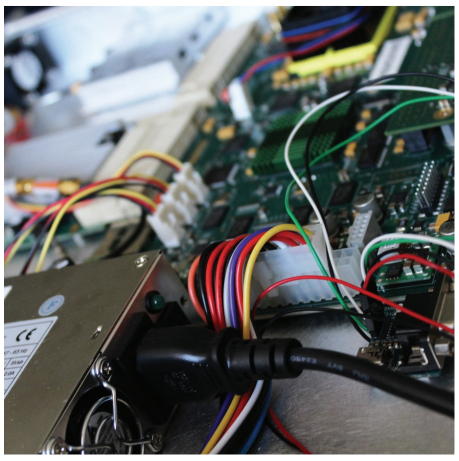
FACULTY FOCUS

A MONDAY MONTHLY SUPPLEMENT

FACULTY OF ENGINEERING & THE BUILT ENVIRONMENT

EBE



CREATIVE, INGENIUS & SOCIALLY ENGAGED

TALENT FOR THE 21ST CENTURY

A word from the dean

To be an engineer before 1950, or any time between 1750 and 1950, was to be a leader; a participant in a great adventure; a hero of society. Even Walt Whitman wrote:

"Singing my days,
Singing the great achievements of the present,
Singing the strong light works of engineers."

With 1952 and the exploding of the first H bomb; the 1960s and the sobering predictions of Rachel Carson's *Silent Spring*; the 1970s threat of nuclear annihilation; followed by the 1990s and fears of irreversible climate change, the Golden Age of the profession began to tarnish.

However, we are now at a point where engineers and professionals of the built environment have the opportunity to be heroes again, as (however unlikely it seems now) they were in the novels and short stories of the late 1800s. With our abilities to rise to complex and undefined challenges, wicked problems, and the innovation and creativity inherent in the training and the profession, we are ideally placed.

"I am very proud to be part of a faculty that not only has the skills, the abilities and the ambition to tackle the challenging global problems of the 21st century, but is also living out its vision."

This supplement highlights the true awesomeness of the talent and potential held in the Faculty of Engineering & the Built Environment, from our 3 000 undergraduate students to 1 200 postgraduate students (of which 208 are PhD students) spread across six departments; to our seven SARChI Chairs and two endowed chairs (the Anglo Platinum Chair in Mineral Processing and the SANRAL Chair in Transport Engineering).

Our 4 200 students are looked after by 232 academic and 199 PASS staff[1] housed in nine different buildings on the Upper Campus. Our faculty hosts 51 NRF-rated researchers and 15 URC- accredited research groupings, including the interdisciplinary signature theme African Centre for Cities and the newly accredited UCT-Nedbank Urban Real Estate Research Unit.

The common threads in our faculty and its six departments of Architecture, Planning and Geomatics, the four basic engineering disciplines (Chemical, Civil, Electrical and Mechanical) and Construction Economics and Management are their focus on the key attributes of EBE professionals: strong analytical skills; practical ingenuity and creativity; a focus on good communication, and high ethical standards and professionalism, as well as the ability to be lifelong learners. In addition, one of the core aspects of our vision as a faculty is to: "*develop outstanding graduates and scholars … who contribute to society and address socioeconomic challenges through their work.*"

As the new Dean, I am very proud to be part of a faculty that not only has the skills, the abilities and the ambition to tackle the challenging global problems of the 21st century, but is also living out its vision.

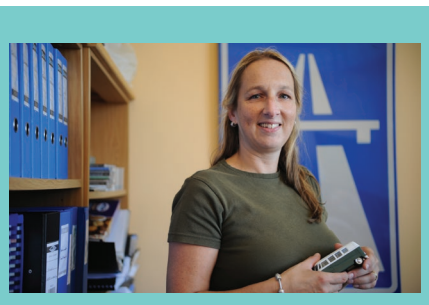
Enjoy the read.

Prof Alison Lewis
Dean of EBE

[1] These include T1 and T2 contract staff. For permanent staff, the numbers are 158 academic and 148 PASS staff

Photo by Michael Hammond

To find out more about the Faculty of Engineering & the Built Environment, visit www.ebe.uct.ac.za. Alternatively, get in touch directly on 021 650 2699, or send an email to ebe-faculty@uct.ac.za.



Page 4 Engineers break down stereotypes and paradigms

Page 7 EBE students roll up their sleeves and get to work

Page 8 Seeking solutions to the energy and looming water crisis

Page 10 Clever robots and canny machines in the making

Page 12 Chemical engineering shows the way in transformation

FACULTY FOCUS

Over the course of 2014 and 2015, UCT's newsroom has been bringing out special supplements to Monday Monthly focused on the university's six faculties, as well as the Graduate School of Business (GSB) and the Centre for Higher Education Development. Coming up later this year is the GSB.

To read past editions, head online: www.uct.ac.za/faculties/faculty_focus

Manager, Newsroom and Publications: Chris Mitchell
Head, Newsroom and Publications: Judith Browne
Contributors: Helen Swingler, Yusuf Omar, Abigail Calata, Je'nine May, Michael Hammond, Andrea Weiss
Designer: Monique Mouissie
Proofreader: Dave Buchanan

CITIES IN THE GLOBAL SOUTH: CRUCIBLES OF CHANGE

The world is facing unprecedented rates of urbanisation, mainly in the Global South. Here, migrants seeking the benefits of cities head to swollen places already ill-equipped to sustain burgeoning needs.

Story by **Helen Swingler**

Photo by Akintunde Akinleye (courtesy of African Centre for Cities)

The largest cities in the world, such as Lagos in Nigeria (above), are now concentated in developing countries faced with a range of challenges. These cities are also sites of emerging markets, promising economic growth, innovation and investment.

Mega slum-cities are mushrooming, and we'll need a 360-degree change in thinking to deal with urbanisation in the Global South, says Professor Gordon Pirie, deputy director of the African Centre for Cities.

The United Nations estimates that the world's slum dwellers will reach two billion by 2030. The Global South will carry this burden: Africa, Central and Latin America, and most of Asia – 157 of the world's recognised 184 states.

LEAP OF IMAGINATION

The largest cities are now concentrated in countries that already confront a mix of poverty, environmental degradation, human and civil rights abuses, ethnic and regional conflicts, and refugees.

But these are also the sites of emerging markets offering hope for economic growth, innovation and investment.

Asia has the largest number of urban agglomerations, with Africa in second place. India's Maharashtra slum city near Mumbai is the world's largest, and expected to accommodate over 20 million people by 2017. In that time, India's urban slum population is expected to reach 104 million.

Absorbing the current rates of urbanisation in the Global South will require "a massive leap of imagination, knowledge and collaboration", says Pirie.

But there are few precedents for the Global South.

