ANNUAL REPORT
Faculty of Engineering

2019

Fakulteit Ingenieurswese
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ENGINEERING EZOBUNJINELI INGENIEURSWESE

Contents

The current Dean, Prof Wikus van Niekerk (far right), and four former deans of the Faculty of Engineering attended the 75-Year Gala Dinner: from the left, Profs Christo Viljoen, PW van der Walt, Arnold Schoonwinkel and Hansie Knoetze.

The Faculty of Engineering celebrated its 75th year of existence in 2019 and also did a substantial amount of preliminary work for programme renewal. We made good progress with increasing the diversity of students and staff, and appointed a number of new lecturers; also and especially from the designated groups. The Engineering Campus Renewal Project is well underway.

A transforming student experience

In the course of the past ten years the Faculty made significant progress with diversifying the composition of the undergraduate student cohort. The target set for 2021, that our first-year intake should comprise at least 40% black African, coloured, Indian and Asian (BCIA) students, was achieved in 2019 already. The Faculty goes all out to recruit students from the designated groups, with the support of our own marketer. A number of initiatives were adopted to support particularly first-year students to succeed academically, and included group study sessions, Dean's periods, and staff in die Dean's Division and the departments who provided additional student support. The Engineering programmes are challenging and demanding, and the Faculty has been using the services of two part-time educational psychologists for the past years to assist Engineering students in dealing with anxiety and stress and in learning more effective study methods.

Networked and cooperative teaching and learning

The year 2020 commenced with the renewal of our academic programmes, which had necessitated a considerable amount of preliminary work and marketing in 2019. The Faculty of Engineering will be offering the first BEng degree in Data Engineering in South Africa from February 2020. This degree has become a new specialisation stream in die existing undergraduate degree in Electrical and Electronic Engineering, that is, BEng (E&E), and for that reason ECSA has accredited it as a suitable qualification for registration as Professional Engineer. The aim is to prepare engineers specifically for the Fourth Industrial Revolution, where the world of work has fundamentally changed. A veritable deluge of data has to be structured, modelled and analysed to enable data-led organisations to discover underlying knowledge and to take informed decisions.

Our postgraduate programmes, too, have seen some renewal. From 2020, a structured master's degree and a postgraduate diploma in Industrial Engineering will be offered, focusing specifically on Data Science. Another field that has gained increasing popularity in the past few years is Biomedical Engineering. The Institute for Biomedical Engineering, seated in this faculty, will therefore offer new postgraduate programmes from 2020: A PhD in Biomedical Engineering (research) and a master's degree in Engineering Science in Biomedical Engineering (research). The doctoral and research master's programmes are aimed at training specialist researchers with specific skills in Biomedical Engineering to develop new knowledge at the forefront of health technology. On the other hand, the structured master's programme is aimed at people who already work in the industry, and the Postgraduate Diploma in Engineering Science is mainly intended to act as a bridging programme between the three-year BSc programmes and the master's programmes.

Research for impact

The Faculty of Engineering is research-intensive and takes pride in the large number of postgraduate students, especially doctoral students, who graduate every year. Engineers, because of the kind of work they do, contribute to the improvement of the quality of life of people and communities and to economic

In 2019 het die Fakulteit Ingenieurswese sy 75ste bestaansjaar gevier en heelwat aanvoorwerk gedoen ten opsigte van programvernuwing. Ons het vêr gevorder met die uitbreiding van die diversiteit van studente en personeel en verskeie nuwe dosente is aangestel, veral ook uit die aangewese groepe. Die Ingenieurswese Kampushernuwingsprojek is goed op dreef.

'n Transformerende studente-ervaring

Oor die afgelope tien jaar het die Fakulteit beduidende vordering gemaak om die samestelling van die voorgraadse studentekorps te diversifiseer. Die teiken dat ons eerstejaarinname ten minste 40% bruin, swart Afrikaan-, Indiër- en Asiër-(BSIA-)studente verteenwoordig, wat eers vir 2021 gestel is, is reeds in 2019 bereik. Die Fakulteit doen baie moeite om studente uit die aangewese groepe te werf en word hierin deur ons eie bemarker ondersteun. Heelwat inisiatiewe is ingestel om veral eerstejaarstudente te ondersteun om suksesvol te studeer. Dit sluit onder andere in groepleersessies, dekaansperiodes en personeel in die Dekaansafdeling en die departemente wat bykomende studente-ondersteuning verskaf.

Ingenieursprogramme is uitdagend en veeleisend en die Fakulteit het die afgelope paar jaar twee deeltydse opvoedkundige sielkundiges in diens om uitsluitlik ingenieurstudente by te staan met die hantering van angs en spanning en die aanleer van doeltreffender studiemetodes.

Genetwerkte en samewerkende onderrig en leer

Die jaar 2020 is ingelui met vernuwing van ons akademiese programme, wat heelwat aanvoorwerk en bemarking in 2019 geverg het. Vanaf Februarie 2020 bied die Fakulteit Ingenieurswese die eerste BIng-graad in Data-Ingenieurswese in Suid-Afrika aan. Die graad word 'n nuwe spesialisasiestroom in die bestaande voorgraadse graad in Elektriese en Elektroniese Ingenieurswese, oftewel BIng (E&E), en is daarom ook deur ECSA geakkrediteer as die toepaslike kwalifikasie vir registrasie as Professionele Ingenieur. Die doel is om ingenieurs spesifiek voor te berei op die Vierde Industriële Revolusie, waar die wêreld van werk wesenlik verander. Daar is 'n vloedgolf data wat gestruktureer, gemodelleer en ontleed moet word om organisasies wat deur data gelei word in staat te stel om onderliggende kennis te ontdek en ingeligte besluite te neem.

Daar is ook vernuwing van ons nagraadse programme. Vanaf 2020 word 'n gestruktureerde meestersgraad en 'n nagraadse diploma in Bedryfsingenieurswese wat spesifiek op Datawetenskap fokus, aangebied. 'n Ander gebied wat oor die afgelope paar jaar toenemend gewild geword het, is Biomediese Ingenieurswese. Daarom bied die Instituut vir Biomediese Ingenieurswese, gesetel in die Fakulteit, vanaf 2020 nuwe nagraadse programme aan: 'n PhD in Biomediese Ingenieurswese en 'n meestersgraad in Ingenieurswetenskap in Biomediese Ingenieurswese (navorsing). Die doktorale en navorsingsmeesters-programme is daarop gemik om spesialisnavorsers in Biomediese Ingenieurswese met spesifieke vaardighede op te lei om nuwe kennis op die voorpunt van gesondheidstegnologie te ontwikkel. Die gestruktureerde meestersprogram is weer gerig op mense wat reeds in die bedryf werk en die Nagraadse Diploma in Ingenieurswetenskap is veral daarop gerig om gegradueerdes van driejarige BSc-programme tot die meestersprogramme te oorbrug.

Navorsing vir impak

Die Fakulteit Ingenieurswese is navorsing-intens en trots op die hoë aantal nagraadse studente, veral doktorale studente, wat elke jaar gradueer. Uit die aard van hul werk dra ingenieurs by tot die verbetering van die lewensgehalte van mense en gemeenskappe en die ontwikkeling van die ekonomie, wat albei noodsaaklike elemente in 'n ontwikkelende land soos Suid Afrika is. Navorsingsonderwerpe is in die

Dr Shirley Ann Jackson, President of RPI, received an honorary doctorate from Stellenbosch University in April 2019.

Dr Shirley Ann Jackson, President van RPI, het in April 2019 'n eredoktorsgraad van die Universiteit Stellenbosch ontvang.

development. Both these aspects are essential elements in a developing country like South Africa. Most of the research topics are aimed at addressing real-life engineering problems. One interesting dissertation in 2019 dealt with the global refugee crisis. Dr Christa de Kock constructed a framework that would make it easier for humanitarian organisations to collect essential data – which could mean the difference between life and death – on forced migration, and to use it in strategic planning.

The modern tendency is to do interdisciplinary research. Dr Wouter Bam's doctorate was not only interdisciplinary; it was also an excellent example of cooperation with an international institution. In his research he investigated whether it would be more advantageous for countries to export or process their own raw materials, with the focus on industrial policy-making in developing countries that are rich in minerals. This subject overlapped geography, economics and development studies, and Dr Bam undertook his research jointly with KU Leuven. In this way he obtained a PhD (Industrial Engineering) from SU as well as a PhD in Economics from KU Leuven.

Purposeful partnerships and inclusive networks

The Faculty strengthened its ties with industry and alumni in June by presenting a research expo in Gauteng – the first of its kind in that province. The programme comprised a series of talks by researchers, as well as posters presenting 24 current research projects. Visitors could view the posters and had an opportunity to speak to researchers with a mind to possible cooperation. The Faculty also houses the newly established Centre of Excellence in Energy of the African Research University Alliance (ARUA) network.

Preferred employer

At this faculty, engineering has long since stopped being regarded as a career solely for men. Bright and capable female students and staff members are increasingly successful. Two women, Prof Natasha Sacks and Prof Jacomine Grobler, have respectively been appointed as full professor and associate professor at the Department of Industrial Engineering. Civil Engineering boasts with their first woman as full professor: Prof Celeste Viljoen. As an Engineering student at Maties, she was the recipient of both an ECSA merit award and the Chancellor's medal. In 2019 she was inducted as a Fellow of the South African Institution of Civil Engineering (SAICE) with three of her colleagues, Profs Kobus du Plessis, Gideon van Zijl and Jan Wium.

