risky and limited funding from government. A company called Anza Capital was established with the aim of alleviating this gap and worked with the cleverest people in society across Africa who were creators and designers of innovative products and services, and wanted to make a lasting impact to leverage funds.

The South African economy was thought of in terms of its citizenry and Rands, and not as being part of the much larger African economy that had all kinds of legislation that would make the continent more attractive. The fact that money was beginning to flow into Africa should be relevant to the national agenda, the creators, the universities, the scientists and the technologists in society.

The Partech 2020 Africa Tech Venture Capital Report provided insight into that state of the tech startup space. The report identified a $42 trillion gap in early stage funding, which was the reason why top-notch IPs failed to reach market and why funding was needed to get products from their creation into the market. The report highlighted trends in Africa as a marketplace. One of these trends related to venture capitalists proving their ideas in South Africa and then moving them to Europe. Anza Capital's mission was to invite entrepreneurs and creatives to South Africa to create and then expand into Africa. This was a new space to co-create.

Given that 20% of the world's population lived in Africa and 60% of those were under the age of 25, the target audience should be the youth. Six of the world's ten fastest growing economies were in Africa. Africa was doing incredibly well in FinTech because rapid technology adoption of FinTech solutions had caused

innovation to leapfrog and Africa to become the world leader in this area. Africa had the world's highest entrepreneurship rate. Startups lacked access to growth capital to help them take off. The venture capital ecosystem was starting to pick up and had seen growing investor interest and entrepreneurship at scale, driving impact and accelerating socio-economic growth for Africa. The work SAIS had been doing in the South African economy and the African economy was based on the above context.

In South Africa, the tendency was to take note of large corporates and disregard startups. The intellectual spaces where a huge impact could be made were energy alternatives and Just Energy Transition, financial service, agricultural service, smart cities, logistics, education, health and entertainment. In 2018, Africa accounted for $1.6 billion in investment across 164 rounds of investments in early stage startups. In 2021, it surpassed $4 billion and in March 2021, there were two Unicorns (the economic term for a company that had a turnover of more than one billion dollars) on the continent of Africa, and by October there were ten Unicorns. The creative economy needed to start thinking about how to enable the growth of impactful startups that started small, but with adequate financing would grow from nothing to being a Unicorn within five to ten years. This would bring rapid change to the economy and the African continent.

The group of companies that started SAIS, together with Anza Capital, tried to create an ecosystem that spoke to the triple helix (a model of innovation that referred to a set of interactions between academia, industry and government to foster economic and social development), but had struggled to achieve this. A space was needed where tech startups were originated. The South African economy had spent billions of Rands in the incubator space and more and more universities were also associating with incubators, yet there was no huge engine of origination. The company collaborated with all the incubators that wanted to collaborate and come together to talk about best practice in this space, and then chose 60 to 80 best tech startups and showcased them to the world every year. Investors from across the world were invited and for many years a lot of deals were made. Apart from money, a lot of work and a variety of support was needed to make them investment-ready so that they were able to engage with investment to grow their companies. A lot of capacity building was done and t the tech drive accelerator and virtual mentorship programme were developed to assist entrepreneurs to become investment-ready. The startups were fed into large businesses because they needed contracts to grow significantly. This ecosystem could be scaled significantly across Africa, but this type of collaboration was also needed in society. Government and large corporates needed to be able to invest in and do business with small businesses that delivered innovative products (such as the creative industry), buying locally instead of from abroad. Creatives, enablers and implementers were needed. This was what was created in minute scale as a contributing agent into South Africa mainly, but also into Africa.

SAIS had seen a footfall of 3700 and around 1600 applications for tech startups each year. The ecosystem produced numerous success stories of startups that had gone through the pipeline. Many of them did not come from universities. An understanding of what a tech startups meant and what they required in order to grow was completely absent from the current instruments. Most investments in local tech startups came from overseas and the success stories from Africa, mostly South Africa, began to emerge within three years.

The work done by startups impacted on many of the Sustainable Development Goals (SDGs) and could ultimately influence all of the SDGs. Anza Capital’s ambition was to create at least ten such funds. The investment focus for the next 15 to 25 years would be on high impact sectors across select countries in Africa, concentrating on food technology, energy and green technology and education technology.

The South African Development Community (SADC) offered a $1.2 billion market, a free trade zone, legislation, payment solutions, talent (and the ability to recruit from elsewhere in the world), an ecosystem, finance and innovation readiness. Anza Capital put much effort into resolving the early stage gap in the market by helping investors understand the African landscape and adapt their way of thinking in terms of how finances worked to an African mindset, as well as getting the pipeline investment-ready and understanding what investors wanted in terms of alignment between expectations and offerings. It was important to consider the population demographics in order to know what type of products were needed in the African and South African economies. South Africa was currently second in the world in terms of tech startup spending and ecosystem building, and the world leader in the FinTech space, but also did extremely

well in health-tech, ed-tech and energy. Investor interest was at an all-time high, but untapped opportunities were still being missed when it came to global venture capital funding.

Dr Verhaeghe shared the principles that could make a difference in the innovation space and the commercialisation space, and where research and technology products could make a huge difference in society, namely:

- Learn to work with and respect the private sector for its drive for implementation, not for its money
- Work on market readiness in equal measures to technology readiness
- Work on investment readiness and investor readiness
- There is not enough early-stage money for commercialisation
- There is not enough early-stage support for budding tech entrepreneurs
- Stop categorising tech startups and small businesses as one because they are very different
- South Africa is part of Africa and the world.

Dr Verhaeghe could be contacted at Audrey@anza.holdings.

Q & A SESSION

In response to a question about how many Unicorns there were in South Africa, Dr Verhaeghe explained that there were no Unicorns in this country, mainly because although the economy was strong, it focused on big business and not on tech startups, and there was no understanding of what it took to get a successful company off the ground.

Dr Verhaeghe clarified that there were no Unicorns in South Africa and that most Unicorns were funded by investors in America and Europe. The problem was that those countries would claim the Unicorns. There were several groups in Africa that were trying to get more local funding. As to whether part of the problem was a lack of public awareness, she indicated that Anza Capital had done a lot to ensure that the startups received good media coverage, but this was costly and the good news was always more difficult to spread than the bad news. It would be helpful if everybody did their part in terms of raising publicity for South African ideas and startups.

Prof. Mike Bruton asked whether the SAIS could be made more affordable to retired people who were still active in the innovation areas but did not have institutional support. Dr Verhaeghe indicated this was a challenge as the SAIS was a private space that needed to charge a fee for its services in order to survive. The online component was a way to make it more accessible to those who could not afford to pay their way.