RESEARCH NEEDED

"We probably cannot and should not replicate the urbanisation types and trajectories of the Global North," says Pirie.

Neither do we want cities only built for the rich and elite – modern, glossy exhibits like Dubai for image-conscious African leaders and developers.

Or smart cities, dependent on computer-controlled infrastructure and resources.

"At best, grandiose approaches to urban design need discussion," says Pirie.

Urban development in Africa requires tactics that aren't always interventionist.

"It's a challenge for education institutions and researchers, but if steps aren't taken soon, Africa's crisis of poverty, inequality and lack of resources will deepen."

With this in mind, UCT's African Centre for Cities (ACC) aims to understand and work with cities on their own terms, and to create the interdisciplinary knowledge base needed to support the emergence of more equitable African cities; cities that are livable and sustainable.

> "We should stop demonising cities like Kinshasa, so difficult to read but with its own inner success and dynamic. There is workability and vibrancy there, a bit like District Six and Sophiatown at scale."

Working with policymakers and planners, the ACC, a UCT signature theme, has become the pre-eminent hub of multidisciplinary urban research on the continent. It is an intellectual consortium of urban planners, political scientists, climate change specialists, sociologists and geographers.

The ACC is working with African partner institutions to set up a continent-wide network of urban institutes to train the graduates who will be needed to manage our cities in the future.

In this respect, India has taken the lead. The new Indian Institute for Human Settlements in Bangalore annually graduates some 80 PhDs in city planning, architecture, design, management, and planning.

Africa is some way behind. South Africa for example, has never had a coherent urban policy. Recently the Presidency co-opted ACC director Professor Edgar Pieterse to draft one, as part of Trevor Manuel's National Development Plan.

NO READY RECIPE

So what does make for an exemplary, workable city in the Global South?

There's no recipe, says Pirie.

"It's a mix of elements and we shouldn't think too technically, managerially and instrumentally about cities. It's partly about revisiting our notion of what a city is. We should stop demonising a city like Kinshasa, so difficult to read but with its own inner success and dynamic. There is workability and vibrancy there, a bit like District Six and Sophiatown on a larger scale."

We should not lose sight of the "the soul of the city", he adds. "Slums may have wretched physical fabric and conditions, but they are toeholds for millions of desperate people. They achieve amazing things despite diabolical circumstances."

While there are few precedents we should adopt from the Global North, with its different past and present, Pirie suggests that northern cities might need to look to Africa for answers to their future challenges.

"Africa is a glimpse of the urban future: there will be a lot to learn from how our cities deal with resource shortages, climate change, food security, turf battles, and rights and access to slim budgets and to fractured political power."

"Cities are sites of tremendous difficulties, but also crucibles of change."

FAST FACTS

- Africa is second only to Asia in its number of urban residents.
- The United Nations Department of Economics and Social Affairs (UNDESA) predicts that Africa will be 50% urban by 2030 and 60% urban by 2050.
- Researchers in UCT's African Centre for Cities estimate that the South African middle class will double by 2050 and the population of informal dwellers is set to treble.
- The African Centre for Cities trains postgraduate students. They also offer a short course for city professionals in energy, water and policymaking. These are often middle managers who want refresher courses, and for continuing professional development.
- In 2016 the ACC and the University of Basel will kickstart a master's course in urban studies.
- The ACC hosts City Labs, which bring together civil society, academics, city officials and practitioners for debate and research.

ENGINEERS WHO BREAK THE MOULD

Staff, students and alumni share their thoughts about re-engineering some of the stereotypes and paradigms in the field.

Compiled by **Helen Swingler**

NEW GENERATION

WIEBKE TOUSSAINT
CEO of Engineers Without Borders South Africa

After a brief and underwhelming experience as a piping engineer after graduating from UCT in 2011, I found tremendous fulfilment in developing a data-driven industrial decision support tool for my sponsor company. This early career experience brought valuable insights. The life of the mechanical engineer of the future will blend traditional engineering with the Internet, and thus I couldn't afford to be clueless about modern technology any longer.

To acquire programming and data analysis skills I subsequently spent a year working as a business analyst for an online fashion retailer.

Since July this year I've been fully committed to growing Engineers Without Borders South Africa (EWB-SA). My passion lies where technology meets people and engineering touches society. Technically, I'm gearing my career to using data and networks to build engineering communities.

GEEKS AND GADGETS

The image of the traditional engineer is that of a self-proclaimed geek who loves gadgets and taking things apart (though not necessarily putting them back together), or who sits in the corner of the office making calculations. In South Africa, this engineer is typically white, male and of a certain age.

Now zoom out and picture a colourful and noisy group of young tinkerers ready to engage in opinionated discussions. In their spare time they are skateboarders, play in bands, write blogs, start social enterprises, design fashion, and are constantly looking for new ways to engage with the world.

They're not satisfied with meaningless, repetitive assignments that stifle their development.

This is our EWB-SA tribe: 1 500 women and men, students and professionals, representing over 15 different engineering specialisations and different university chapters. We all want to use our engineering skills to build South Africa.

Take EWB-UCT's Langa Skate Park Team as example. A group of skater engineering students started the problem identification process to build a skate park in Langa in their mid-year vac. Over that month I saw an evolution in their understanding of what it means to be an engineer.

As the Langa Skate Park Team discovered, EWB-SA sees engineering as a means to an end, not as the end itself. Breaking the stereotype in engineering means co-envisioning that end: discovering our role of providing the means while collaborating with the beneficiaries of our services.

Wiebke Toussaint

Photo supplied

"My passion lies where technology meets people and engineering touches society."

ADAPT OR DIE

Reinventing stereotypes is critical for survival. In a constantly changing world we must 'adapt or die'. Engineers are problem-solvers, but our problems have changed in 20 years. Many of the difficult technical challenges that the previous generation tackled are now solvable using software programs.

Years of systems and procedures development have turned complex engineering challenges into well-defined, pre-solved problems that have ready-made, off-the-shelf solutions. This may be a great step forward, but it's not good for individual engineers who get their kick from applying ingenious thinking to solving practical problems.

Engineers need to rethink their role in society to ensure that they claim the space of solving the most challenging, most fascinating problems out there. This means looking at problems beyond the purely technical realm of traditional engineering.

DRIVING CHANGE

To solve the 21st century's problems, Africa's young engineers must start addressing issues of inequality, sustainability, transformation, integration and decentralisation.

For example, Africa is a continent of entrepreneurial abundance, but engineers are not promoted in small-business conversations.

We are trying to grow industry, without including those who are best equipped to build industry.

University curricula should provide a more balanced view of the relevance of engineering skill sets in entrepreneurship and business, non-profit, social enterprise, public and corporate sectors.

Engineers should also drive change and development in Africa. We have the ability to harness energy, to control the flow of water, to prevent the spread of disease, to connect civilisations.