A flourishing Stellenbosch University

It has become of crucial importance to renew, modernise and densify the 50-year-old Engineering buildings so that they can accommodate more students and staff, and will comply with modern safety regulations. The Engineering Campus Renewal Project is well underway. The cost of this wide-ranging project with a timeframe from 2016 to 2026 is estimated to amount to R750 million. In 2019, progress was made with the renovation of the Mechanical and Mechatronic Engineering Building, the refurbishment of the Electrical Machines Laboratory, and the construction of a modern new Pavement Laboratory for the Department of Civil Engineering.

Looking forward

The Faculty of Engineering is managed by a team of professional engineers and academics and is excellently positioned to make an important contribution to the systemic sustainability and transformation of the University. At the same time, it is ready to deliver graduate engineers, high-level skills and applicable solutions to assist in developing and improving the economy and further improving the quality of life of all South African citizens.

The tridentate monument, erected in Victoria Street 50 years ago in honour of engineering, was relocated to the Faculty's building complex in Banghoek Road in August 2019. Left Prof Wikus van Niekerk (Dean: Engineering) and Prof Wim de Villiers (Rector and Vice-Chancellor).

algemeen daarop gemik om werklike ingenieursprobleme te takel. Een interessante proefskrif in 2019 handel oor die wêreldwye vlugtelingkrisis. Dr Christa de Kock het 'n raamwerk saamgestel wat dit vir humanitêre organisasies makliker maak om noodsaaklike data – wat die verskil tussen lewe en dood kan beteken – oor gedwonge migrasie in te win en ook vir strategiese beplanning in te span.

Die moderne neiging van navorsing is om interdissiplinêr te werk te gaan. Dr Wouter Bam se doktorsgraad was nie alleen interdissiplinêr nie, maar ook die toonbeeld van samewerking met 'n internasionale instelling. In sy navorsing het hy ondersoek of dit voordeliger is vir lande om uit te voer of hul eie grondstowwe te verwerk, met die fokus op bedryfsbeleidmaking in mineraalryke ontwikkelende lande. Hierdie onderwerp oorvleuel met geografie, ekonomie en ontwikkelingstudies, en is as 'n gesamentlike graad met KU Leuven gedoen. Só het dr Bam 'n PhD (Bedryfsingenieurswese) aan die US én 'n PhD in Ekonomie aan KU Leuven verwerf.

Doelgerigte vennootskappe en inklusiewe netwerke

Die Fakulteit het sy bande met die bedryf en alumni versterk deur in Junie 'n navorsingstentoonstelling in Gauteng aan te bied. Dit was die eerste in sy soort in Gauteng. Die program het bestaan uit 'n reeks praatjies deur navorsers asook plakkate wat 24 huidige navorsingsprojekte vertoon het. Besoekers het die geleentheid gekry om die plakkate te besigtig en met navorsers te gesels met die oog op moontlike samewerking. Die Fakulteit huisves ook die nuwe Sentrum van Uitnemendheid in Energie, aan hom toegeken deur die netwerk African Research University Alliance (ARUA).

Voorkeurwerkgewer

By dié fakulteit word ingenieurswese lankal nie meer as 'n beroep slegs vir mans beskou nie. Knap vrouestudente en -dosente is besig om toenemend sukses te behaal. In die Departement Bedryfsingenieurswese is twee vroue, naamlik proff Natasha Sacks en Jacomine Grobler, onderskeidelik as volprofessor en medeprofessor aangestel. Siviele Ingenieurswese spog met hul eerste vrou as volle professor: prof Celeste Viljoen. As Matie-ingenieurstudent was sy 'n ECSA-merietemedaljewenner asook 'n Kanseliersmedaljewenner. In 2019 is sy as 'n Genoot van die Suid-Afrikaanse Instituut vir Siviele Ingenieurswese (SAISI) saam met drie van haar kollegas, proff Kobus du Plessis, Gideon van Zijl en Jan Wium, ingelyf.

'n Florerende Universiteit Stellenbosch

Dit het noodsaaklik geword dat die 50-jarige Ingenieursgeboue hernu, gemoderniseer en verdig word om groter studente- en personeelgetalle te huisves en aan moderne veiligheidstandaarde te voldoen. Die Ingenieurswese Kampushernuwingsprojek is goed op dreef. Hierdie omvattende projek, wat van 2016 tot 2026 strek, beloop R750 miljoen. In 2019 is daar hoofsaaklik aan die opknapping van die Meganiese en Megatroniese Ingenieurswesegebou, die herinrigting van die Elektriese Masjienelaboratorium en die bou van 'n nuwe, moderne Plaveiselaboratorium by die Departement Siviele Ingenieurswese gewerk.

Vooruitsig

Die Fakulteit Ingenieurswese word deur 'n span professionele ingenieurs en akademici bestuur en is uitstekend geposisioneer om 'n beduidende bydrae tot die sistemiese volhoubaarheid en transformasie van die Universiteit te lewer, terwyl dit gegradueerde ingenieurs, vaardighede op hoë vlak en toepaslike oplossings lewer om die ekonomie te help ontwikkel en te verbeter en om die lewensgehalte van alle burgers van Suid-Afrika verder te verhoog.

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Dekaan: Ingenieurswese.

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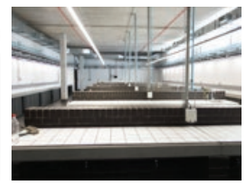
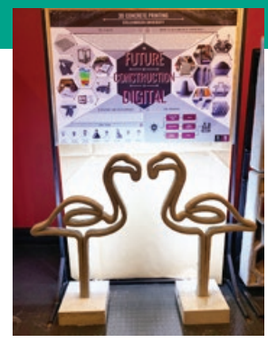
Civil Engineering



The façade of the New Pavement Laboratory (top) and a selection of some of the sections for specialised work in the laboratory.



Main photograph: Marchant van den Heever (left) and Frederick Bester with the bench and table X-Furniture prototypes they manufactured by means of 3D printing of concrete. Bottom right the 3D printing process of a concrete flamingo. Top right the elegant flamingos at the SA Innovation Summit exhibit.

Civil appoints first female full professor

In 2019 the Department of Civil Engineering reached a special milestone with the appointment of its first woman as full professor, Prof Celeste Viljoen. Over the past 21 years she has made her mark as a student and an academic. She joined the academic corps of the Department ten years ago and was promoted to full professor in July 2019.

Even during her study career as a Maties civil engineering student she displayed exceptional talents. In her final year in 2001, she was Chair of the Engineering Students' Council and received the ECSA Medal of Merit as top Stellenbosch engineering student. Her academic acumen resulted in her master's degree being upgraded to a PhD. At the graduation ceremony in 2006 where she received her PhD degree, she was also announced the winner of the Chancellor's Medal, Stellenbosch University's highest honour bestowed on a student.

She worked as a consulting engineer designing bridges and buildings for about five years before joining the Department of Civil Engineering at the end of 2009. Her main field of expertise is structural reliability and she is nationally and internationally involved in standardisation of structural design. Currently she is Head of the Structures Division in the Department.

Research project a purpose and a calling says winner of national competition

Thabani Mtsi, a Maties civil engineering student, won the SAICE National IP Showdown held in March 2019. The competition (hosted by the South African Institution of Civil Engineering since 2013) selected the best undergraduate project amongst the 2018 final-year civil engineering students from the top six universities in South Africa. Thabani was selected by a panel of judges for his topic: *Mobility as a Service (MaaS) Model for the Stellenbosch Student Population*.

"Competition at the SAICE's National Showdown, with the theme *Pushing the Boundaries*, was tough," says Prof Johann Andersen, Thabani's project leader. "Thabani competed against the top students from the Universities of the Witwatersrand, Pretoria, Cape Town, KwaZulu-Natal and Johannesburg. Participants had to show an in-depth understanding of their research project and adequate communication skills. Thabani's presentation was excellent and well rounded. He challenged the audience and responded to the tough questions posed by the panel and the audience in a very convincing manner."

Thabani investigated the readiness of the Stellenbosch student population for mobility as a service. Some of the tough aspects of his project were to change people's perceptions. "The beauty of the topic was that I am working with people's attitudes. It extends beyond the technical and the scientific and includes social dynamics and socio-economics." Thabani continued with this topic in his postgraduate studies in 2019 and regards it as not just a research project, but a purpose and a calling.

In 2019, this talented student counted amongst 92 Stellenbosch University students who were honoured for excellent achievement in areas ranging from academics, sports and culture to social impact and co-curricular. He received two Rector's Awards in the categories Excellent Service Provision and Excellent Leadership.

Research Output	
Journal Articles (subsidised)	60
Proceedings International	39
Proceedings National	26
Books	1
Doctoral completed	9
Master's completed	63

3D Printing of concrete in the spotlight at SA Innovation Summit

Postgraduate students Frederick Bester and Marchant van den Heever exhibited their work on 3D printing of concrete at the SA Innovation Summit in Cape Town in September where their display attracted much attention.