Prof. Deshen Moodley asked for advice concerning large tech not-for-profit startup that produced cutting edge tech and had a turnover of around R20 million and was considering starting a for-profit component, which would have consequences, but this would have consequences. Dr Verhaeghe referred to her principle about learning to work with and respect the private sector for its drive for implementation, not for its money, adding that she would never create a not-for-profit organisation because the rules were very strict about what work it could do, forcing it to beg for money constantly because it could not create value and exchange it for money. On the other hand, a proprietary limited (Pty Ltd) company allowed a social entrepreneur to be incredibly impactful and do any kind of work. The South African obsession with not-for-profit was not good for the economy.

Prof. Elvis Fosso Kankeu asked Dr Verhaeghe about the kind of assistance her company provided to academic researchers who had a new technology. She responded that her tech tribe had a market readiness programme and worked with a lot of academic researchers who wanted to understand what needed to be built in and created around their products to make them market ready. They also made companies aware of what they needed to do to build an organisation out of their product.

Ms Niehaus inquired about employment creation from the startups and the role of universities in this regard. Dr Verhaeghe mentioned that employment creation from startups was very different from other

environments, but surprisingly big and involved skills such as digital marketing, coding and data scientists. It created careers in the creative economy and the knowledge economy. Many startups, regions and large firms spent a lot to develop the skills they needed. A lot of work was needed to create the talent needed to fill the tech startups. No South African university had ever enquired about internships at tech startups because their thinking was that graduates needed to work in large corporates. She anticipated that within the next ten years internships in tech startups would be sought after as they were the best learning spaces.

Ms Niehaus asked Dr Verhaeghe to give examples of startups that were specifically in the creative economy. Dr Verhaeghe that there were several design and digital marketing enterprises, but SAIS could never attract funding for spaces such as fashion, film-making and textile design. Perhaps this was a matter of mindset as those in the creative industries thought they were not technological enough to call themselves 'innovative' and rather called themselves 'creative'. A lot of creatives did play in the marketing space.

Ms Niehaus pointed out that the discussion forum had brought up the question of how to bring the creative industries and technological innovation closer together. There were spaces in which these two spaces met, but it had not yet taken root.

Dr Verhaeghe suggested that the closeness between the creative industries and technological innovation differed between regions of South Africa and depended on whether society used the local products. Cape Town started with a creative drive and innovation was added to that, while the creative drive in Johannesburg seemed disconnected from the strong science and innovation drive in that city.

Ms Niehaus thanked Dr Verhaeghe for having presented another perspective on the creativity-innovation debate. Innovation was certainly incredibly important, but progress had been very slow despite the many intense efforts that had been put into it. A lot of work needed to be done in this regard and creativity ought to be fostered.

MY WORK AND HOW I CREATE ART FROM PLASTIC WASTE (MR MBONGENI BUTHELEZI, ARTIST)

Mr Buthelezi had been experimenting with a new and unique art technique using discarded plastics since 1991. The lack of resources to pursue his dreams as a young artist was one of the factors that prompted him to start making art in this form, as traditional ways of making art using oils, water colours and canvas were very expensive. This forced him to work around the problem and look at other options. Being involved in an art centre in Soweto introduced him to a number of different ways of making art and encouraged him to think out of the box. Making collages from discarded magazines was a starting point for him and inspired him to go on to achieve his goal in life of becoming a professional artist, and this was how the plastic paint medium came about. At the time, it was the only way for him to progress as an artist.

When he started making art from reused plastics in 1991, it had never been heard of before but several years later ideas about using recycled materials to make artworks began to grow and a wide variety of options became available in this area. Exploring and experimenting brought the medium to a point where it became respected in the art world. In 1998 he was invited by Wits University to be one of their advanced students. This opened doors for him and brought him recognition as an artist working with the specific medium of recycling plastics.

The real breakthrough came in 2017 when he was invited by King Abdullah University of Science and Technology in Saudi Arabia. It then dawned on him that he was not the only artist using plastics and that this could make a contribution to saving the environment. Consequently, he was invited by a tourist company in the Maldives as a guest artist to share his expertise with guests at its resorts. In 2020, he was invited by one of the universities in Germany to discuss ways of bringing science and art together. He worked with young Masters students sharing ideas of how science and art could make a difference in an interesting way. This experience made him acutely aware of the meaningful contribution that artists could make to society through their art.

In 2021, the United Nations Educational, Scientific and Cultural Organisation (UNESCO) through the

German Alliance for Marine Research and the German Development Institute saw the need to invite Mr Buthelezi, as an artist from South Africa, to be part of a forum that brainstormed ideas to come up with innovative on ways of saving the oceans and identify the role of art in bringing awareness to the world. Art had a role to play beyond producing works that focussed on identity to produce a new kind of art that reflected issues affecting the entire world. Much could be achieved through the dialogue between artists and scientists by looking closely at how the disciplines complemented each other, and how collaboration between them could offer exciting ways for society to engage with the environment.

Workshops, exhibitions, collaborations, presentations and outreach programs could be used to reach out to society and bring ideas together that would broaden awareness about what was achievable when artists and scientists worked together and across disciplines to ensure that progress was made with regard to saving the environment as a whole.

Q & A SESSION

Ms Niehaus pointed out that Mr Buthelezi should be regarded as an inventor and an artist. The plastic artworks shown in his presentation were examples of his fascinating work. Sustainable development was an important part of his work, which also related to the international theme for 2021- The Creative Economy for Sustainable Development.

Mr Buthelezi explained that the art centre in Soweto was a completely different world. It was a creative world and one that allowed him to be himself. He believed that artworks could not be objects that conveyed no message at all. They had to attract interaction. The world was beginning to realise that his work was not only about beautiful images, but also about raising awareness and inviting people to think differently. Artists needed to work with their communities and be alert to the challenges in society and be passionate in reflect the issues in their work. It was about bringing different ideas together and making sense out of that. Job creation was another important aspect of making art. If people saw meaning and depth in art they would be willing to pay for it.

Ms Niehaus added that art materials were not being produced locally and had to be imported, making them incredibly expensive. This was a major barrier to entry for artists.

Prof. Mike Bruton had written extensively on the nature of creativity and in the arts and sciences, and how the two disciplines needed to work together far more. He was involved with an art gallery in Cape Town where several artists worked with plastics and other recyclable materials to make their art. He viewed art as an agent of change and saw the need for artists to work far more closely with scientists and conservationists to bring the very important message about biodiversity conservation to a larger audience. A lot of people found science to be technical and complex and chose not to listen to the scientific message, but if this message could be conveyed through art broadly, it would mean that a whole new tranche of people could be reached. He undertook to make contact with Mr Buthelezi.