To do this, EWB-SA is building a platform to facilitate this connection, while leveraging our members' collective vision to drive change at all levels of civil society, government and industry.

Watch this space. Next year we'll be launching EWB-SA Work Groups, to create a voice for engineers in the country's development conversations.

11 The number of fields in EBE in the top 20 list of national scarce skills listed by Minister of Higher Education and Training Blade Nzimande in June 2014

Genevieve Langdon

Photo by Mary Hilton

ENGINEERING FOR CONTEXT

SHAMISO KUMBIRAI
Master's student, civil engineering

In 2010, local news was dominated by violent protests over some 55 unenclosed toilets in Makhaza, a suburb of Khayelitsha. These ongoing disputes between Makhaza residents and the City of Cape Town continued into 2011, and came to be known in the media as the 'Toilet War'.

I've always taken a keen interest in how the technical and social sciences interact in public infrastructure design and implementation. For my research I chose the 'Toilet War' because it became a turning point in the way sanitation infrastructure and service delivery is viewed in South Africa.

In particular, it showed the limitations of viewing access to sanitation from a technical and demand-driven focus, compared to one integrating important social considerations.

That's a paradigm shift.

PERCEPTION GAP

My research suggests there's a considerable gap in perceptions and expectations between stakeholders providing technical expertise in the planning and implementation stage of a project, and the beneficiaries involved and affected by it.

In designing the sanitation facilities, in this case, the technical experts were focused on a resource-based approach to planning, based on financial constraints and meeting minimum technical requirements. The beneficiaries expected a more rights-based approach, in which issues such as human dignity, health, safety and hygiene would be primary considerations in the design.

The government felt they'd followed the correct public participation processes, and made concerted efforts to meet the beneficiaries' requests.

The residents, however, believed that attempts to engage them were a form of placation that didn't translate into power-sharing in decision-making.

I learnt that the idea of improvement means different things to different stakeholders. If these conflicts aren't properly articulated and addressed early in a project, they could jeopardise its success.

REFORM CURRICULUM

The value of contextual knowledge that citizens contribute ought to gain them a seat at the table of experts. Despite their socio-economic or educational background, citizens should be taken seriously when decisions are made about projects and participatory processes should be designed and implemented with this in mind.

In the provision of infrastructure and service delivery to informal settlements, I believe it's important that stereotypes are not only reinvented, but removed altogether.

Data on residents' perspectives indicate that they don't want to be stereotyped as 'objects' that ought to accept whatever 'handouts' are given to them. They want to be – and if need be, they are willing to fight to be – treated as people whose opinions matter and whose rights are respected.

The greatest opportunity to break stereotypes lies in reforming the engineering curriculum.

The last few years has seen the development of elective courses such as the Social Infrastructures course geared towards raising students' social awareness. It's important that courses like this become mandatory in the engineering curriculum. Graduates need to understand the sensitivities around the social context in which they'll be applying their technical skills.

Shamiso Kumbirai

Photo supplied

"The value of contextual knowledge that citizens contribute ought to gain them a seat at the table of experts."

OPENING MINDS

PROF GENEVIEVE LANGDON
Mechanical engineering

Some engineering fields have fared better at the gender balance, for example electrical and chemical engineering. But mechanical engineering remains male-dominated. In my work at the Blast Impact and Survivability Research Unit, I investigate the response of structures to blast loading. It's very hands-on and experimental, and often involved in defence applications. Both are almost exclusively male-dominated areas, and I break stereotypes just by being who I am in a world where (as a woman) that makes me the 'other'.

Sometimes students walk into my office and ask to see Professor Langdon. They're shocked to find that's me. Because I'm (relatively) young and female I'm often assumed to be an admin assistant to the professor. It used to frustrate me, but now I see I'm changing their world and opening their minds.

MAXIMISE TALENT

No country can afford to look for solutions from only one portion of its population, when talent is distributed throughout all people, regardless of our differences. South Africa has huge challenges to overcome and we can't afford to waste talent, or treat people disrespectfully. We owe it to the next generation to learn to see everyone as a person first, and stop trying to insist they meet our stereotypical expectations.

More female engineers? Definitely. More male nurses? Yes please.

We're doing well as a faculty in creating space where everyone can thrive, and I'm encouraged that we've chosen our first woman dean. But that's easy for me to say, as I've personally been well supported and successful.

We must be very careful to listen to the voices of others when they do not have similar good experiences, because privilege is usually invisible to those that hold it. I think that as a university, some of our processes may favour people with a particular cultural background – those who are able to engage in rigorous verbal academic debate, and are not shy in expressing their opinions. We must be careful as a faculty that we listen to all voices, and don't just go with the loudest ones.

"No country can afford to look for solutions from only one portion of its population, when talent is distributed throughout all people, regardless of our differences. South Africa has huge challenges to overcome and we can't afford to waste talent, or treat people disrespectfully."

Harro von Blottnitz

Photo by Michael Hammond

NEW SKILLS NEEDED

PROF HARRO VON BLOTTNITZ
Chemical engineering

I plough a range of fields: even though my name is attached to chemical engineering, I don't fit the stereotype of the highly specialised academic. Systems thinking gives me contextual mobility; the counter-intuitive behaviour of systems; the platform from which to challenge received wisdom.

Take our research on the role of biofuels in sustainable development. Our highly-cited paper on bio-ethanol fuel challenged the notion that biofuels are green alternatives to fossil fuels and always good for the environment. More recent research has confirmed that biofuels could exacerbate a range of environmental impacts.

This is but one example of skilled but overspecialised scientists of the 20th century gifting society with both amazing inventions and loads of unfinished business. The result is inequality and environmental degradation. So we need new types of skilled thinkers and leaders, who can finish the business of integrating amazing inventions fully into our economy and society.

For that we might have to consider new stereotypes: the pattern on my coffee cup is square and green.

As for teaching and learning stereotypes,... oh, now you're pressing buttons! I'd like to see serious discussions about shifting the education of the 21st-century engineer from calculus-focused mathematics to social competencies.

In that sense, the replacement of physics 1B with statistics in the chemical engineering curriculum was the first and a very small step towards modifying the 20th-century mathematical school of engineering: stochastic numeracy challenging deterministic precision prediction.

If that's too theoretical and long-term for the term of a deanship, then let's talk about breaking the practice of growing our class sizes every year by a couple of percent (there are limits!).

If there's to be growth, how about adding a new qualification to our mix? Anyone for energy engineering? Bioneering? Mobility engineering?

ROADS FOR PEOPLE

ASSOC PROF MARIANNE VANDERSCHUREN
Civil engineering

I'm a transport engineer whose work is changing a major paradigm in the developed world: that roads are built for cars. But it's about people, and not about people in cars. It's about accommodating and protecting pedestrians and cyclists, and creating shared roads and associated infrastructure like pavements and crossings that accommodate vulnerable road users.