"3D printing of concrete promises to become a disruptive technology in the construction industry. It has the potential to reduce construction times and waste drastically, while also enhancing architectural freedom through its ability to produce geometrically-complex elements when compared to traditional methods of construction," says Frederick.

Frederick and Marchant are part of the diverse seven-member Stellenbosch 3D concrete printing team under the leadership of Prof Gideon van Zijl. The team's research includes printable concrete material development, comprising foam concrete, high-performance standard and fibre reinforced concretes. In addition to research conducted on rheo-mechanical print process optimisation and durability assessment; the design and analysis of reinforcement strategies, prefabricated structural elements and the feasibility of 3D concrete printing in the South African context are investigated.

Civil Engineering boasts four new SAICE Fellows

The Department of Civil Engineering is proud to have four new SAICE Fellows in its midst. They are Profs Kobus du Plessis, Gideon van Zijl, Celeste Viljoen and Jan Wium. They joined the South African Institution of Civil Engineering (SAICE) in 1993, 2001, 2002 and 1979 respectively.

A Fellow is a Corporate Member of SAICE who has achieved appropriate recognition in the civil engineering profession, displaying substantial responsibility and initiative in the practice of civil engineering, and who has considerable professional experience. A nominee is usually nominated for this honour and the nomination has to be supported by three Corporate Members, at least one of whom must be a Fellow. Nominations are considered by the SAICE College of Fellows, that comprises the current President, President Elect, Immediate Past President and two recent Past Presidents. Approved nominees are recommended to the Executive Board.

Profs Du Plessis, Van Zijl, Viljoen and Wium may now proudly display FSAICE behind their names.

Prof Jan Wium
Chair: Civil Engineering.

by Prof Richard Walls

Fire safety engineering for Africa

Large-scale fire test on three informal settlement dwellings, as part of a PhD study by Antonio Cicione.

Internationally fire safety engineering is a rapidly growing field that occupies a space between civil and mechanical engineering. Structural fire engineers typically keep a building from collapse during a fire, and look at the construction materials used in it. Mechanical engineers are often responsible for the design of sprinkler systems, smoke ventilation and similar systems.

The Department of Civil Engineering at Stellenbosch has taken a bold step by starting formalised fire engineering training through the Fire Engineering Research Unit (FireSUN), making it the first post-graduate fire safety programme in Africa. Work has been supported by the Lloyd's Register Foundation and the EPSRC (both of the United Kingdom). A taught module in Structural Fire Engineering was introduced in 2019, and a course on Fire Behaviour will be run in 2020. The demand for this specialised engineering skill can be easily seen in the fact that the team, which started in 2017, has grown to have a postdoctoral researcher, 6 PhD students and 8 MEng research students in 2020.

The team has been involved in undertaking exciting research in fields such as informal settlement fire safety (having conducted the world's largest shack fire experiment), recycled plastic bottle structures (Ecobricks) and understanding South African timber buildings considering fire safety. The team was part of a project that investigated the Knysna fire disaster and looked at why almost 1 000 homes were destroyed in that event, and have made recommendations regarding how to make homes on the wildland-urban interface in South Africa safer.

The team has received media coverage on BBC TV and radio, Reuters, SABC, SAfm, CapeTalk and various other stations.

Recent work has involved the development of testing and analysis facilities that will promote the development of fire safe construction products.

In 2020 additional funding has been received from the Royal Academy of Engineering and Lloyd's Register Foundation to appoint a new team member to assist the work for the next two years.

Structural Engineering

Research is carried out on construction materials, steel and concrete structures, structural reliability, fire engineering, as well as sustainability of the built environment. Structural reliability considers probabilistic load and resistance provisions. Research in fire engineering includes computational and experimental investigation of structural performance in a fire, fire spread and fire loads. Sustainability of the built environment includes durability of materials and structures, objective modelling and subsequent minimisation of environmental impact.

Civil Engineering Informatics

Civil Engineering Informatics focuses on the needs of the civil engineering practice in an information-driven environment. Application of Information Technology in civil engineering is concerned with collaborative engineering, intelligent modelling of the design process in structural engineering, support systems for engineering management and technical aspects of urban engineering.

Water and Environmental Engineering

Research fields include water resources development, flood hydrology, environmental water requirements, the design of large hydraulic structures such as dams higher than 100 m, river abstraction works and bridges, river hydraulics, sediment yield and fluvial morphology of rivers and estuaries, reservoir and harbour sedimentation, coastal engineering, port engineering and design, breakwaters, coastal and estuarine hydro- and sediment dynamics, dredging, coastal environmental studies, hydrodynamic modelling of river, lake and estuary flow patterns and water quality, water and wastewater treatment, stormwater systems and water services which include bulk water supply, water demand and water conservation, end-use modelling, alternative water sources, peak flows, stormwater quality, small-scale water treatment systems, hydraulic modelling of water systems, system pressure, pressure management, leaks and intermittent supply.

Transportation and Geotechnics

Geotechnique research focuses include understanding the engineering behaviour of Cape Flats sands, design of settlement sensitive geodesy structures, slope stability analysis (3D vs 2D analysis, knowledge-based systems, landslide hazard communication, material point method and reliability), deep excavation design (code development and soldier pile interaction) and human factors in design (qualitative and quantitative practices in site investigation, engineering judgement, and expertise and digitisation).

In Pavement Engineering, student-orientated research includes performance evaluation of secondary materials (crushed concrete, masonry, glass, etc.) for use in roads, accelerated testing of asphalt including MMLS testing and beam fatigue tests, environment-friendly bitumen stabilised materials researched using triaxial and fatigue tests, development of a performance-related seal design method for bitumen and modified binders, and a mix design and analysis system of asphalt bases.

Within the field of Transportation, research is carried out primarily on Road Safety and Intelligent Transport Systems (ITS). Road Safety research includes road crash causation, the influence of human factors, the role of geometric design, speed, public transport safety, and pedestrian safety factors. Research in ITS focuses on public transport user information, multimodal data base development, appropriate technology applications in developing countries and freeway management information applications for travel time estimation and incident management systems.

Construction Engineering and Management

Research addresses the management and development of multidisciplinary capital projects. It focuses on modular construction, construction risk, design management, constructability, sustainability and advanced technologies in construction.

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Electrical and Electronic Engineering

The Electrical Machines Laboratory was refurbished in 2019.

Left Christo Nicholls (holder of the SUN-USRC Chair) and
Dr Herman Kamper (winner of a Google Faculty Award).

BEng (E&E) Data Engineering

2019 was a busy year for the Department of Electrical and Electronic Engineering as it prepared to introduce the new BEng degree in Data Engineering from February 2020. The purpose of this new specialisation in Data Engineering is to prepare students for the Fourth Industrial Revolution where the world of work has fundamentally changed and there is a deluge of data that needs to be structured, modelled and analysed. It should enable data-led organisations to discover the underlying knowledge and make well-informed decisions.

Data Engineering encompasses all tasks required to make data available for analytics, knowledge discovery and decision-making processes. Data engineers develop and maintain an organisation's data pipeline systems, and implement algorithms to transform data into a useful format for analysis.

From the first year of study, the Data Engineering specialisation is built on the solid foundation of Mathematics, Statistics, Computer Science and Artificial Intelligence. The specialisation also introduces new undergraduate modules in Data Engineering that cover topics such as Big Data Platforms, Probabilistic Graphical Models for Machine Learning and Fundamentals of Deep Learning and Artificial Intelligence. Students will develop the engineering skills to create mathematical, physical and statistical models of real-world systems, including data systems. The existing BEng programmes and specialisations have a limited exposure to Data Science, but the new specialisation in Data Engineering will go into depth into the mathematical and statistical fundamentals of Data Science.

In 2019 the Faculty also received confirmation that the new BEng degree in Data Engineering will be fully accredited by the Engineering Council of South Africa (ECSA) for registration as Professional Engineer. Through the agreements in the Washington Accord this means that the degree will also be accepted in a number of other countries as the required academic qualification for registration as professional engineer.

Stellenbosch University Utility Solutions Research Chair

A new Chair, the Stellenbosch University Utility Solutions Research Chair (SUN-USRC) sponsored by Macrocomm, was introduced in the Department in 2019. The new Chair focuses on research in the fields of smart metering, big-data analytics, internet-of-things technologies, low-power wide-area networks, smart capacity building, hosted software solutions and utility performance forecasting. The Chair will also form partnerships with the other research and funding institutions in the general field of utility solutions, engage in specialised consulting activities for industry and pursue other funding streams.

The holder of the Chair, Christo Nicholls, is an alumnus of the Department of Electrical and Electronic Engineering. He joined his alma mater after gaining invaluable international experience in the above-mentioned fields. "I have always had a passion to return to academia where I can focus on applied research on real-life problems that will benefit the whole country," he says.