Ms Poppie Sera commented that Mr Buthelezi's work challenged mindsets about 'waste materials' as it was evident that a lot of innovation and technology could come from using plastics in art. She asked if there were any current projects in South Africa where research students could become involved in. Mr Buthelezi was unsure about such projects, but mentioned that he had been receiving many more invitations from science institutions to share his expertise with scientists in recent times.

Ms Niehaus mentioned that one of the NSTF discussion forums that was held in 2019 looked at plastic substitutes versus recycling. Research was being conducted in this area, but there was a gap in the research with regard to the (permanent) reuse of waste materials. Mr Buthelezi emphasised the importance of looking at how to constructively (re)use the waste materials that already existed instead of producing more of those materials.

Prof. Elvis Fosso Kankeu was working with microplastics in the ocean and wanted to collaborate with Mr Buthelezi who welcomed the invitation to collaborate with anyone who was willing to work with him. Mr Buthelezi commented that through his work he always wanted to achieve collaboration, sharing and

discussion to the benefit of everyone.

Ms Niehaus commented that Mr Buthelezi's presentation brought the perspective of a practicing visual artist to the discussion and highlighted the technical issues that he dealt with, his ideals and the expression of his art.

THE BASICS OF LAW: IP AND CCIs (MS TECLA SPILLER, LAW STUDENT)

The presentation was given by Ms Niehaus on behalf of Ms Spiller and in her absence due to illness. It provided an overview of the legal framework for IP and CCIs in which creatives functioned.

The World Intellectual Property Organisation (WIPO) was formed by the United Nations in 1967. Rationale for the adoption and protection of IP was to give statutory expression to the rights of creators and innovators in their creations and innovations balanced against the public interest in accessing creations and innovations, and to promote creativity and innovation, so contributing to economic and social development.

Introducing IP
IP law was a property right that related to intangible property. IP referred to creations of the mind, such as inventions, literary and artistic works, designs, symbols, names and images used in commerce. IP was protected in law by patents, copyright and trademarks for example, which enabled people to earn recognition or financial benefit from what they invented or created. Relevant forms of IP were copyright, which protected the form of the idea and creative content, and industrial IP, which protected the idea itself through patents and included patents and trademarks, and traditional art forms.

IP and Indigenous Knowledge Systems (IKS)
Globalisation and global trade were creating consequences of social exclusion, cultural homogeneity and environmentally unsustainable patterns of growth. Creativity and culture were plausible responses to these challenges. Arts and culture were socially transformative tools and had to do with the expression of artists that had to do with society and its problems and struggles and inspiring ways to deal with these.

The economic importance of CCIs was explained in the following extract, ''International trade in cultural goods and services had been growing at a faster rate than overall international trade, and digital technologies and the global internet were important drivers of this growth. Second, under Engel's Law, cultural consumption is positively correlated with economic development" (Flew, 2014: 12).

Indigenous Knowledge (IK)
IK was knowledge that was developed within an indigenous community and assimilated into the cultural make-up or essential character of that community, and included knowledge of a scientific or technical nature and of natural resources, and indigenous cultural expressions.

The legal definitions described traditional cultural expressions as those that had cultural content developed within indigenous communities and assimilated into their cultural make-up or essential character, including phonetic or verbal expressions, musical or sound expressions, expressions by action and action tangible expressions.

The World Health Organisation (WHO) stated that 80% of the population in Africa use traditional medicine for primary healthcare. The 2009 South African Social Attitudes Survey findings indicated a positive attitude towards IKS, supporting the idea that IKS could be a leading contributor to South Africa's progress and development. The survey found that over 70% of South Africans felt that there was too much trust in science and not enough in indigenous knowledge and cultural beliefs and practices. The majority of South Africans felt that government should do more to document IKS in South Africa and that government should do more to support communities involved in IKS, to promote small business using IKS and to spend more on protecting IKS. The majority also felt that big businesses were exploiting the indigenous knowledge of communities and that government should be proactive in this respect.

The University of the Western Cape's Science and Indigenous Knowledge Systems programme linked with decolonisation of knowledge systems, but there were questions about how available for use IK should be and its exploitation by international big business. There were tensions between IP and IKS in relation to rights of the individual versus the collective nature of cultural knowledge and to the idea that fixation was a problem in copyright application because much of IK was oral and usually intergenerational rather than pertaining to one lifetime. In addition, the protection of IK through IP was very costly and burdensome.

The Intellectual Property Laws Amendment Act (IPLAA) used standard IP concepts such as copyright and patents that were not fit for purpose when dealing with IK. Therefore, the IK Act (IKA) (2019) was effected but did not replace the IPLAA and was used alongside it. The Protection, Promotion, Development and Management of Indigenous Knowledge Act (2019) addressed the establishment and functions of the National Indigenous Knowledge Systems Office (NIKSO), the management of rights of indigenous knowledge communities, the establishment and functions of the Advisory Panel on IK, access and conditions of access to knowledge of indigenous communities, and the facilitation and coordination of indigenous knowledge-based innovation.

The IKA protected IK through the concept of *sui generis (*of its own kind or unique) and therefore did away with the traditional IP distinctions between copyright for works of art and patents for crafts by using the concept of *sui generis* to incorporate all forms of IK. The DSI described the IKA as being essentially about redress and bringing indigenous knowledge into the main stream, and as transformative because it addressed how indigenous communities could contribute and become part of the mainstream economy using their own IK.

Protection of IK was legislated in the IKA through the following clauses in particular:

- Clause 9, which provided for the subject matter under protection, within the meaning of section 25 of the Constitution. In addition, the sub-clause provided for IK as property vesting in the relevant indigenous community.
- Clause 10, which provided for the duration of protection of the subject matter which would persist for as long as the eligibility criteria set out in clause 11 were met.
- Clause 11, which delineated the eligibility criteria for protection of the subject matter (IK) which was passed on from generation to generation within an indigenous community, developed within an indigenous community, and associated with the cultural and social identity of that indigenous community.
- Clause 12, which affirmed custodianship of IK eligible for protection vested in the trustee of that indigenous community, who held the IK in trust on behalf of the indigenous community and was responsible for and accountable to the indigenous community for the protection of their rights.
- Clause 13, which provided for indigenous communities holding IK to have the exclusive right to any benefits arising from its commercial use, be acknowledged as its source, and limit any unauthorised use of the IK.