Do you know that the first time road fatalities were called an epidemic worldwide was as recently as 1973?

Most South African road engineers are trained in America where space is plentiful and fuel is cheap. But with less space and heavier fuel costs, Europe has been the frontrunner in pedestrian- and cyclist-friendly cities.

We need more of this thinking in South Africa, where 57% of road fatalities are pedestrians.

Apartheid planning in this country has further hamstrung the transport infrastructure, with highways and green belts designed to separate communities.

Recently, I wrote a new set of transport guidelines for non-motorised transport for the Department of Transport, to show the way to people-friendly roads designed to attract cyclists and pedestrians.

We didn't do it in a day. The process began in 2013, and culminated in the large document that entered the public domain in March this year, titled *Non-Motorised Transport Facility Guidelines*.

Now the aim is to get this into practice.

Working with the Department of Environmental Affairs a similar project was developed, under the Green Cities banner, as the *Non-motorised Transport Best Practice Manual*.

This promotes more zebra crossings, better infrastructure on the sides of roads (broader pavements, dropped kerbs for special-needs users, etc), and introduces more traffic-calming measures, such as bollards, neck-downs (where the road is narrowed in areas to accommodate pedestrians) and chicanes. These are artificial narrowings or turns that force cars to slow down, as in motor racing circuits.

Another measure to restrict speed is to introduce third-tier roads in suburbs, which impose a 40km speed limit.

While it's important to maintain the existing road network (a growing economy demands this), it's also important to reconfigure some important roads to accommodate sharing: by building in traffic-slowing measures and adding cycle lanes to the infrastructure.

It means introducing more special lanes for buses and taxis. The Bus Rapid Transport (BRT) system of bus-only lanes was pioneered in Curitiba, Brazil, in the 1970s, to counter traffic congestion and as a low-cost, sustainable urban transport system.

When the taxi lane was introduced on the N2 highway in Cape Town, the taxis managed an extra trip in peak traffic, increasing their passengers by almost 30%. And the travel time for cars decreased too.

We're challenging the 'more is better' thinking. Statistics have shown that the wider the road, the more fatalities there are. So standard engineering practice does not work for transport engineering. Road infrastructure plays a large role in accommodating safety. But it's also about air and noise pollution – and sustainable energy.

"We're challenging the 'more is better' thinking. Statistics have shown that the wider the road, the more fatalities there are."

Marianne Vanderschuren

Photo supplied

STUDENTS AT WORK

The fruits of good engineering are enjoyed every day. These UCT EBE students make it their mission to create what some may take for granted.

Curated by **Yusuf Omar**

FROM WATER PLATFORMS TO SPORTS PAVILIONS

In the Imizamo Yethu township in Hout Bay, some 9 464 households make use of shared toilets and taps. The service ratio is an average of 61.1 households per toilet and a staggering 394.3 households per tap, says UCT lecturer Mike Louw.

To help address this dearth of services, UCT's second-year architecture students, plus a few key members of staff, have designed and built water platforms in Imizamo Yethu during the June vacation over the past five years.

These water platforms are a way of providing additional services, more dignified places for water collection, and spaces to wash clothes. The platforms are integrated with shared toilet facilities where these are in close proximity. They serve as social gathering spaces and cleaner areas for children to play. The first four platforms were primarily focused on washing facilities, while a much-needed water point and seating area was provided at the new Imizamo Yethu football field.

During 2015's June vacation, in an annual tradition, architecture students with a few key staff members and members of the local community helped to construct the sixth platform situated at Imizamo Yethu. Moreover, a second seating pavilion was constructed at the Hout Bay Sports Ground to add to the first one that was built last year.

The design of the platform and its parts was integrated into the course curriculum, and after designs had been developed and the necessary planning and community liaison had been completed, the project moved on site.

"The students did earthworks, built formwork, tied and installed reinforcing, placed concrete, and finished the structure within quite a limited timeframe despite the winter weather," says Louw, who teaches in the School of Architecture and Geomatics and is a key driver of this initiative. Initial reports from the community suggest they are pleased with the additional pavilion, and there are tentative plans to build a few more in due course, he said.

"There have been a number of parallel projects with the platforms, which included outreach workshops, the provision of 20 planting boxes at the Ikhaya Letemba school which were filled with vegetable and herb seedlings during a very successful planting workshop held with the children, and the provision and installation of approximately 200m² of high-quality laminate flooring in the Imizamo Yethu youth centre, which is earmarked for use as a crèche/aftercare facility and a gym," said Louw.

During the June 2015 vacation, architecture students along with key staff members and residents of Imizamo Yethu helped to build a watering point and seating platform for the football field.

Photo supplied

LANGRUG PARTNERS WITH UCT PLANNING STUDENTS

Nothing for us, without us.

This was a key message from the impoverished community in Langrug, Franschhoek, for UCT students and staff from the School of Architecture, Planning and Geomatics. In 2012, the students went to Langrug for their first official site visit and data-gathering as they began researching ways to improve living conditions in the informal settlement.

First-year master's students in city and regional planning and architecture were tasked with recommending upgrades for the squalid environment the 4 000 Langrug residents are forced to cope with every day.

The project formed the core of the department's 'Basic planning skills in situ upgrade' course that introduced the designers of South Africa's geo-political future to the physical, social, economic, environmental and political circumstances that inform the current social structure.

That course also aimed to introduce community leaders to relevant urban planning legislation, national housing policies, and geographical information systems. This initiative was supported by the Faculty of Engineering & the Built Environment and was part of a collaborative project between UCT, CORC/ISN (an NGO and social movement that facilitates community engagement with the state), the Stellenbosch Municipality and the community of Langrug.

"Apart from the physical construction and projects, students report learning skills such as planning, co-ordinating, budgeting and material calculation, as well as the importance of communication."

Students visited Langrug near Franschoek to look at potential solutions to the squalid conditions at this informal settlement.

Students created these mosaic designs at the Tembaletu school for the physically and mentally disabled in Gugulethu.

Photos supplied

BUILDING FACILITIES

UCT first-year construction students have been spending their mid-semester vacations smoothing out the ergonomics for learners at the Tembaletu school for physically and mentally disabled children in Gugulethu.

As part of an annual build organised and run by the Association of Built Environment Students committee (ABES), and senior lecturers Karen le Jeune and Mark Massyn, the students built a wheelchair obstacle ramp (based on a concept by UWC occupational therapy students), revamped bathrooms with swanky paint jobs and much-needed repairs, and made two compost bins for the school's vegetable garden.

For the school's inner courtyard, the students designed and erected formwork moulds, as well as mixing their own concrete to form part of the timber bench design. In addition, this group of students also refurbished the Tembaletu school sign.