Mr Nicholls elaborates: "Where research is concerned, the new Utility Solutions Research Chair will conduct applied research in the African context. The Chair will drive the Smart Municipal Areas Programme which consists of two research streams. The first stream focuses on distribution, supply and services normalisation. This covers innovative debt curtailment, timeous payment of current accounts and alternative means of load shedding. The second stream focuses on the smart consumer experience that will operate on specific data and analytical platforms, such as a mobile app, for reporting municipal issues, requesting municipal bills and handling bill and general query resolutions. The Chair is already in partnership with a municipality in the Northern Cape where the two research programmes will be run. This is the first municipality that has chosen Stellenbosch University as its research partner in this field."

Mr Nicholls concludes: "In the next two or three years, we would like to include more countries in the SADC region in the programme. Furthermore, the Chair also has the vision to have a strong presence as the preferred Utility Solutions applied-research partner on the African continent."

Research Output

Journal Articles (subsidised)	46
Proceedings International	92
Chapters in Books	1
Doctoral completed	16
Master's completed	45

Young academic wins coveted Research Award

Dr Herman Kamper received a coveted Google Faculty Research Award, one of only a few made to researchers in Africa so far. He says: "Google would like to build and maintain good relationships with universities and academics and therefore has a programme that focuses on funding world-class technical research in Engineering and Computer Science and related fields. These awards fall into different categories relevant to Google's products and services. There are over 20 categories and my award falls under the category of Speech."

Dr Kamper is a young academic in the Department of Electrical and Electronic Engineering. His main fields of research are machine learning and pattern recognition, with special reference to speech, vision and language processing.

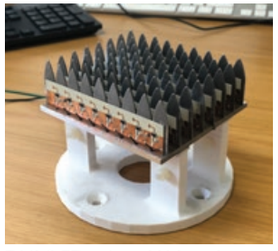
"To come into consideration for a Google Faculty Research Award, one has to submit a two-page summary of your research project where you propose what you would do with the funding if it was awarded to you. The topic of my research project was *Low-resource semantic speech search using visual grounding*."

According to Google, the award is highly competitive – only 15% of applicants receive funding – and each proposal goes through a rigorous Google-wide review process. Google Faculty Research Awards are structured as seed funding to support one graduate student for one year and are awarded as an unrestricted gift.

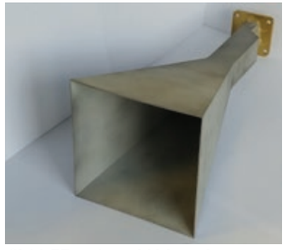
In November 2019, Dr Kamper was also a 2019 joint-winner of the Faculty of Engineering's annual Upcoming Researcher Award.

Prof Herman Engelbrecht
Chair: Electrical and Electronic Engineering.

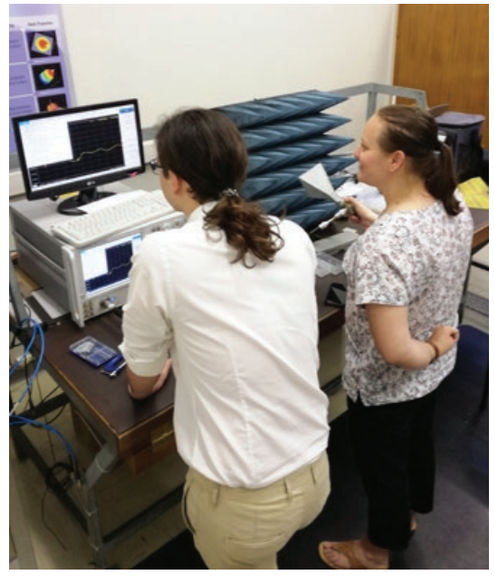
3D printing for the manufacture of microwave components



DMLS 3D printed X-band Vivaldi Array with integrated low noise amplifiers.



SLM 3D printed X-band horn antenna.



Dr Jacki Gilmore (right) and Kobus Kotzé (master's student).

Until recently, the most prevalent form of manufacturing microwave components was machining, which presented several difficulties, especially given the level of accuracy required for high-frequency applications. The component design had to incorporate the access necessary for large machining tools, which meant that the overall majority of components were designed in parts that had to be assembled after machining. Apart from being a fairly labour intensive process, more opportunity was created for the introduction of manufacturing inaccuracies.

Additive manufacturing, or 3D printing as it is more widely known, presents an excellent opportunity to rethink the field of microwave engineering. A few methods exist with which metal components can be directly printed, including Selective Laser Melting (SLM) and Direct Metal Laser Sintering (DMLS). Both these techniques involve "building up" a component by fusing small layers of metal powder across the surface that is to be printed using a laser. The main difference between the techniques is in the power of the laser – with DMLS, the metal powder is not melted but merely sintered using a laser while SLM uses a high-powered laser to melt the layers.

Using SLM 3D printing, an X-band horn antenna (including the feed) was printed as one solid piece that allowed excellent manufacturing tolerances to be achieved especially on sensitive parts with stringent specifications. Consequently, the difference between the measured and the simulated results were so small that no further adjustments to the model were required.

DSLM was used to manufacture a planar X-band Vivaldi Array. The array was designed such that printed circuit boards with low noise amplifiers feeding all the elements could easily be integrated into the rows of the array. The results were, once again, very encouraging which showed that with the ease and accuracy of metal 3D printing even arrays could be designed to require minimal assembly and easy integration with the rest of the signal chain.

While many more avenues are available for exploration – metal 3D printing offers a new and exciting way of designing microwave components that is likely to lead to innovations in the field given that design no longer has to adhere to access requirements for large machining equipment. Furthermore, both DMLS and SLM allow for all excess metal powder (powder that did not form part of the component) to be reused, resulting in a much more sustainable manufacturing method. Future developments in laser technology, such as the introduction of the femtosecond laser, could improve the manufacturing tolerances of metal 3D printing even more, allowing for microwave components of ever-higher frequencies to be printed as well.

Robotics

In the Electronic Systems Laboratory (ESL), research, development and projects concentrate mainly on the control of remote sensing platforms. These platforms include satellites (e.g. CubeSats), manned and unmanned aerial vehicles (UAVs) as well as autonomous underwater vehicles (AUVs) and unmanned ground vehicles. As most of the research is done as part of a larger system, students are exposed to the full breadth of the management and technical activities required in complex system development.

Electromagnetics

Current activities focus on the following projects: RF and microwave antennas for communications and radar systems, FEM, FDTD and MoM modelling of antennas and wave propagation in complex electromagnetic environments, development of numerical methods and software for simulation of electromagnetic fields, free-space and near-field measurement techniques, optimising complex antennas and microwave components, the Karoo Array Telescope (KAT) and the Square Kilometre Array (SKA). Other activities include superconducting elements, nanosensors, electromagnetic compatibility, microwave filters and non-linear circuits. An antenna and microwave laboratory, supported by sophisticated instrumentation and powerful computing facilities, provides the infrastructure for research work.

Electrical Energy

This division focuses in research on electrical energy in terms of conversion, distribution, control and management, and renewable energy. Specifically, attention is given to multilevel power electronic converters, electrical machine design and drive systems, energy efficiency, and the measurement and management of electrical energy. In renewable energy, the focus is on photovoltaic solar energy, wind generator systems, system identification and grid integration. The facilities include world-class laboratories and instrumentation for prototype testing and measurement. The Department has the only high-voltage laboratory in the Western Cape for amongst others advanced insulator tests and research.

Telecommunications and Informatics

This division works in a variety of areas that involve the manipulation of information-bearing signals. This comprises both extracting and embedding information in the signal (digital signal processing), the transmission of such signals over large distances (telecommunication) and through complex networks (communication networks), and the automatic learning and recognition of the signal content (machine learning) with particular focus on speech and image signals, as well as specialised sensor signals.

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Industrial Engineering

The Stellenbosch Technology Centre – Laboratory for Advanced Manufacturing, in the Department of Industrial Engineering, is part of an international Fraunhofer Institute project on Biological Transformation in Manufacturing. One of the aims of the project is to develop and test (safe) microbial-based metal cutting fluids for greener machining processes. Some of the team members in front of the machine setup in their safety gear are from the left, Martin Bezuidenhout (PhD student), Thembeka Nxiba (STC Machine Technician) and Dr Emad Uheida (postdoctoral fellow).

Photo left shows the experimental setup with the biological cutting fluid and the machined titanium block.

Profs Natasha Sacks (left) and Jacomine Grobler.

Voigt Chair in Data Science

The Voigt Chair in Data Science was established in the Department of Industrial Engineering in 2018. Prof Andries Engelbrecht, an A-rated scientist as rated by the NRF, was appointed in January 2019 in the position. Since then, the activities associated with the Chair had been expanded by appointing Prof Jacomine Grobler, who focuses on the application of Data Science in Industrial Engineering applications such as Supply Chain and Logistics, Dr Thorsten Schmidt-Dumont, as a postdoctoral fellow, and at the end of 2019, also Dr Christa de Kock.

An important focus in 2019 was the design and establishment of a new structured Master's and a Postgraduate Diploma in Industrial Engineering with a Data Science focus. This programme that was approved at the end of 2019 with the first intake in 2020, is the first postgraduate programme at Stellenbosch University with Data Science as a focus.

Industrial Engineering was also the first engineering discipline to make Data Science a required undergraduate module from 2019 onwards. All other engineering disciplines are now following this example, also exposing their students to this exciting area from 2020 onwards.