IP and Computer Generated Content

The South African Patents Act of 1978 stipulated that anything consisting of a programme for a computer or a scheme, rule or method for performing a mental act, playing a game or doing business, would not be regarded as an invention. This provision made it difficult to protect computer/video games in terms of IP.

Modern video games contained at least two main parts:

- The software which technically managed the audio-visual elements and permitted users to interact with the different elements of the game could not be patented, but code could be copyrighted.
- Audio-visual elements (including pictures, video recordings and sounds), which could be copyrighted.

According to the Copyright Act (1978), copyright comprised the following video game elements: musical works, storyline or literary works, artistic works, coding, characters, box design and website design. It was a negative right that granted the holder the right to authorise others to reproduce a work or prevent them from doing so.

The question about who owned the copyright of works created by AI-powered machine was exemplified in the case of “The Next Rembrandt” in 2016. The artwork was created by a 3D printer that analysed hundreds of well-known Rembrandt paintings and used machine and deep learning techniques to mimic the artist’s work. The rules regulating the United States Copyright Office stated that the office “will register an original work of authorship, provided that the work was created by a human being ... will not register works produced by a machine or mere mechanical process that operates randomly or automatically without any creative input or intervention from a human author...”. Similarly, in the 2012 case of Achos Pty Ltd v Ucorp Pty Ltd, the Federal Court of Australia declared that a work generated with the intervention of a computer could not be protected by copyright because it was not produced by a human.

An AI algorithm would be categorised as a "computer program" under South African law and was protected by the law of copyright (not patent). In the law of copyright ownership of original work was vested in the author (or co-authors) of the work. It was therefore critical to identify who the author was. In respect of a computer program, the Copyright Act stated that the author was the "person who exercised control over the making of the computer program“. Where the work was created in the course and scope of employment, the employer will hold the copyright. Where a computer program had been commissioned, the person commissioning the work would be the author.

The Copyright Act defined an “author” in relation to various works as “the person”. Legal persons - both natural and juristic – did not only refer to humans. However, AI had not been considered at the time of drafting the Act. If the machine was truly autonomous, the work would be technically ‘original’. This raised the question of who the author was and showed that legal lacuna needed to be developed in order to keep up with technological developments.

Q & A SESSION

Ms Niehaus commented that IK was not sufficiently valued in South Africa, and recognised that this was partly due to the move away from traditional practices and ways of making a living in general, which would become more of a trend with the 4IR. This highlighted the importance of preserving IK.

With regard to the loss of IK and traditional practices, Prof. Mike Bruton emphasised the importance of ensuring that traditional practices did not become extinct. In researching traditional fishing methods of Africa for his book on this topic, he was alarmed to find that so many of the very innovative traditional fishing practices had been lost or had diminished to such an extent that they would soon be extinct. Other countries, such as Japan, had taken steps to preserve the IK and ensure that their traditional fishing methods would continue for generations to come.

SOUTH AFRICANS ARE RESOURCEFUL, CREATIVE, AND INNOVATIVE (PROF. MIKE BRUTON, AUTHOR)

Prof. Bruton had done a study on what was good science and how scientists contributed most productively to society and incrementally to build the body of knowledge. Among scientists, there were risk-takers who often worked on the interface of disciplines, broke the rules and came up with novel ideas. This was what inspired Prof. Bruton as he developed an interest in the nature of creativity in science and a comparison between it in science and in other disciplines, such as arts and economics.

Prof. Bruton had documented South African and African inventions in a number of books that also discussed innovation concepts and case studies, and in this process the nature of invention and innovation in South Africa and why the country punched well above its weight in the innovation arena became clearer to him. His most recent book called ‘*Curious Notions - Reflections of an Imagineer’* was a series of essays in which he discussed the greatest South African inventors, creativity and the arts and sciences, and Africa's Nobel Laureates and other top achievers.

Sadly, some of the great inventions and innovations made in the past could not be attributed to anyone and would always remain anonymous. Arguably, one of humankind's greatest innovations was the controlled use of fire, a very enabling technology, the first evidence of which was found by South African paleontologist

Dr Bob Brain and others in South Africa and also in Namibia. Early humans created a fantastic variety of stone and then metal tools, many of which could be found in the 3000 or so middens around South Africa's coastline. The oldest known abstract artwork was found in this country around 77,000 years ago and a carved baboon fibula with 28 notches and called the lunar stick dated back 37 000 years and was the oldest mathematical device known. There was also the famous Golden Rhino of Mapungubwe, which was a display of the use of plate gold that had reached an incredibly sophisticated level.

The value of IKS was beginning to be understood. One of the pioneers of IKS did the detailed study of the hunting and tracking methods of the San people of the Kalahari and developed the Cyber Tracker, which was a GPS system using icons instead of letters and numbers for input. The practices were documented and analysed and trends were identified. There were many examples in South Africa where traditional knowledge had been beneficiated and commercialised, although credit had not always been attributed appropriately.

Some examples of South Africa's modern inventors and innovators were:

- James Greathead, who became known as the father of the London Underground, because he invented the tunneling apparatus that was used to drill the first tunnels for the London and Manchester undergrounds. He also invented other machines and was regarded as a great innovator.
- Eric Merrifield invented the dolos that were used to protect the shores of over 120 countries around the world.
- Trevor Wadley was South Africa's greatest inventor and an extraordinary man who made a series of innovations and inventions around radio, radar and radio that totally transformed that field around the world. He was particularly famous for his Tellurometer, a widely used land surveying device.
- A whole range of the best pump-powered pool cleaners in the world were developed in South Africa, but all of them had been sold to overseas companies.
- The Computerised Axial Tomography (CAT) scanner was co-developed by Allan Cormack together with a medical technologist in England. It was ranked as the 53rd greatest invention of all time and took the medical world into the digital era.
- Dave Woods and his team developed a series of hand-held medical operators such as the pulse oximeter, that did not require electricity or batteries and were therefore useful in rural clinics.
- Mulalo Doyoyo, a technology entrepreneur who specialised in solving problems related to sustainable living and the use of waste material for useful purposes. He also developed the hydrogen motorbike and other products.
- Sandile Ngcobo, who together with others, developed the digital laser.
- Lucky Netshidzati, who invented the innovative a smart glove that translated sign language into voice and text.

The country's big science projects with multiple innovations included the Square Kilometre Array (SKA) Reconfigurable Application Board and there were numerous innovations in the financial transactions field.