More paving stones were created, with mosaic designs embedded in the concrete. These paving stones were placed around the water fountain installed by last year's students.

Apart from the physical construction and projects, students report learning skills such as planning, co-ordinating, budgeting (they had to raise most of the funding for building materials themselves) and material calculation, as well as the importance of communication. This, in addition to honing hard building skills such as mixing mortar, laying block work, erecting formwork, mixing and pouring concrete, and numerous other skills required in the construction of the ramp.

CREATING SOLUTIONS

Compiled by **Abigail Calata**

Photo supplied

Over the past four years, renewable energy has proven its ability to contribute positively to the South African economy by helping to avoid load shedding on 15 days, according to the CSIR.

ENERGY

Since 2008, South Africa's energy sector has been battling an energy crisis, with the state-owned power utility Eskom struggling to match supply and demand. UCT engineers are hard at work finding solutions to the myriad problems that plague the sector and threaten the livelihood of all South Africans.

UCT's Department of Mechanical Engineering is home to two of the specialisation centres linked to the Eskom Power Plant Engineering Institute (EPPEI).

Established in 2012, EPPEI sees Eskom, the state-owned power utility, partner with six leading South African universities to align their research with its needs. At UCT's specialisation centres, students embark on postgraduate studies guided by an industrial mentor and academic supervisor.

In the initial phase, only Eskom engineers with a bachelor's degree and two to four years' experience at the power utility are qualified to enter the programme. Presently, under certain conditions, Eskom bursars can join the programme on completion of their graduate studies. Initially, prospective students also had to complete courses at the Eskom Academy of Learning in the year before they registered at university; at present some are exempted from such courses.

ENERGY EFFICIENCY

The Eskom Specialisation Centre in Energy Efficiency aims to improve the availability, reliability and environmental impact of Eskom power plants by increasing the efficiency of energy production. "Students' research is focused on modelling the fluid flow processes that happen at power stations," says Dr Wim Fuls, who heads up this centre.

"Load shedding happens when plants break down and are not available to generate electricity due to age, poor maintenance and poor flow control, among other reasons. We're trying to solve this unavailability problem by modelling the plant process flow," he explained

The Specialisation Centre in Material Science resides at UCT's Centre for Materials Engineering (CME) and is concerned with the engineering materials (mainly steels) used for components at power plants.

"Power generating plants operate under highly demanding conditions that include high temperature, high stress, a corrosive environment and a complex mechanical wear environment. At its most basic, power plant reliability is critically dependent on the integrity of a broad range of engineering materials that make up the structures, machines and systems within the plant," says CME director Prof Rob Knutsen.

"Advances in technology have allowed engineers to operate plants beyond their design life, but there is still considerable opportunity to improve equipment life prediction and monitoring, so as to optimise life extension and maintenance decisions.

"New materials development is required to handle increasingly challenging conditions, and the South African power industry must be developed to manage the use of new materials during design, construction, operation and plant maintenance," says Knutsen.

More than 15 students are currently working on research at the energy efficiency centre, with eight engaging in research at the CME. The target for all eight EPPEI Specialisation Centres is for an annual intake of 60 engineers.

It is envisaged that this skills development programme will be extended to benefit not only other players in the South African energy industry, but the rest of Africa since Eskom accounts for 40% of the power generated on the continent.

> "Power generating plants operate under highly demanding conditions that include high temperature, high stress, a corrosive environment and a complex mechanical wear environment."

A CATALYST FOR MORE POWER

UCT's Department of Chemical Engineering hosts one of the Hydrogen South Africa (HySA) centres of competence – HySA Catalysis.

Led by Sharon Blair, HySA Catalysis – in partnership with Mintek, the South African national mineral research organisation – develops materials and components in the early part of the fuel cell and hydrogen generation value chain.

A fuel cell is an energy converter that uses the chemical energy stored in hydrogen or another fuel to produce electricity cleanly and efficiently. Fuel cells are being used for several applications, ranging from automotive power trains to stationary off-grid, back-up power generators for telecom towers, hospitals, rural schools and mobile clinics. A key component of fuel cells is platinum.

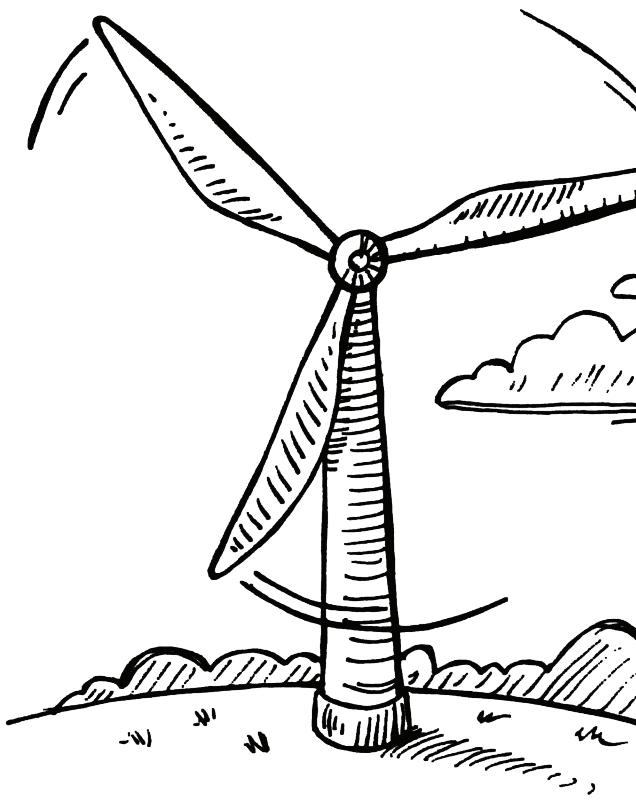
South Africa supplies some 80% of global platinum demand, and the HySA programme, established in 2008, aims to move the country from being a mere supplier of raw platinum to a manufacturer of value-added components.

"HySA's main goals are to develop local expertise, knowledge, human capital and skills within fuel-cell and hydrogen platinum group metals (PGM) catalyst technologies; and through that capture 25% of the world's fuel-cell catalyst market by 2020," explains Blair.

"We also want to be recognised internationally as a fuel cell and hydrogen research institute. More importantly, we want to develop a pool of South African engineers and scientists for the fuel cell industry," she says.

Since 2010, HySA Catalysis has developed competitive technologies for current fuel-cell markets, namely a platinum-coated fuel-cell catalyst.

To commercialise its technologies, HySA Catalysis established HyPlat (Pty) Ltd – a company 100% owned by UCT – in 2014. HyPlat will initially seek to establish itself as a supplier of quality catalysts to component developers and manufacturers, with a product range that either matches or exceeds the performance of any other catalyst on the market.