Research in this area had not been neglected. The team produced more than 25 publications in journals and conferences in 2019, and a number of postgraduate students (master's and PhD) were enrolled in 2019.

The plans for the future are exciting. The newly established School for Data Science and Computational Thinking will become an important vehicle for collaboration across the university in the field of Data Science, and the Chair plans to play an active role in the School. The new structured Master's and Postgraduate Programme is gaining visibility, and FNB is one of the first major banks who are sending employees onto the programme. We expect to see more industry becoming involved. The newly registered research-based postgraduate students are growing, and the first students will be delivered at the end of 2020. The Faculty's new undergraduate programme in Data Engineering will also become a focal point in the near future, with the Industrial Engineering team presenting a significant portion of the curriculum.

Industrial Engineering appoints two women in high-level posts

In 2019 the Department of Industrial Engineering managed to attract two experienced academics for high-level posts, namely Prof Natasha Sacks (full professor) and Prof Jacomine Grobler (associate professor). Prof Sacks, who joined the Department in October, is an eminent expert in the field of Advanced Manufacturing. Furthermore, she is the first women to be appointed a full professor in this department. Before moving to Stellenbosch, she worked at the University of the Witwatersrand for 15 years. She did her undergraduate and postgraduate studies in Materials Engineering at UCT, followed by a Dr.Ing at Germany's Friedrich – Alexander University Erlangen – Nürnberg. She teaches Manufacturing Systems to third-year students. On the research front, she is the group leader for the Advanced Manufacturing Research Group. Prof Sacks has an impressive track record and serves on numerous bodies such as review panels and international editorial boards and conference committees.

Prof Grobler's area of expertise is the application of Data Science within the field of Industrial Engineering. She obtained all her industrial engineering degrees at the University of Pretoria (UP): BEng 2006, HonsBEng 2007, MEng 2009 and PhD 2015. During her study career she received 12 awards, including the 2017 South African Institute for Industrial Engineering Award for Outstanding Young Industrial Engineering Researcher. She spent six year in industry (Denel and the CSIR) before returning to UP as a lecturer in Supply Chain Management. She lectures Production Management to Industrial and Mechanical Engineering students, and Industrial Management to third-year Industrial Engineering students. In 2019 Data Science was incorporated in the latter module for the first time, making this department the only Industrial Engineering department in the country to include Supply Chain Data Science in the curriculum.

Research Output

Journal Articles (subsidised)	63
Proceedings International	41
Proceedings National	15
Chapters in Book	3
Doctoral completed	19
Master's completed	33

Three academics receive PhD degrees

Three young academics in the Department of Industrial Engineering, Drs Louzanne Bam, Wouter Bam and Christa de Kock, received their PhD degrees in December 2019. It was the first time in the history of the Faculty that a married couple received their PhD degrees together.

Dr Louzanne Bam

Title: *Foundational elements of a managerial framework to support team creativity in engineering organisations: Organising and expanding the body of knowledge.*

The research presented finds that the likelihood of collective unethical behaviour associated with team creativity increases when the members experience increased stress levels. Secondly, this research contributes to the literature by means of a comprehensive meta-analysis of antecedents of team creativity.

Dr Wouter Bam

Title: *Industrial policy-making in mineral-rich developing countries.*

The research presents two novel analytical frameworks that support the appraisal of the strategic value of different downstream processing activities. It also presents a framework that enables the appraisal of the factors driving the location of a particular activity. The dissertation thereby provides practical tools to policy-makers in order to support improved developmental outcomes.

Dr Christa de Kock

Title: *A framework for modelling conflict-induced forced migration according to an agent-based approach*.

The practical value of the framework was demonstrated by applying the framework successfully in the design of an agent-based simulation model of migration patterns induced by the current conflict in Syria. (See Focus article on page 26.)

Prof Corne Schutte
Chair: Industrial Engineering.

Modelling the movement of forcibly displaced people

Dr Christa de Kock during a visit to the Centre for Refugee Studies at York University, Canada.

In 2015, one in every 113 people worldwide was forcibly displaced from their place of residence, whether as an asylum-seeker, a refugee or a person displaced within the borders of their own country. The United Nations High Commissioner for Refugees estimated the total number of forcibly displaced people in 2017 to be 68,5 million, 40 million of whom were people displaced within their countries of origin, and 28,5 million as refugees fleeing across international borders.

Over the course of the past decade, numerous calamities worldwide have led to phrases such as "refugee" and "undocumented migrant" becoming commonplace in the public discourse. Conflict-induced displacement and the various challenges it creates have received notable attention. A particular challenge posed by the management of sudden migration of large groups of people lies in a general inability to predict the scale and dynamics of such movement accurately. This problem is further complicated by the fact that data associated with such migration are largely incomplete or untrustworthy.

Presently, there is a significant lack of data required to perform strategic, long-term planning related to current and future conflict crisis situations. One of the most fundamental challenges faced by researchers and humanitarian aid organisations when addressing forced displacement is an inability to predict the types of movement and the destinations of those who are forcibly displaced. The provision of a reasonably accurate estimation of the number of forcibly displaced people is potentially a critical input for the planning of logistics and management of structures supporting those fleeing violence and persecution.

Dr Christa de Kock proposed a framework for assisting in the development and application of agent-based simulation models for predicting conflict-induced migration. The framework comprises five phases which encapsulate the formulation, conceptualisation and development of such a model, as well as the associated model execution and documentation. The purpose of the framework is to facilitate the design and development of agent-based models that incorporate the determinant factors of localised decision making and generate the resulting emergent large-scale movement patterns of forced migration.

Collaboration with various subject matter experts throughout the development of this framework allowed for significant insight to be gained from the confluence of research in the fields of forced migration, computer simulation and human decision-making processes, which does not presently appear in the literature. The approach suggested for modelling human decision making is endorsed by knowledge gained from this research confluence, which has been corroborated by expert opinion. To the best of the knowledge of the consulted subject matter experts, no such framework encompassing such a wide variety of factors and implications pertaining to forced migration modelling in the presence of conflict presently exists and, as such, the research has sparked significant interest in the international research community.

A framework of this nature may prove invaluable in the accommodation of incoming refugees, internally displaced migrants and undocumented migrants in different areas, by predicting the population fluctuations in affected areas during times of conflict, natural disaster, or other forced migration-causing events.

Engineering Management

Includes project, risk, innovation, quality, performance management, and feasibility studies:

- Enterprise Engineering: analysis of enterprises (design, implement, operate) including knowledge and information, innovation, financial and technology management.
- Sustainable Systems: the transition to a more sustainable economy and society, placing emphasis on management, planning and design of infrastructure/technology.
- Health Systems Engineering: conceptualising novel, engineering based solutions to challenges facing the healthcare sector.
- Innovation for Inclusive Development: analysis, development and evaluation of inclusive innovations, inclusive innovation systems and innovation platforms.
- Industrial Policy and Beneficiation: Investigates how mineral-rich countries might improve their sustainable development.

Manufacturing

The development of resource efficient process chains for sustainable and smart manufacturing of products through digital, economically-sound process chains that minimise negative environmental impacts, while conserving energy, natural resources and empowering communities.

The focus areas of Additive and Subtractive Manufacturing are used to manufacture customised products, prototypes and novel materials for several industries including medical, aerospace, manufacturing and mining.

- Micromanufacturing: The micromachining (milling and turning) and microassembly of microproducts in which micromaterial handling systems are utilised.

Operations Management

Operations & Supply Chain Management focuses on process excellence from both intra-organisational and inter-organisational points of view.

- Asset Management: The coordinated activities of an organisation to realise value from assets.
- Supply Chain Management: A key focus is on the digitalisation of operations, supply chains, and value chains in both the manufacturing, retail, and service environments.
- Learning Factories: The Stellenbosch Learning Factory provides a research facility for research topics related to the "smart factory" of the future (in line with the Fourth Industrial Revolution).
- PRASA Engineering Research Chair: Strategic corporate decisions must be supported by a sound scientific baseline. This in turn requires that the operations of PRASA be analysed and improved on in terms of efficiency and effectiveness.

Systems Modelling, Operations Research and Decision Support

Focuses on the development of mathematical models and their incorporation into computerised systems aimed at supporting effective decisions in industry. These models draw from the areas of applied mathematics, statistics, industrial engineering and computer science and are applicable to complex problems which admit a large variety of trade-off solutions. Examples include:

- Routing and scheduling decisions for fleets of delivery vehicles.
- Employee duty roster or timetabling construction.
- Shelf-space allocation and inventory decisions for retailers.
- Crop irrigation and agricultural pest-control strategy decisions.
- Power generator maintenance scheduling decisions in the energy sector.
- Facility location decisions for effective supply chain logistics.
- Optimal production facility layout.

Data Science

Focuses on the development of machine learning and optimisation techniques to produce novel, efficient and robust data science technologies. Data science techniques can be used on extremely large data sets to reveal patterns, trends and associations, especially relating to human behaviour and interactions.
Examples include:

- Forecasting customer demand from millions of retail transactions to understand demand patterns.
- Determining optimal segmentation of customers to customise service delivery and develop targeted marketing strategies.
- Using machine learning to predict order delivery times in a distribution scenario.
- Analysing imaging data for real-time inventory decision making.