Prof. Bruton's most recent book, *'Harambee: The Spirit of Innovation in Africa'* was an ambitious attempt to provide an overview of innovation throughout the African continent. It argued that in this century Africa would become the bright continent and gave examples of over 600 innovators and the myriad inventions that they had made, focusing on a range of innovations from very low tech to very high tech. The book attempted to communicate the many 'Africa firsts' that could be traced back to IK through to the modern world, to as many people as possible, and provided many examples of successful innovation in other African countries. The book also highlighted the many heroes of African innovation, many of whom had remarkable stories of how they worked under difficult conditions to achieve success. There were very positive trends occurring in Africa - its rapid technology, its strong entrepreneurship and the extent to which there was a 'step ladder' from low to medium to high tech innovation, which allowed young men and women, often with disadvantaged educational backgrounds, to step up and become world class innovators.

Klaus Schwab, the very prominent economist and founder of the WEF, had proposed that the world was in the 4IR, which he claimed was all about disruption and up-ending economies and social norms, but he was not the first to come up with these ideas. In the 1990s, the United States Military came up with the concept

of VUCA (volatility, uncertainty, complexity and ambiguity), which described the sort of trends that would define society in future. Prof. Bruton agreed with this concept, but did not support Schwab's suggestion that there were four industrial revolutions. Although the first three industrial revolutions had brought many benefits, they had also done a lot of harm as they had brought uncontrolled human population explosion and the explosion of domesticated and farm animals, the development of conspicuous and wasteful consumption, highly materialistic cultures, wider society imbalances, major damage to the environment, accelerated climate change, compromised life support systems and unsustainable lifestyles. He argued that instead of the 4IR, this was the first post-industrial revolution and a major change of mindset and behavior was required in order to be able to take full advantage of its implications. At best, this post-industrial revolution had completely different qualities to the industrial revolutions. There were small and big economies, young people taking part and much more participation from the developing world. It was capable of undoing many of the wrongs of the first three revolutions by taking right decisions. This presented an opportunity to harness resources in an unprecedented way to solve global problems.

This first post-industrial revolution was characterised by digital tools and fueled by ideas. It was highly disruptive and a form of social intervention, even social domination (if one looked at the impact of the internet and smartphones). It facilitated technology leapfrogs and tended to democratise technology by making it available to people at all economic levels. This was happening because of the internet, which had not just connected people, but entangled them, and connected people to the IoT, which had resulted in a science-technology development and problems being resolved by a multi-brand, multi-generational, super organism - a kind of collective genius that humankind had never had before - group intelligence and the ability to co-create solutions and collaborate. The participation of young people was an extremely important element of this post-industrial revolution, especially the Generation Xers, Millennials and post-Millennials who tended to be globally connected, digitally competent, entrepreneurial, ambitious, self-authored and often rebellious, rejecting the status quo and constantly questioning the value of previous societies. This was a post-industrial revolution, especially in Africa, because there were two kinds of entrepreneurs:

- Social entrepreneurs, who were collaborative, often worked in adverse environments and tended to generate social value and plough their profits back, and were often involved in anti-global trends. South Africa and Africa had a particularly strong core of social entrepreneurs.
- Commercial entrepreneurs, who were an important part of the mix. They worked in opportunity-rich environments and their goal was to maximize their profits.

Science was not about certainty, stability and top down authority. The first three industrial revolutions were characterised by top-down authority and a relatively small proportion of the population contributing to them. Today, there were rebellious young people with their own minds and science was able to take place in the environment and it was all about doubt, skepticism, questioning the status quo and constantly testing alternate ideas and solutions. This was a key characteristic of this post-industrial revolution and one of the reasons why some of the past problems would be able to solved.

It was important to recognise that the world survived through a biological process. The COVID-19 pandemic had revealed the extent to which humans were part of nature. There was a need to recognise that humans were no longer part of wild nature, although they were part of the essential ecological processes. People had become servants of their machines, trapped in unsustainable urban environments and were the first animal to domesticate itself and to lose its ecological place, its niche. This was a dangerous situation because natural selection tended to kick out those species that were unfit in the evolutionary sense. Although humans were now the biggest population of large mammals to ever exist, it was important to remember the passenger pigeon that used to have numbers of hundreds of billions and was now completely extinct. Humans were not exempt from going extinct. Humanity was at the crossroads and its ability to manipulate the environment was unprecedented. It had exceeded the planet's ability to compensate for its actions and this was dangerous and the reason for climate change. Humans needed to evolve into the custodians of the biosphere. The other species on the planet were totally dependent on humans to make good decisions in order to reverse the bad decisions made in the past.

Prof. Bruton formulated the idea of the so-called education information value chain, arguing that in this information age it was not enough to just convey raw information to people. The information had to be contextualised into useful knowledge; that knowledge had to be used to make wise decisions; that wisdom

had to be used to change mindsets when necessary; the changed mindset needed to lead to changed behavior and then others needed to be influenced to change their mindsets and behavior. It was only once the education information value chain had been entrenched in society that the very challenges that faced the world today could be addressed.

Prof. Bruton concluded that:

- South Africans and Africans were tremendously innovative, and this needed to be recognised and widely communicated.
- The '4IR' was not just another routine industrial revolution where humans would further trample over nature and destroy essential ecological processes. It was a connecting, problem-solving, post-industrial revolution and full advantage ought to be taken of the opportunities that it offered and it was necessary to recognise that Africa had a very strong role to play in this regard.
- It was recognised that industry needed to continue but would have to observe the triple bottom line and become part of the solution rather than part of the problem.

Q & A SESSION

Ms Niehaus thanked Prof. Bruton for reminding the forum of the resourcefulness of South Africans and for his provoking thoughts about the 4IR. The idea of a super organism that had collective intelligence became reality in the COVID pandemic when there was unity of collective intelligence in the way that scientists worked together to make a difference in the fight against the pandemic.

Prof. Bruton commented that the reaction of humanity to the COVID pandemic was a wonderful example of how countries with different ideologies, cultures and histories could work together. Humans had the ability to work together if they faced a common enemy. As the world was emerging from the pandemic, it was important to mobilise that same level of international collaboration to solve the much bigger problem of biodiversity loss and climate change. There was no vaccination against species' extinction or climate change. Everyone would be affected. COVID also highlighted the increasing anti-science and pseudo-science sentiments, which had been trumpeted using the megaphone of social media. It was more important than ever for scientists to communicate the truth and scientific results to the public in as many different ways as possible, including through art, music and the performing arts. Important messages needed to be deciphered, demystified and conveyed to the public.