The future for the international fuel-cell market looks bright. There is a growing demand for fuel cells in the global telecoms and automotive industries. Anglo American 2013 forecasts for PGM volume requirements for fuel cells are as high as 595 tons by 2050. This represents massive opportunities in mining, manufacturing and employment for South Africa.

RENEWABLE ENERGY

A focal research area for UCT's Energy Research Centre (ERC) is renewable energy ,and in this vein the centre is investigating how renewable energy resources could be exploited in hybrid gas turbines.

"There is enormous potential for exploiting renewable energy resources to drive gas turbine power plants in the country, with solar energy being the most promising," says Dr Amos Madhlopa, ERC's group leader in renewable energy.

ERC findings show that solar-driven turbines have the greatest potential to generate electricity efficiently. Eskom's emergency turbines run mainly on diesel, with the bill to keep them going coming to R2 billion a month.

A basic gas turbine comprises a compressor, combustion chamber, turbine and generator. Air enters the compressor, and is compressed to higher pressure and temperature levels at the exit of the compressor. Fuel is mixed with the compressed air and then burnt in the combustion chamber. The expanding gas mixture drives the turbine, which in turn propels the generator. The exhaust energy from a simple gas turbine can be recovered and input to a steam turbine thereby forming a combined-cycle gas turbine. Combining a simple gas and a steam turbine increases the energy efficiency of the system.

"The intermittent nature of renewable energy resources such as wind and solar radiation is one reason for investors to prioritise investment in conventional energy sources such as coal and diesel. However, the hybridisation of two or more energy sources could assist in overcoming this problem of resource intermittency," says Madhlopa.

ECONOMICALLY VIABLE

Over the past four years, renewable energy has proven its ability to contribute positively to the South African economy in the short term.

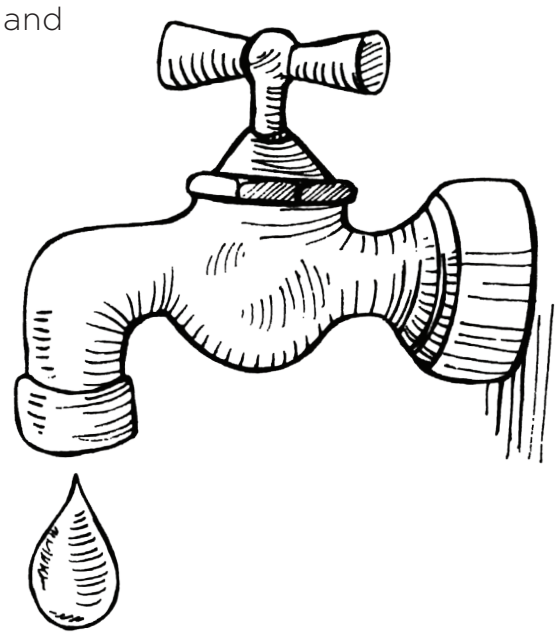
The Council for Scientific and Industrial Research (CSIR) found that in 2014, renewable energy resources contributed R800 million net benefit to the economy. In the same year wind and solar photovoltaic (PV) cells, which convert solar energy to electricity, helped to avoid load shedding on 15 days. Furthermore, between November 2011 and August 2014 tariffs for solar PV cells dropped from R3.44 to 82c per kWh, and from R1.42 to 65c per kWh in the case of wind.

"While the ERC consistently pursues research into longer-term outlooks, possibilities and constraints, it remains mindful of the urgency for supplying energy security. Renewable energy is clearly proving its ability to contribute positively in this area."

ERC is a multi-disciplinary centre widely recognised for the positive contribution it makes to a deeper understanding of issues of energy and development in South Africa, sub-Saharan Africa, the Global South and across the world.

WATER

Not only do South Africans face the prospect of water shortages, but with ageing and insufficient water infrastructure, the spectre of substandard water quality is also a very real prospect. UCT engineers are at the forefront of research and programmes to address this looming crisis.



Last year a Water Research Commission study found that at least a third of water in distribution systems is being lost through leaking pipes. The government must spend roughly more than 100 times its current budget allocation for water management (R300 billion) over the next four years to avoid a full-scale water crisis.

Water rationing, akin to the load shedding imposed by Eskom, has recently been implemented in some regions in KwaZulu-Natal, due to the critically low levels of the Hazelmere dam.

UCT's Department of Civil Engineering's Prof Kobus van Zyl believes that switching off the water supply is the worst thing that can be done to a water distribution system.

Van Zyl heads up a research group on water distribution systems that aims to understand the mechanisms of leakage in water distribution systems. Other areas of interest for the group include the operation and maintenance of water distribution systems, water demand management and smart water metering.

"As soon as there is no pressure in the pipes, polluted water from outside the pipes enters through the leaks," explains Van Zyl, referring to the 'water shedding' in KwaZulu-Natal.

"Thus the first thing to go is the ability of the distribution system to provide safe drinking water to the community. Furthermore, intermittent supply increases the rate at which the pipes deteriorate and has been shown to increase the failure rate of pipes by 300%."

Van Zyl also points to the socio-economic ramifications of an intermittent water supply. "Air and grit pass through water meters and consumers are then billed quite literally for air. Water meters are also damaged by the materials (soil and stones) passing through them. It becomes easier to make illegal connections when there is no pressure in the pipes. Unscrupulous opportunists get water from the part of the region where there is water, and sell it to the residents who don't have water at exorbitant prices."

RESOURCE RECOVERY

Acid mine water is another threat to South Africa's precious water supply. Engineering & the Built Environment Dean Professor Alison Lewis's research team offers the process of eutectic freeze crystallisation as a solution to this problem. The process separates acid mine water into potable water and salts, some of which have commercial value in the mining industry. "We need to move to thinking about resources and not toxins, and resource recovery not waste," she says.

URBAN DESIGN

The Urban Water Management (UWM) group is an accredited research unit currently investigating ways to place water at the centre of cities' design processes. It combines the expertise of six departments across three UCT faculties, and aims to seek integrated and sustainable approaches to water management in an urban setting.

> "The Urban Water Management group is an accredited research unit currently investigating ways to place water at the centre of cities' design processes."

The UWM furthers its goals through involvement in projects like the Liesbeek River Plan. According to Dr Kirsty Carden, the UWM research officer, the plan looks to provide new knowledge and designs for the Liesbeek River to not only improve its ecological condition, but also boost its social and amenity value.

"A main outcome of the plan is the development and inclusion of citizens 'contributions to the river rehabilitation process," says Carden of the project, which is a collaboration with Friends of the Liesbeek.

Research around the plan is centred on urban river restoration, integrated urban water management and new theories on governance. "The conceptual phase of the project is complete and the next phase involves drafting plans and designs for planned modifications and processes," she says.