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Five Maties engineering students were amongst the *Top 100 Most Employable Students* in the GradStar Programme. Furthermore, Travis Defty (far right) was selected as one of the *10 Finest Top Students*. The GradStar Progamme, organised by BlackBark Productions, recognises the Top 100 tertiary students across the country based on leadership qualities and readiness for the workplace. There were several thousand entries and students go through a rigorous four-phase judging process, which culminates in a day of workshops hosted by potential employers. The final stage of judging, deciding on the "10 of the Finest", took place in Johannesburg on 19 September 2019. Two students of the Stellenbosch University Faculty of Economic and Management Sciences were also amongst the Top 100.

From the left are Danielle Kruger (BComm Economics and Investments), Nicholas Tutt (BEng Mechanical), Shahina Patel (MEng Electrical), Kendrick Mashego (BEng Chemical), Liana Maheso (PDE Transport and Logistics) and Travis Defty (BEng Mechatronic). Absent: Newton Mapowo (MEng Engineering Management).

Mechanical and Mechatronic Engineering

The MAD engineers or (probably) better known as the Mechatronic, Automation and Design Research Group engineers (Faculty of Engineering, Stellenbosch University), started research into digital manufacturing in 2017 and since then developed Digital Twin architectures that are able to connect current and future equipment and processes to their counterpart (Digital Twin) in cyberspace. Under the supervision of Prof Anton Basson and Dr Karel Kruger the current MAD research group consists of local and international students. In the photo from the left are: Nicole Taylor, Carlo Human, Dennis Fuchs (Germany), Dale Sparrow, Dr Anro Redelinghuys and Loïc Lacombe (France).

The graphic (top) depicts the concept of the Mechanical and Mechatronic Engineering building. The photograph on the right shows construction as seen on 2019.07.08.

Campus Renewal Project

Construction of the Mechanical and Mechatronic (M&M) Engineering building started in November 2018 and continued throughout 2019. These renovations are all part of the larger Engineering Campus Renewal (ECR) project of R750 million spanning from 2016 until 2026.

After 50 years it had become essential to renew, modernise and densify the Engineering building complex to accommodate greater student and personnel numbers and to comply with modern safety standards.

The environment of such an extensive building project is very complex. Before construction started on the M&M building, personnel and postgraduate students had to be "decanted" into other surrounding buildings. This resulted in the Department being spread out and not in one central place.

After completion of the refurbishment, the new building will house a brand-new FIRGA (Faculty of Engineering computer use area) that will be accessible to students 24 hours a day, three electronic classrooms and a brand-new Mechatronic laboratory, the existing Workshop as well as modern office and open plan space for personnel and postgraduate students.

In the next phase of the ECR project, which involves the refurbishment of the Civil and Electrical and Electronic Engineering buildings, personnel will be decanted into a brand-new building being constructed across the road on the same site where Facilities Management and Information Technology are housed. This new Decanting Building will serve the entire Stellenbosch Campus and will accommodate staff while their permanent office space is refurbished to reduce the disruption during construction projects.

Faculty gains expert in renewable energy

The Faculty of Engineering is fortunate that a highly-experienced process engineer, award-winning patent holder and author joined its academic corps in 2019. Prof Craig McGregor was appointed as an associate professor in the Department of Mechanical and Mechatronic Engineering from 1 June 2019. He also serves as Director of the Solar Thermal Energy Research Group (STERG).

"I am a process engineer by training and obtained my PhD in Reactor Optimisation at the University of the Witwatersrand," he says. "After university I joined Sasol where I worked in many areas over 20 years. I worked in the Research and Technology department of Sasol where I was involved in the development of a number of technologies. Two of these were completely novel to the chemical industry.

"Towards 2010, Sasol became interested in developing technologies in the renewable space. I was tasked to develop a technology development roadmap for concentrating solar power and put together a team of engineers for this task. This was an exciting time for me for I have always had a passion for renewables."

Prof McGregor now has the ideal opportunity to apply his industry experience to the benefit of his research group at Stellenbosch. He says: "Teaching is a new thing and it excites me. It is an honour to be in a position where I am now able to pass on my experience and the skills gained over 20 years to a younger generation."

In his capacity as researcher and Director of STERG he will lead a very strong, well-established and globally-recognised research group. "I see this as a fantastic opportunity to bring some of my insights from industry to the University to help make an impact in terms of the renewable energy space. I believe South Africa, with its abundant sunshine, has the ability to become a leader in using concentrating solar energy for process heat. It is my hope that Stellenbosch University, with our world-recognised thought leadership, can light the way." he concludes.

Research Output

Journal Articles (subsidised)	40
Proceedings International	31
Chapters in Books	2
Patents	8
Doctoral completed	5
Master's completed	47

Dr Karel Kruger wins Teaching Excellence Award

Dr Karel Kruger, a lecturer in the Department of Mechanical and Mechatronic Engineering, was one of Stellenbosch University's 2019 Distinguished Teachers awards winners in the category Developing Teacher. He finds great satisfaction in witnessing the development of his students. Dr Kruger grew up in a household where both parents were teachers and this meant that teaching would always have a permanent presence in his life.

The Excellence Awards were launched in 2017 and acknowledge lecturers in two categories, Distinguished Teacher and Developing Teacher, based on their experience and leadership in the scholarship of teaching and learning. Applicants have to submit a portfolio that demonstrates their reflection on and evidence of four main components: context, students, knowledge and professional growth. They also have to indicate the lessons they had learned on their journey to becoming excellent teachers.

"I have been teaching formally since my appointment in the Department of Mechanical and Mechatronic Engineering in 2016. However, I taught in informal settings (i.e. small group tutoring and mentoring) since I finished my undergraduate degree in 2010," he says. "It is uplifting to receive this recognition. However, I do not consider such recognition as motivation for striving for excellence in my teaching. I have always been driven by my passion for student development. What this award does represent, is a reaffirmation of the importance of teaching and facilitating student learning within Stellenbosch University, which inspires me to continue to improve my own contribution to teaching and learning at this institution."

Prof Kristiaan Schreve
Chair: Mechanical and Mechatronic Engineering.

by Prof Johan van der Spuy & Dr Mike Owen

Cool Power

Even though the South African power industry has been inundated with negative publicity in recent times, it still holds significant research opportunities. Many power stations in South Africa (both fossil-fuelled and renewable) make use of steam-driven turbines to generate electricity. In order to complete the closed steam cycle, the turbine exhaust steam must be condensed before being pumped back to the boiler. Wet cooling towers are currently the most effective and therefore popular method of condensing power plant steam. Unfortunately, the effectiveness of these wet cooling towers comes at the expense of the evaporation of a large amount of the cooling water and this method of cooling is therefore highly water intensive.

Dry-cooling offers a sustainable alternative to wet-cooling and has been used in South Africa for many years (South Africa operates the world's largest direct dry-cooled power stations). A particular dry-cooling technology called an air-cooled condenser (ACC) is a structure very similar to that of a car's radiator but about 50 000 times bigger. The steam inside fin-tube heat exchangers is condensed by forcing air over the outside of the fins by means of axial flow fans. The ACC is therefore reliant on the sensible properties of the air to condense the steam.

The operation of a dry-cooled power station is much more challenging than a plant using a wet-cooled system due to the inferior heat transfer properties of air and the subsequent sensitivity of dry-cooling systems to ambient conditions. The power station also experiences higher parasitic power losses due to the power consumption of the condenser fans. However, the water consumed in ACCs used for cooling approaches zero and as such the water-usage of a dry-cooled plant is less than 10% of that of a wet-cooled plant. Therefore, the water saving benefits of dry-cooling mean that these systems are becoming increasingly popular and necessary.

This is particularly the case for concentrated solar power (CSP) plants, which are built in regions of high solar resource, typically coincident with restricted access to water. To counter stability issues in dry-cooled CSP plants, experienced under hot windy conditions, these plants are usually provided with an "over-designed" ACC. This is certainly not ideal.

Stellenbosch University recently took part in the European-funded Horizon2020 MinWaterCSP Project.

The full-scale test facility purposely designed and constructed at Stellenbosch University.

The project provided cost- and water-effective solutions to address the concerns associated with the use of dry-cooled CSP plants through:

- Custom designed high efficiency axial flow fans to reduce auxiliary power consumption in existing plants.
- The design and demonstration of a directly integrated deluge cooled condenser cell. The deluge system provides the plant operator with the option of introducing small amounts of wet-cooling during adverse ambient conditions (hot and / or windy), to protect or control turbine power output and to secure sufficient electricity on demand. The water consumption of this novel system is ~80% less than of a wet-cooling tower for a similar plant.

A full-scale test facility was purposely designed and constructed at Stellenbosch University to demonstrate the performance of a large diameter axial flow fan under installed conditions and to test and develop the water reticulation system of a deluge condenser cell (see above photo). The facility allows for the testing of 7 m diameter fans, as well as isothermal testing of the novel directly integrated deluge condenser cell system. It is the only test facility of its kind internationally.

By maintaining close relationships with power plant cooling system suppliers, it is foreseen that Stellenbosch will continue playing a significant role in cooling system research for the near future.