Dr Angela James suggested that there should be a common programme on IK for all the universities and schools and commented on the importance of the aspect of inventors and inventions from Africa and the inclusion and recognition of IK in education. Science was much more than words in a text book. It was about living lives and how to live them best in terms of the better good.

Prof. Bruton pointed out that South Africa had a very weak science culture and suggested that the status of scientists should be elevated to the same level as sports stars. A lot could be done to strengthen the science and technology culture in this country.

Ms Niehaus mentioned that prominent views expressed at the two NSTF discussions forums on COVID-19 were about the importance of communication during the pandemic and raising awareness about what science actually was. Some progress had been made in this regard during the pandemic.

Prof. Bruton emphasised that communicating science should not only be about the outcomes of discoveries and inventions, but also about the scientific method and how science worked. People became skeptical about the value of science because they did not understand the scientific method. It was healthy for scientists to disagree with one another and to reject previous hypotheses and replace them with new hypotheses on the basis of in a more recent research.

Ms Niehaus agreed that much work needed to be done in this regard using the lessons learnt during the pandemic.

Prof. Bruton pointed out that the way in which humans lived in dense societies and with domestic animals

also made them very vulnerable to future pandemics.

CREATIVITY AND ARTIFICIAL INTELLIGENCE (PROF. DESHEN MOODLEY, DEPARTMENT OF COMPUTER SCIENCE, UCT)

Artificial Intelligence

Some important distinctions and nuances needed to be made in terms of AI. AI itself was not seen as a technology or a solution and should be viewed more as an enabling technology for digitalisation. It typically sat within a digital system and was not an independent technology. The interest in and hype about AI was due to the fact that substantially increased levels of automation of complex human activities could be achieved and there was more potential to come up with digital products and solutions.

It was also important to realise that the boundary between automation and intelligence could be vague. About 50 years ago, a computer that could do complicated calculations that humans could not do was considered to have a degree of intelligence. One of sophisticated uses of AI was Google Maps, which did dynamic planning, and although it was simple to use, the background activity involved a large amount of AI. Intelligence (even human intelligence) was relative and very hard to measure, but the bar for AI tended to be set at human ability.

Tools used by humans had evolved over the centuries from hammers, axes and chisels, to machines such as mills, tractors, cars and stoves, to programmable machines or computers that could do multiple tasks, to the present where there were adaptable, learning machines in the form of intelligent computers, which could adjust their programmes to the changing environment and adapt to humans. This was where intelligent systems and computers, or AI, came in. Given this background, AI could be viewed as computers that could learn from experience and adapt to changing situations. At the core of AI was the learning and adapting ability together with rapid fusion, analysis and communication of vast amounts of information in real-time over local and global networks.

The quest for AI had traditionally been toward building fully autonomous machines and this had raised a question about the role of humans in AI. The idea was to leverage the strengths of both human and machine, where humans worked in tandem with machines and machines were not fully autonomous. AI learnt and adapted to the human user and in the same way the human user learnt and adapted to the AI. Humans sets tasks and objectives and the AI helped humans to efficiently complete the task. This very particular approach to AI was referred to as Augmented AI. AI had its roots in computer science, but the Augmented AI approach was interdisciplinary.

The Intercontinental Academia (ICA) was a global network of future research leaders where a select group of young academics worked together on paradigm-shifting, cross-disciplinary research, mentored by eminent researchers from across the globe. The 4th edition of ICA (2021-2022) focused on Intelligence and AI, and explored fundamental interdisciplinary questions at the intersection of cognitive science, neuroscience and AI. Eminent mentors and 19 Fellows were selected from different continents and across diverse disciplines. Prof. Moodley was privileged to have been selected as a Fellow of the ICA and found the many different perspectives very refreshing. He was convinced that an interdisciplinary approach to AI was the best way forward.

Emotional intelligence was a core aspect of intelligence. The human-AI interface required innovative thinking and creative solutions, which needed an interdisciplinary approach between technologists and social scientists. The idea of moving AI into medicine and healthcare using AI for health and wellbeing was another areas that was receiving attention.

AI in South Africa

The Centre for AI Research (CAIR) was the DSI's flagship AI research and capacity development programme. It was a distributed research centre in AI research involving ten research groups and two emerging groups across eight universities in the country. The idea of setting up the centre came about when it was realised that the individual computer science departments of the various universities were too small to compete with international groups in the AI space. When the centre started in 2011, it was hosted

between the CSIR and UKZN and expanded in 2015 and again in 2019 to 2020. The current structure of the Centre covered a broad range of AI areas. The idea was to have a core in computer science but bring in people from other disciplines to create an interdisciplinary environment. From Prof. Moodley's experience, it was extremely difficult to set up structures such as the CAIR in the South African landscape as people were suspicious and skeptical of new ideas.

CAIR had produced some technology and had developed a strong industry link, and had advised a variety of companies, including international corporates in South Africa, on how to scale up their use of AI. In terms of high level policy insights and thought leadership in AI, CAIR had reported on the state of AI in Africa at the first meeting of the African Panel on Emerging Technologies (APET) initiative funded by the African Union and provided technology guidance and innovation roadmaps in healthcare through CAIR's Health Architecture Lab (HeAL). CAIR's Ethics of AI Research Group played an active role at UNESCO's Bioethics and Ethics of Science and Technology Unit and contributed to national and global discussions around the ethical use and societal impact of AI.

In terms of the AI research and innovation ecosystem in South Africa, AI and robotics was one of six foundational digital capabilities identified in the DSI's Decadal Plan for establishment over the next ten years. The establishment of an AI Conference (SA Conference on AI Research (SACAIR)) was very important, particularly for computer science researchers and AI researchers because conference proceedings, and not journals, were the primary publication venue in these fast-moving fields. The first major international conference, the International Joint Conference on AI, would be held in 2023 in South Africa.

AI Technologies

As to whether AI could be used to generate digital content and whether computers could be truly creative, the subset of AI known as Computational Creativity (CC), created digital works automatically. It explored creativity specifically through the medium of computational systems through diverse applications such as games, art, music, writing and animation. The problem was that the quality was hard to judge and more work was required to design frameworks for understanding emotional responses.