The Liesbeek River plan looks to provide new knowledge and designs for the Liesbeek River to improve its ecological conditions and boost its value as a social space for people who live and work close to its banks.

Photo by Michael Hammond

INGENUITY IN THE MAKING

The Faculty of Engineering & the Built Environment is home to some clever machines and some canny experimental robots, produced by lecturers and postgraduate students. Here is a sample of the faculty's workhorses and prototypes.

Compiled by **Helen Swingler**

CHEETAH TAIL INSPIRES ROBOT CAR

Electrical engineering's Dr Amir Patel (in picture) built two small robot cars feautring actuated tails for his PhD, Dima I and Dima II (a name derived from a Sotho word meaning "flash of lightning).

This technology was inspired by the mechanics of a cheetah's tail, with the goal being to provide a deeper understanding of these specialised predators.

"The robot is inspired by the cheetah, which actively controls its tail during high-speed manoeuvres," says Patel. "Similarly, the tail (of Dima I) allows the robot to stabilise itself during rapid turns – much like the cheetah does when chasing prey."

"These [robot cars] were deliberately designed to be able to achieve high speeds with a high centre of mass, a combination that works best, (and usually only) when driving in straight lines.

"Turning at any speed you might charitably call 'exciting' leads to an immediate toppling over. But the addition of an actuated tail that can swing in the roll axis of the robot effectively keeps it stable," said Patel. "The robots can make stable turns at twice the speed."

The actuated tail was upgraded in the second version of the robot (Dima II) to enable stabilisation of turning, as well as rapid linear acceleration – much like the cheetah.

This technology has promising applications in wheeled robotics – particularly for search-and-rescue mission where time is critical, says Patel. Additionally, future legged robots will benefit from a tail when manoeuvring at high-speeds in unstructured environments.

Amir Patel developed this robot car by observing the way in which a cheetah uses its tail for stability and maneouvrability.

Photo by Michael Hammond

MEASURING HIGH-FREQUENCY ELECTRICAL NETWORKS

The Radar and Remote Sensing Group (RRSG) in electrical engineering hosts a new Agilent network analyser (the full name is Agilent N5247A PNA-X 10 MHz to 67 GHz).

This instrument is used to measure high-frequency electrical networks in radar systems, radio astronomy receivers and communications applications and is typically used to characterise the electrical performance of components and parts of these systems.

The network analyser operates over microwave and millimetre-wave frequencies with an impressively wide bandwidth up to 67 GHz. The instrument is hosted in the upgraded Microwave Laboratory and is used for educational and research purposes by the RRSG's senior undergraduates, postgraduates and staff.

Discussing a QEMSCAN prepared sample are (from left) Mpho Ramanugu (NRF intern), Dr Megan Becker, Gaynor Yorath and Lorraine Nkemba.

Photo by Je'nine May

UNLOCKING MINERALS

One can't imagine the modern world without metals – no computers, no cars, no smartphones.

These metals have to be extracted from minerals. These minerals have to be extracted from ores. These ores have to be mined. But globally, the easy- to-process ores are running out. New ore bodies are more remote, deeper, harder, lower grade, finer grained and more mineralogically complex.

Extracting valuable minerals from ores with grades as low as 3g/ton is a challenge. "Tools such as QEMSCAN are key to unlocking the value of these ores," said QEMSCAN facility manager Dr Megan Becker of the Centre for Minerals Research.

Custom-designed for the mining industry, the QEMSCAN (Quantitative Evaluation of Minerals by Scanning Electron Microscopy) is a state-of-the-art automated mineral analyser. It offers fast, reproducible and statistically reliable quantitative analysis of minerals and certain man-made materials.

"QEMSCAN tells us which minerals host the valuable metals, how fine we need to grind to liberate the valuable minerals, what do the milled particles look like – critical information needed to develop a sustainable and energy efficient beneficiation strategy," adds Becker.

The CMR QEMSCAN, housed in the New Engineering Building, is predominantly used for mining- and mineral processing-related research. However, any study needing detailed quantitative mineralogical and textural information of particulates can use QEMSCAN. Possible applications included metal recycling, air pollution and dust monitoring, environmental geochemistry, viticulture and even forensic studies. The QEMSCAN was financially supported by the Department of Science and Technology in partnership with the National Research Foundation, South Africa.

METAL TEST

The Gleeble 3800 thermomechanical process simulator is a workhorse in the Centre for Materials Engineering, allowing researchers to perform high-temperature deformation simulations of metals like aluminium and stainless steel at high strain rates.

This gives researchers the opportunity to simulate the processing parameters experienced during industrial manufacturing and production, says the centre's Dr Sarah George. Another interesting area where the Gleeble 3800 has been used is research into aluminium rolled sheet production.

"With South Africa's move to the local production of an all-aluminium beverage can, where previously the top, or can-end, was an aluminium alloy and the can-body was made from tin-plate steel, there has been a dramatic increase in industry related research in the field of aluminium alloys, focusing on alloy choice and processing parameters."

George adds that currently their most relevant research is into creep damage of piping materials used by Eskom power plants, where the material is susceptible to damage owing to the high temperature environments.

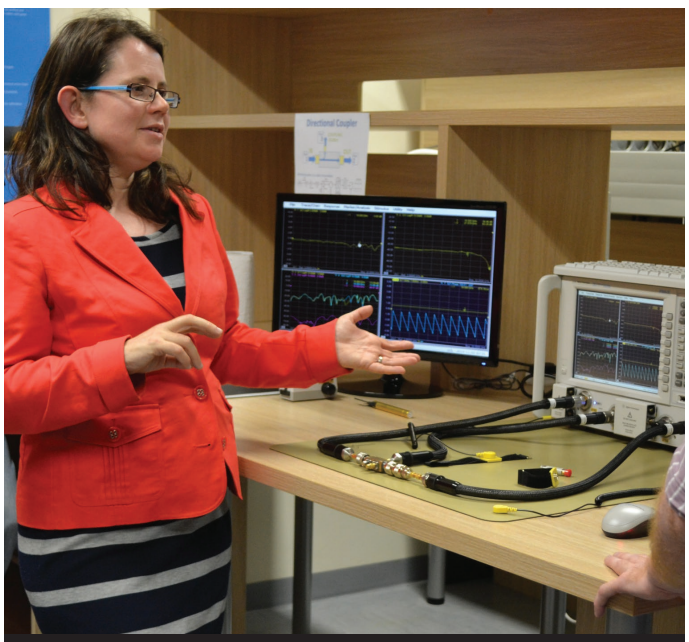


Photo supplied

Assoc Prof Riana Geschke with the new Agilent network analyser

Dr Sarah George with the Gleeble 3800

Photos by Je'nine May

"This research looks at simulating the welding cycles that are used when parts of creep-damaged pipes need to be replaced in-situ during maintenance on the plants, and how this affects the remaining predicted service life of that part."