Energy and the Environment

In close collaboration with the Centre for Renewable and Sustainable Energy Studies, the Department contributes towards fundamental research into a wide range of energy generation technologies. Addressing transport needs, the group investigates the performance and impact of biofuels and blends in compression-ignition and spark-ignition engines. Uniquely South African solutions to concentrating solar thermal power and energy storage systems are researched. The group's world-leading research in air-cooled heat exchangers and cooling towers is well known. Excellent experimental capabilities and strong computational expertise enable the group to develop special fans, compressors and turbines, e.g. ocean current, wind, and solar energy exploitation-, and air-cooled systems. Research covering the energy efficient design of ship propulsion, ship hulls and various turbomachinery is supported by the only 90 m long towing tank in Southern Africa. The Department boasts the largest fan test facility (7 m diameter) in South Africa.

Mechanics and Dynamics

Activities are divided into fundamental research on materials, behaviour of structures and failure mechanisms and criteria. The materials research focuses on powder metal processing and products, material property extraction using digital image and volume correlation, characterisation of granular materials and qualification of additive manufactured parts. The structures research looks for fundamental understanding of the behaviour of structures under static and dynamic conditions and, in the case of vehicles, aircraft or ships, their impact on humans. Failure mechanisms and criteria of composite materials and fracture and creep deformation of steels are researched.

Mechatronics, Automation and Design

Diverse mechatronic systems such as reconfigurable manufacturing systems, unmanned aerial vehicles, robots and medical devices are researched. Practical solutions to the challenges of Industry 4.0 are found. It finds applications in automation of assembly systems, digital twins, inspection and quality control using machine vision and calibration and maintenance of heliostats for concentrating solar power systems.

Computational Modelling

The group's expertise in optimisation theory and algorithm development, finite element methods (FEM), computational fluid dynamics (CFD), discrete element methods (DEM) and continuum methods is world-renowned. The DEM work is applied to mining and earthmoving equipment, particle dampers, conveyors, etc. The optimisation methods are often linked to the FEM and CFD work in applications related to fluid structure interaction, turbomachinery, combustion and various renewable energy technology applications. The group also has expertise in the modelling and simulation of metal casting processes with emphasis on solidification analysis and segregation.

Biomedical Engineering

Technologies such as 3D printing, microcomputers and artificial intelligence are opening up new opportunities for engineering in the biomedical field. This group is developing innovative minimally invasive devices to collect healthcare information, mechatronic devices for telemedicine and finding customised solutions for the treatment of specific diseases as well as developing and testing medical sensors for in vivo testing of the human knee's biomechanical properties.

Design and Mechatronics

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Process Engineering

Dr Margreth Tadie, a lecturer in Department of Process Engineering, is one of 30 scientists in Africa to have been selected for the FLAIR (Future Leaders – African Independent Research) research fellowships. FLAIR is a two-year programme of The African Academy of Sciences and the Royal Society, with support from the United Kingdom's Global Challenges Research Fund.

At the Gala Dinner at The Lanzerac Hotel in Stellenbosch where academics and industry partners celebrated the Department's 50-year milestone in style were from the left Prof Steven Bradshaw, Prof Hansie Knoetze, Marius Louw (son of founder, the late Prof Nico Louw), Pia Nel (wife of Carel Nel), Prof Jannie van Deventer and Dr Eric Horsten.

Process Engineering celebrates 50 years

The Department of Process Engineering celebrated its 50th year of existence in 2019 with a Postgraduate Conference on 13 September. This was followed by a Gala Dinner at The Lanzerac Hotel in Stellenbosch where academics and industry partners celebrated the Department's milestone in style. A highlight was when three former and two current academics were honoured with unique glassblown trophies for their contribution in the categories founding member, research, and serving for more than 25 years. The recipients were the late Prof Nico Louw (founder and exceptional long-term contributor), Prof Jannie van Deventer (exceptional research contribution) and Carel Nel, Prof Hansie Knoetze and Prof Steven Bradshaw (all three for exceptional long-term contribution).

Prof Hansie Knoetze, former Dean and then acting Chair of the Department, said: "By 2011 our student numbers increased to such an extent that the Annexe had to be added. An excellent undergraduate programme, dedicated academics and excellent laboratory facilities have always been a hallmark of the Department. Employers have always been very impressed with the quality of graduates from the Department.

"From the 1980s postgraduate education and research started to play an ever-increasing role in the Department. Since then the Department has become known worldwide for the work in minerals processing/extractive metallurgy, bioresource engineering, separation technology, intelligent process systems, water technology and waste valorisation. At present three of the five academics with the highest Scopus h-factors in the Faculty are from the Department of Process Engineering, and the Department has awarded six DEng, 101 PhD and 393 MEng degrees."

Personnel excel with fellowship and awards

Dr Margreth Tadie, a lecturer in Department of Process Engineering is one of 30 scientists in Africa to have been selected for the FLAIR (Future Leaders – African Independent Research) research fellowships. FLAIR is a two-year programme of The African Academy of Sciences and the Royal Society, with support from the United Kingdom's Global Challenges Research Fund, and is designed to help talented early-career researchers whose science is focused on the needs of the continent, establish independent careers at African institutions and ultimately, their own research groups. Each scientist receives £300,000 (R5 472 003) over the two-year fellowship to help them with independent research. Her research project will specifically look at the waste left behind from gold mines in South Africa and she aims to develop a framework strategy that looks at sustainable ways to extract minerals so that less waste is created in the process. She hopes that this framework strategy will be applied to different sites and eventually influence policy change within the mining industry.

Dr Mohsen Mandegari, a postdoctoral researcher at the Department of Process Engineering, was recognised as one of the Top 20 Postdoctoral Researchers in 2019 at Stellenbosch University. His research focuses on biorefinery developments, and in 2019 he co-authored four journal articles and two chapters in books. He has also served as a panel member for the Postdoctoral DRD Travel Grant award.

In this year the National Research Foundation rated him as a Y-rated researcher (Promising Young Researcher). The rating of individuals is based primarily on the quality and impact of their research outputs over the past eight years, taking into consideration the evaluation made by local and international peers.

In terms of international recognition, Dr Mandegari has spoken at the International Biorefinery Conference in Johannesburg, he has reviewed several top journals in his field, and he has also been invited by the Department of Energy (DoE) in the USA to review bioenergy and biorefinery-related research proposals.

Dr Robbie Pott, a senior lecturer in the Department, was honoured as one of the 12 winners in the SU Teaching Excellence Awards for 2019. Waking away with an award in the category for Developing Teacher, he says this shows that excellent teaching is encouraged, supported and recognised at SU. "My main goal is to impart an inquisitiveness and sense of fascination in my students. We have tools at our fingertips to change the world and create new things – I hope to help them realise that they also have access to these tools, and to teach them how to use these," he says.

"I am not only a teacher – I chose to stay in academia because I believe in the impact one can have as a researcher and a lecturer. I spend much of my energy on my research and my postgraduate students. I also enjoy my undergraduate students, and relish the challenge of trying to meet them where they are and induct them into engineering – as they will be the ones building our nation in years to come."

Research Output

Journal Articles (subsidised)	60
Proceedings International	1
Chapters in Books	4
Doctoral completed	8
Master's completed	28

Matie's prize-winning edible straws help the environment

Leila Siljeur, a second-year Chemical Engineering student, won a massive cash prize as a result of her passion for the environment. Moved by a Facebook post of a sea turtle with a plastic straw stuck in its nose she felt she had to do something to help reduce plastic pollution. She decided to design her own brand of edible and environmentally friendly straws and won R50 000 for her invention in an Allan Gray Orbis Foundation National Jamboree.

Registered under the name *Eat Me Straws*, the straws come in three ranges – regular, health and vegan and do not become mushy when put in a wet substance. She believes this is an improvement on what has been done thus far with edible straws.

Prof André Burger
Chair: Process Engineering.

by Dr Riccardo Swanepoel

Online monitoring of phase boundaries in linear low-density polyethylene production

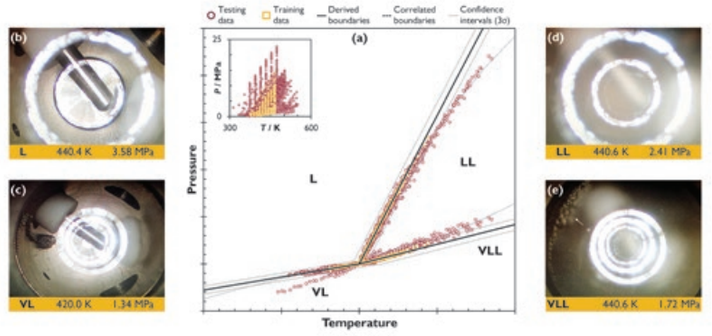

Figure 1. Phases and phase boundaries found in the solution process reactor: (a) schematic representation of the universal phase boundaries governing (solvent + LLDPE) phase behaviour, and the data used to develop and test these boundaries; (b) photograph of a liquid region in a high-pressure cell; (c) photograph of a vapour–liquid region in a high-pressure cell; (d) photograph of a liquid–liquid region in a high-pressure cell; (e) photograph of a vapour–liquid–liquid region in a high-pressure cell.