Artificial Neural Networks (ANN) was one of the prominent AI techniques used in machine learning. It was based around the notion of a network of neurons as in the brain. For example, ANN was used to generate an image of a handwritten character. Another technology, Generative Adversarial Networks (GANs), could be used to reverse this process to generate a handwritten character from an image. Some GANs were created just for art, such as the Creative Adversarial Network (CAN), which could produce photorealistic landscapes and pieces of art for a given style, for example. AI had limitation in terms of creativity. Some were of the view that AI could never be creative and that the art created by AI was cold, disconnected and impersonal. This was not surprising because computers were designed with analytical and mathematical capabilities, and not emotional intelligence.

Prof. Moodley had done some work on the idea of Artificial 'Emotional' Intelligence in controlling non-player characters in 3D game environments to make the non-player character more 'human-like', and on the emotional state in health and wellbeing through assessing, predicting and improving emotional wellbeing using wearables. AI, especially Augmented AI, could be empowered if there was a specification of emotion and feeling.

In summary:

- AI techniques such as GANs would accelerate the development of digital content
- AI was providing tools for augmenting the creative process and rapid content generation, both in the digital and physical world
- Augmented AI would require new interfaces that incorporated notions of empathy.

Some possible future trends were:

- Innovation around human-AI interfaces
- Creating 3D digital content in virtual worlds towards an African metaverse (such as Ubuntuland)
- Gaming worlds and photorealistic animation

- Interactive story telling
- Digital twins.

Q&A SESSION

In response to a question, Prof. Moodley explained that swarm intelligence was a part of something called multi-agent systems. An example would be a large group of really small drones that came together to do given tasks. On the multi-agent system side, the control mechanism to make them work together was the technique used, such as particle swarm optimisation, which could also be used for learning to design, as part of neuro evolution, and find a solution in a very complex space.

Ms Niehaus asked whether digital art created by AI was also art and whether AI was useful in creating art. Prof. Moodley believed that there was a use for AI in creating art, but this raised questions about what digital art was and what creativity was. AI-created music and AI-created art had been sold for huge sums of money. The ability to use AI tools to create art would mean that even those who were not artists could be part of the creative community. A completely new and unique piece of art (digital image) could be created using AI techniques to bring together several pieces of art in a similar genre. This raised interesting questions about whether the digital art piece would be considered to be art.

Prof. Moodley asked the participants whether they thought that artists would use AI tools. Ms Niehaus indicated that such a decision would be made on the basis of functionality, but any form of art would depend on the human response to it and this would be the way to judge the quality of digital art. The sciences and the arts differed enormously in this area.

Prof. Moodley explained that Ubunutuland, a commercial entity that in due course would create an African metaverse, was being used by at least one prominent African artist as a marketplace to showcase his work. He was of the view that industrial revolution was a buzzword and a strange way of looking at things. Things evolved at different paces and even though there were some milestones, there could be no boundaries between the phases of history. What had changed from an art perspective was the notion that a machine could create and build other machines, and the machine could do things that it had not been created for. He gave the example of a game of chess where the AI actually invented strategies that no human player had ever seen before. This was very profound and would change where the world was heading because it was not only humans that created things. The trajectory in terms of technology evolution had changed.

Prof. Moodley mentioned that as part of CAIR's multidisciplinary approach, the University of Pretoria's (UP's) Department of Philosophy was involved in one of the tracks at the SACAIR that focused on Ethics of AI. He added that in terms of language processing, AI had been trained in international languages and much work still needed to be done in terms of local African languages. AI could learn to speak by listening to human interaction and would be useful when it came to translating from African languages.

Mrs Sybil Otterstrom (Zoom chat) asked whether the idea was for AI to replace humans, what the dangers would be if AI started thinking like humans and if it was widely distributed from a robotics point of view. Prof. Moodley emphasised that he did not want AI to replace humans and that this was one of the big dangers of AI. The idea of the singularity where the machines took over was something to keep an eye on but would not necessarily become reality. However, someone in a research lab or garage could probably stumble on this kind of singularity where the super intelligent machine started taking over things as been depicted in hundreds of movies. The chances of that were very slim because there was not the investment (in money) into the science and technology to make it happen. The huge investment in terms of resourcing was going into research and innovation in AI by the big tech companies that were definitely looking towards building human-computer interfaces in terms of things that humans could consume or that augmented humans. The everyday use of Google should not be underestimated and raised the question of whether Google was replacing humans. In some ways, it was taking over because no-one used paper maps anymore. However, this was very different from Google taking over completely, which was unlikely to occur in the next 20 to 30 years.

CLOSING

Ms Niehaus thanked the audience and speakers for their participation in and valuable contributions to the discussions, and reminded them that all the presentations, recordings and proceedings of the two-day event would be available on the NSTF website, and a media statement summarising the issues that were discussed would be released soon.

ANNEXURE A: LIST OF ATTENDEES

DAY 1

Title	Name	Surname	Organisation Name
Dr	Tebogo	Mabotha	Academy of Science of South Africa (ASSAf)
Mr	Shaun Earl	Harris	Afrika Moves Media Agency
Mr	Thabiso Mudau	Mudau	Agricultural Research Council (ARC)
Mr	Ivan	Pillay	AMEK Consulting
Miss	Amogelang	Sedutla	Ask Afrika (Pty)Ltd
Miss	Welna	van der Berg	Central University of Technology (CUT)
Ms	Tamsin	Oxford	Coffee Content
Mrs	Sharon	Muller	Columbus Stainless Steel
Dr	Mokae	Bambo	Council for Mineral Technology (MINTEK)
Ms	Thando	Siyongwana	CSIR
Ms	Thandokazi	Delaharpe	Cushycoat and Co (Pty) Ltd
Mrs	Nelia	Venter	CUT
Mr	Ramsey	Maharaj	Department of Agriculture, Land Reform and Rural Development (DALRRD)
Mr	Mathala	Mokwele	DALRRD
Mr	Thabo	Motsepe	DALRRD
Ms	Patience	Mphumbude	DALRRD
Mr	Kgomoamogodi	Petje	DALRRD
Ms	Ledile Makgoale	Makgoale	Department of Communications and Digital Technologies
Ms	Mapula Rachel	Mpe	Department of Water and Sanitation
Ms	Lindiwe	Gama	DSI
Ms	Indrani	Govender	DUT
Mr	Johann	Venter	Ecosense
Mr	James	Boyers	Elevate Property Management
Ms	Deidre	Batchelor	Embassy of the Kingdom of the Netherlands
Miss	Jessica	Glendinning	Embassy of the Kingdom of the Netherlands
Mr	Riaan	Van der Bergh	Federation of Governing Bodies of South African Schools (FEDSAS)
Mr	David	Mann	Freelance
Mr	Tshegofatso	Monama	Infrastructure South Africa
Ms	Sanari	Malele	Limpopo Department of Agriculture and Rural Development (LDARD)
Dr	Dimakatso	Masindeni-Ndou	LDARD
Mr	Lucky	Mamanyuha	LDARD
Mrs	Sybil	Otterstrom	Mail & Guardian
Dr	Nqobile	Xaba	Mapungubwe Institute for Strategic Reflection (MISTRA)
Mr	James	McCarthy	McCarthy Legal
Mr	Melusi	Malaza	National Research Foundation (NRF)
Dr	Kurt	Van Der Heyden	NRF