Although the Gleeble 3800 has been part of the furniture in the centre for four years, George says the team is still finding new and exciting ways to use it in metal-related projects.

Staying with the theme of producing rolled products, the centre also has a direct powder-rolling facility, which allows for the conversion of titanium powders into sheet metal.

"The optimisation of this process at our centre will contribute substantially to the innovative titanium oxide to metal powder process which has been developed at the CSIR, through support provided from the Department of Science and Technology."

SEARCH AND RESCUE ROBOTS

The Robotics and Agents Research Laboratory harnesses postgraduate students from electrical and mechanical engineering to design research platforms and robots. Some of this work is driven by demand from industry, such as the mining and security industries, for reconnaissance and rescue; robots are deployed in unstable buildings and sites to search for human survivors of natural disaster or acts of terrorism.

1. **The six-legged walker robot** looks and walks much like a spider and acts as a research platform and is used mainly to demonstrate mechanical structures.

The walker can travel up a wall of cliff, inch by inch, by finding the smallest flat spaces and using these as 'footholds' to pull itself up, one leg at a time. Every leg has three independent motors, one for each joint – a total of 18 motors, all working independently.

The idea is to enhance its capabilities via an artificial intelligence team the team collaborates with to programme the walker for path-planning and learning. This means it will be able to store information, learn from its mistakes, and come up with new strategies to suit conditions.

2. **The Ratel** is a large urban search and rescue robot. It features tank tracks for stability and maneouvrability and flippers that guide rotation. It can climb stairs, its arms have multiple degrees of freedom, and it can grip and release objects. The sensor payload head is designed to operate cameras, thermal cameras, carbon dioxide sensors, speakers, and a two-way radio.

"So, if it finds someone trapped in a building, it can determine whether they're alive, provide assistance, and remain at the location to provide two-way feedback until the rescue or recovery has been completed," says lecturer Tracy Booysen.

3. **The Scarab** is a 'pro-ball' robot with a camera, microphone and lights designed to be cheap and replaceable and to operate in structurally compromised situations to ascertain if there are survivors (before rescuers are deployed). It's also useful for police and security forces and private security companies for reconnoitering the scenes of suspected criminal or enemy activity to ascertain the risks. "You can just throw it over a wall, for example, and it drives around gathering information," Booysen says.

It is designed to be worn by the rescue operator in the field. This allows for in-field charging and easy deployment. Because the batteries that allow for this quick charging can be quite volatile if not properly protected - a dummy is used for all testing for safety.

"If the Ratel finds someone trapped in a building, it can determine whether they're alive, provide assistance, and remain at the location to provide two-way feedback until the rescue or recovery has been completed."

From left are students Max Finbow, James Hepworth, Timothy Hope and lecturer Tracy Booysen with 1. The six-legged walking robot 2. The Ratel 3. The Scarab with dummy.

Photo by Je'nine May

A CASE STUDY:

HOW TO TURN THE NUMBERS AROUND

Professor Jenni Case has been working in academic development in the Department of Chemical Engineering since 1996. She reflects on how the department has gone about improving graduation rates, with positive spin-offs for transformation.

Graduation is always a highlight of the academic year. Electrical engineering master's student Ifedayo Akinsolu celebrates her graduation at the ceremony held in June 2015.

Photo by Je'nine Hammond

Of the approximately 3 000 students estimated to have signed up for an engineering degree in South Africa in 2015, fewer than half will graduate after five years, according to the Department of Higher Education and Training.

South Africa isn't alone in struggling with this. In the US only about 50% of engineering students complete their degrees, according to research published in the *Journal of Engineering Education*. In Australia the figure isn't much higher.

One of the earliest attempts to turn this situation around was started in the chemical engineering department at UCT in the mid-1980s. At the time, the department's classes were largely white and male, and the graduation rates were low. A few black students were enrolled, but their success rates were poorer than those of their white peers.

A QUARTER CENTURY OF CHANGE

Nearly 30 years later, UCT engineering undergraduate enrolment rates have risen and white students make up less than 40% of the South African students in the programme. By 2011, the programme posted an overall graduation rate of nearly 70%, with dramatically improved rates for black students.

A group of higher education researchers and I recently worked with data to build a case study of how change can happen in a university department. One of our key questions was: 'What makes educational change possible?'

We wanted to take a long-term view, because so much of our present discourse on social shortcomings – particularly in education – fails to do so.

Jenni Case

EXPLORING THE MAINSTREAM

During the 1980s, driven by the needs of an increasingly diverse student body, South African universities began to develop a new way of thinking about academic development.

The experience of UCT's chemical engineering department over 25 years is an interesting example of what can be termed 'academic development in the mainstream'. This is exciting because it opens the door to universities exploring different routes to greater inclusivity, and explores a space that traditional foundation programmes have not occupied before.

Here is how it was done.

First, an independent advisory board was established for the chemical engineering department. Its members were recruited from key positions in South African industries – a sign that the department was building closer links with business and was receptive to its views.

From its side, industry did not buy any arguments that low success rates were inescapable in engineering. The board also rejected the idea of a separate academic programme for black students, and urged the engineering department to prioritise the social integration of its student body. It was convinced that an energetic department with a strong academic base should be able to build an undergraduate programme that could help students from a broad range of social backgrounds to succeed.

A few years later, a large industry donation led to the creation of an academic post in the department to focus on academic development. I have held this post since 1996.

The department also made changes to its curriculum and introduced new approaches to teaching. They established a first-year engineering course, improved industry exposure at the junior levels, and developed better systems for advising undergraduate students.

LESSONS FROM THE JOURNEY

These are three key lessons from the chemical engineering department's metamorphosis.

First, rather than making pejorative statements about its students, the department took a positive approach and emphasised success, even when pass rates in courses might have suggested otherwise. I found this quite striking, when examining 25 years of departmental deliberations.

Second, the department did not shy away from critical feedback. It did ongoing research and then shared the findings, even when the results reflected poorly on it. For example, a key study showed how good intentions in building a new design course were not being carried through to the level of assessment and feedback.

Third, industry's demands were a significant spur to change.

On some scores, these changes could be considered modest, because they were driven in collaboration with industry, and by a department needing particular outcomes. However, given the persistent challenges in the South African university landscape, the experience of UCT's chemical engineering department deserves attention.

*This is an abridged version of an article originally published in *The Conversation* in May 2015, drawn from the journal article: Case, JM, Heydenrych, H, Kotta, L, Marshall, D, McKenna, S, & Williams, K (in press). 'From contradictions to complementarities: a social realist analysis of the evolution of academic development within a department.' *Studies in Higher Education*.

70%

– the academic development programme's overall graduation rate in 2011