Linear low-density polyethylene (LLDPE) is used extensively in the blown-film industry for the packaging of food. It is frequently produced via the solution process, in which the ethylene monomers and longer α-olefin comonomers are dissolved in an inert hydrocarbon diluent, such as hexane. This stream is them compressed and fed to a reactor where the LLDPE is produced in solution. The monomers, comonomers, and diluent collectively constitute the solvent, such that a (solvent + LLDPE) system is present in the reactor.

Under solution process reactor conditions, the (solvent + LLDPE) system exhibits four phase regions, depicted in Figure 1a. At high pressures and low temperatures, a single liquid region (L) exists where the LLDPE is completely dissolved in the solvent (Figure 1b). This region is separated from the low-pressure vapour-liquid region (VL; Figure 1c) and the high-temperature liquid-liquid region (LL; Figure 1d) by the VL and LL boundaries, respectively. The VLL boundary separates the LL region from the high-temperature, low-pressure vapour-liquid-liquid region (VLL; Figure 1e). The intersection of the VL, VLL, and LL boundaries is termed the lower miscibility endpoint (LMEP).

The reactor is operated as close as possible to the LL boundary to minimise operating costs, but crossing the LL boundary during normal operation leads to the precipitation of a viscous LLDPE-rich phase which adheres to the reactor walls and agitator. This phase cannot be redissolved easily, requiring a shutdown of the reactor to remove the phase mechanically.

It is therefore important to monitor the distance to the LL boundary in real time. Time-consuming experimental measurement and computationally intensive thermodynamic models can therefore not be used to determine the LL boundary's position. Existing empirical methods are also not applicable to the 1-hexene and 1-octene comonomers.

A simple method, with theoretical justification, was therefore developed to estimate the positions of the VL, LL, and VLL boundaries. The method is based on three postulates: (1) a set of universal phase boundaries, derivable from fundamental thermodynamics, exists when the VL, LL, and VLL boundaries are reduced around the LMEP; (2) the LMEP temperature of all (solvent + LLDPE) systems exhibit the same sensitivity to the solvent's molar mass; and (3) the LMEP pressure is approximated by the polymer-free solvent's bubble-point pressure. The method was evaluated using a large dataset of interest to the solution process, which showed that LL boundary pressures can also be estimated within the uncertainty of laboratory-measured data. The method also accurately predicts the effects of longer α-olefins and shows good results when extended to commercial-grade solvents.

Although this method uses significantly fewer input parameters than existing alternatives, its key advantage is its computational simplicity which allows for easy integration into online control and real-time alerts when an LL boundary is approached.

Extractive Metallurgy

The sustainable production of valuable minerals and metals from ore or metal-containing waste material is critical for a sustainable future. Ore is a complex raw material, requiring a wide variety of treatment processes to unlock valuable minerals and metals. The group undertakes research into the fundamental concepts and application of such treatment processes. Key challenges include changing raw material characteristics due to depletion of easy-to-access ore bodies, minimisation of energy and water usage, as well as effectively dealing with the complex behaviour from the intricate flowsheets required.

Waste Valorisation

The successful valorisation of wastes will allow closing the loop in the circular economy, moving closer to a sustainable future. Key challenges include separation and concentration of valuable products as well as functionalisation of relatively inert chemicals. Main focus areas include:

- Waste tyre and waste plastic conversion to high-value chemicals.
- Electronic waste processing for metal recovery (lithium, gold, copper).

Separations Technology

The Separations Technology research group focuses on understanding the fundamentals and thermodynamics of separation processes involving hydrocarbons. Typical processes include distillation, liquid-liquid extraction, adsorption, supercritical fluid fractionation and membrane separation. Much of the work is focused on the separation of compounds where the underlying systems may exhibit azeotropy and association due to hydrogen bonding, and where the systems may involve molecules with varying polarity and asymmetrical structure.

Bioresource Engineering

To ensure a sustainable future, biological resources need to be used optimally. This group focuses on developing industrial bioprocesses that are safe, sustainable and profitable, either through processes that employ biological resources (e.g. live organisms or active biological molecules) to transform raw materials into valuable products, or production processes that use biological raw materials as inputs. There is a strong interdisciplinary focus within the group, and frequent collaboration occurs with other disciplines at Stellenbosch University and with leading foreign institutions.

Water Technology

The group focuses on research and development aimed at addressing local and international challenges in water provision. The objective is to improve existing water treatment technologies as well as develop new technologies that will contribute to addressing this global challenge. The group's strengths include membrane technology (microfiltration, ultrafiltration, reverse osmosis, forward osmosis, membrane distillation and Donnan Dialysis), and in technologies that will be applicable in developing economies. Current projects range from investigation and modelling of basic phenomena, to technology development leading to implementation in the field.

Process Monitoring and Machine Learning

Advances in online monitoring and data collection present an opportunity to enhance the efficiency, sustainability and profitability of chemical engineering processes. This group focuses on the use of machine learning techniques to improve the operation and control of chemical plants, with an emphasis on producing industry ready solutions. Applications include fault detection and diagnosis, causality analysis, operational state identification and actionable advisories.

http://process.sun.ac.za

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Outreach Programmes

The Faculty has been presenting the Women in Engineering afternoon since 2003. Here is the group that attended the function at the Faculty on 11 September 2019.

The ever-popular Open Day is always well attended.

Open Day

The annual Open Day makes learners, parents and the general public aware of the interesting world of the engineer and the vast career opportunities in this field.

Enquiries: Ms Tanya Ficker
Tel: +27 21 808 9403, e-mail: tanya@sun.ac.za

Engineering Winter Week

During the annual Winter Week, Grade 11 and 12 learners get a clear picture of the work of an engineer through presentations by lecturers and engineers, as well as visits to industries and laboratories.

Enquiries: Ms Portia Adonis
Tel: +27 21 808 4203, e-mail: winterweek@sun.ac.za

Women in Engineering

At the annual Women in Engineering afternoon, Grade 10 to 12 girls, who excel in Mathematics and Physical Sciences, find out more about engineering as a career for women when women engineers, lecturers and students address them.

Enquiries: Mr August Engelbrecht
Tel: +27 21 808 4203, e-mail: august@sun.ac.za

Top Achiever Sessions

During sessions presented in Stellenbosch and various major cities countrywide, top achievers (Grade 11 and 12) and their parents are informed about engineering as a career and the Faculty's degree programmes.

Enquiries: Mr August Engelbrecht
Tel: +27 21 808 4203, e-mail: august@sun.ac.za

First Generation Experience

Universities can be quite daunting if you have no experience of academic or tertiary institutions. In 2018 the Faculty launched this new outreach for Grade 11 and 12 top achievers, whose parents have not had the opportunity to study at a university. During a day visit they feel the exciting vibe of campus, hear about the Faculty's degree programmes and other SET fields of study and meet the Dean.

Enquiries: Mr August Engelbrecht
Tel: +27 21 808 4203, e-mail: august@sun.ac.za

Talent Development Programme

This school holiday enrichment programme was initiated by the Department of Science & Technology in collaboration with the Department of Education and SUNCEP (Stellenbosch University). It is rolled out in all nine provinces. Eighty top Grade 11 and 12 (mostly black) learners are brought together per province and instructed by the relevant province's best Mathematics and Physical Sciences teachers. Our Faculty visits these centres for recruitment.

Enquiries: Mr August Engelbrecht
Tel: +27 21 808 4203, e-mail: august@sun.ac.za

Buddy Programme to facilitate integration

Engineering is a demanding and challenging programme and many first generation students (in particular those who do not stay in a university residence) find it difficult to adapt to the new environment and academic culture. During the first semester, senior students act as the students'"buddies" to facilitate their smooth integration.

Enquiries: Mr August Engelbrecht
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Leadership Development

Senior students follow a leadership module at the Frederik van Zyl Slabbert Institute for Student Leadership Development, which enables them to become well-rounded engineers who are better equipped to make a difference in society.

Enquiries: Ms Avril Ford
Tel: +27 21 808 3614, e-mail: aford@sun.ac.za

A joyous group of learners at the Open Day.

TRAC South Africa

The TRAC Programme, the biggest community interaction programme at Stellenbosch University, gives support in Physical Sciences and Mathematics in TRAC laboratories countrywide to learners in disadvantaged communities. It also provides vocational guidance regarding careers in the sciences, engineering and technological fields and assists learners to obtain funding for tertiary studies.

Enquiries: Ms Debbey Olivier
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Minquiz

Minquiz (organised by Mintek) is a science and technology quiz for Grade 12 learners that promotes careers in science and technology, especially in mining, mineral processing and geology. The Department of Process Engineering provides assistance in the Boland and the Western Cape.

Enquiries: Prof Christie Dorfling
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CRSES Schools' Programme

This programme, run by the Centre for Renewable and Sustainable Energy Studies, provides professional development and learning material (free of charge) to assist educators in teaching renewable energy topics. It is implemented in collaboration with the Department of Education, WESSA Eco Schools, Fundisa for Change, Science Centres and Independent Power Producers.

Enquiries: Ms Linda Joka
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SUNSTEP

The SUNSTEP Programme provides learners the opportunity to build their own working electronic circuits. There are also workshops for educators.

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