Title	Name	Surname	Organisation Name
Mr	Whisper	Maisiri	North-West University (NWU)
Ms	Wilna	Eksteen	NSTF
Ms	Kelebogile	Galeboe	NSTF
Miss	Siyabonga	Jonga	NSTF
Mr	Barnard	Manne	NSTF
Ms	Jane	Mokgwatshane	NSTF
Ms	Seipati	Moleleki	NSTF
Mr	Matome	Mphela	NSTF
Ms	Jansie	Niehaus	NSTF
Ms	Nonsikelelo	Nkwanyana	NSTF
Ms	Karabo	Padi	PGCE Teacher
Dr	Gerda	Botha	Private
Dr	Mmboneni	Tshivhase	Private
Mrs	Poppie	Sera	Rand Water
Mr	Raymond	Ndhlovu	Rhodes University (RU)
Mrs	Catherine	Greengrass Smith	RSK (RGM)
Dr	Siva Mohan Reddy	Goddeti	SA Adhesives Pty Ltd
Miss	Lutfiyyah	Patel	Siyafundactc
Ms	Tshepile	Khotseng	South Africa Agency for Science and Technology Advancement (SAASTA)
Miss	Tshegofatso	Mashaba	South African Biodiversity Institute (SANBI)
Mr	Pascal	Motsoasele	South African Institute of Electrical Engineers (SAIEE)
Mr	Thato	Motaung	South African Nuclear Energy Corporation (NECSA)
Dr	Nitesh	Poona	South African Sugar Association (SASA)
Mr	Bulelani	Mqolweni	Stellenbosch University (SUN)
Mrs	Truida	Prekel	SynNovation Solutions (Pty) Ltd
Mr	Sipho	Dikweni	TIA
Dr	Kershini	Iyer	UCT
Prof	Deshen	Moodley	UCT
Prof	Tshilidzi	Marwala	UJ
Dr	Angela	James	UKZN
Prof	Thomas	Netshisaulu	University of Limpopo (UL)
Ms	Dineo	Raphasha	UL
Prof	Elvis	Fosso Kankeu	University of South Africa (UNISA)
Mrs	Daba	Bakhoum	UP
Dr	David Livingstone	Nsibo	UP
Mr	Mocke	Jansen van Veuren	Wits
Ms	Avril	Joffe	Wits
Dr	Brett	Pyper	Wits
Mrs	Heather	Erasmus	Write Connection

DAY 2

Title	Name	Surname	Organisation Name
Mr	Thabiso Mudau	Mudau	ARC
Dr	Tebogo	Mabotha	ASSAf
Ms	Hayley	Axford	Cape Town Science Centre
Ms	Tamsin	Oxford	Coffee Content
Dr	Rembu	Magoba	CSIR
Mrs	Nelia	Venter	CUT
Mr	Ramsey	Maharaj	DALRRD
Mr	Mathala	Mokwele	DALRRD
Ms	Patience	Mphumbude	DALRRD
Mr	Modikoe	Patjane	DALRRD
Mr	Kgomoamogodi	Petje	DALRRD
Dr	Suresh Babu Naidu	Krishna	Durban University of Technology (DUT)
Mr	Johann	Venter	Ecosense
Mr	Aslam	Motala	FM Media (PTY) Ltd
Mr	Lucky	Mamanyuha	LDARD
Dr	Dimakatso	Masindeni-Ndou	LDARD
Mr	Teddy Thaddeus	Mnisi	LDARD
Ms	Sybil	Otterstrom	Mail & Guardian
Mr	Mbongeni	Buthelezi	Mbongeni Buthelezi Art Studio
Prof	Mike	Bruton	MikeBruton Imagineering
Dr	Nqobile	Xaba	MISTRA
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Ms	Jansie	Niehaus	NSTF
Ms	Nonsikelelo	Nkwanyana	NSTF
Dr	Gerda	Botha	Private
Mr	Maatlo	Kgabe	Private
Ms	Tecla	Spiller	Private
Mrs	Poppie	Sera	Rand Water
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Dr	Kershini	Iyer	UCT
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ANNEXURE B: ACRONYMS

4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
ANN	Artificial Neural Networks
ARC	Agricultural Research Council
CAIR	Centre for AI Research
CCIs	Cultural and Creative Industries
COVID-19	Coronavirus 2019
CSIR	Council for Scientific and Industrial Research
CUT	Central University of Technology
DALRRD	Department of Agriculture, Land Reform and Rural Development
DSI	Department of Science and Innovation
DUT	Durban University of Technology
GAN	Generative Adversarial Network
HCD	Human Capacity Development
HSS	Human and Social Sciences
ICA	Intercontinental Academia
IK	Indigenous Knowledge
IKA	IK Act
IKS	Indigenous Knowledge Systems
IoT	Internet of Things
IP	Intellectual Property
IPLAA	Intellectual Property Laws Amendment Act
LDARD	Limpopo Department of Agriculture and Rural Development
NECSA	South African Nuclear Energy Corporation
NFT	Non-Fungible Token
NRF	National Research Foundation
NSTF	National Science and Technology Forum
NWU	North-West University
RU	Rhodes University
SAASTA	South Africa Agency for Science and Technology Advancement
SACAIR	SA Conference on AI Research
SAIEE	South African Institute of Electrical Engineers
SAIS	South African Innovation Summit
SANBI	South African Biodiversity Institute
SASA	South African Sugar Association
SDG	Sustainable Development Goal
SET	Science, Engineering and Technology
STEAM	Science, Technology, Engineering, Art and Mathematics
STI	Science, Technology and Innovation
TIA	Technology Innovation Agency
UCT	University of Cape Town
UJ	University of Johannesburg
UKZN	University of Kwazulu-Natal
UL	University of Limpopo
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNISA	University of South Africa
UP	University of Pretoria
VR	Virtual Reality
WEF	World Economic Forum
Wits	University of the Witwatersrand
WSOA	Wits School of Arts