MACQUARIE University

FACULTY OF SCIENCE AND ENGINEERING

From the Dean

Dear Colleague

Welcome to a new year, which promises to be full of achievements, and some challenges, both global and local. The old year ended on a confronting note, with natural disasters putting some of our smaller struggles into perspective.

But the start of a new year is a good time to reflect on the year just ended, and we have much to be proud of. In 2019 we gained a new ARC of Excellence situated on campus, with Ian Paulsen and his team at the Centre of Excellence in Synthetic Biology set to make major advances in a transformative field of study.

In addition, Professor Ian Wright is a Chief Investigator for the new ARC Centre of Excellence for Plant Success in Nature and Agriculture, based at the University of Queensland. There is a large Macquarie contingent involved, with Professor Michelle Leishman, Brian Atwell, Rachael Gallagher, and Hendrik Poorter all Associate Investigators.

We are set to see a new department, with Phil Taylor, now a Distinguished Professor, building capacity for the Department of Applied Biosciences throughout 2019. Close by the new building for this department, we saw the Macquarie Observatory re-open after some very welcome renovations that will make observing sessions far less trying than they have been in the past.

We also saw FSE involvement in huge discoveries – Richard de Grijs in mapping the shape of the Milky Way, Daniel Zucker in the discovery of the fastest hypervelocity star ever recorded, and Kira Westaway in establishing when Homo Erectus went extinct. But these are just a few high-profile examples of the impressive amount of excellent science the faculty has done and continues to do.

In 2019 we were delighted to see Science and Engineering faculty members win well-deserved awards, with the National Indigenous Science Education Program and the Blue Carbon Horizons team both honoured in the 2019 Eureka Prizes. Our younger researchers were also recognised, with Simon Clulow, Noushin Nasiri, and Chris Reid all winning NSW Young Tall Poppy Awards.

The shocking natural events at the end of 2019 also saw Macquarie scientists active in science outreach and public commentary. A great deal of praise must go to Heather Handley and Mark Taylor, both of whom provided frequent and accessible comment on their fields of expertise despite being out of the country and in inconvenient time zones when the White Island volcano erupted and air quality caused by bushfire smoke became a matter of grave public concern.

As we enter 2020, we have concerns of our own, which can't be ignored. It is no secret that budgets will be tight and that we will be expected to do more with less. At present we must wait to see what decisions are made, but you can be assured that I am advocating strongly on your behalf, and that I will keep you informed as comprehensively and as speedily as I can.

In other news

Two FSE research groups have been awarded ARC Linkage Grants.

Dr Emilie-Jane Ens from the Department of Earth and Environmental Sciences will lead a project with other Macquarie investigators Professor Damian Gore, Professor Neil Saintilan, Professor Andrew Skidmore and Dr Tim Ralph and PhD student Daniel Sloane in partnership with the Laynhapuy Indigenous Protected Area Manager Dave Preece and Cultural Advisor Yumutjin Wunungmurra to explore innovative ways to protect and manage coastal floodplains of northern Australia from feral animals and rising sea levels.

The research team was awarded $507,000 for the cross-cultural multidisciplinary project working with local Yolngu Traditional Owners and Aboriginal Yirralka Rangers to investigate the impact of feral animal control on managing the degradation of tropical coastal floodplains and the complex interaction between feral animals and sea level rise.

Dr Xi Zheng from the Department of Computing received $341,853 to partner with UTS and SilverQuest, to develop an innovative safety-preserving ecosystem for

autonomous driving, to detect and prevent malicious attacks on autonomous vehicles.

Five researchers from Macquarie University have been accepted into the Australian Research Council (ARC) College of Experts, ensuring Macquarie University will have a continuing role in shaping research excellence and innovation in Australia.

Acceptance into the College means that these researchers will have a role in assessing grant applications, make funding recommendations, and provide strategic advice to the ARC in order to achieve a thorough and fair research funding process in Australia. Members are experts of international standing drawn from the Australian research community: from higher education, industry and public sector research organisations.

The new members join five other Macquarie academics already in the College.

“The acceptance of these five researchers into the College of Experts demonstrates the high calibre of academics at Macquarie University,” says Professor Sakkie Pretorius, Deputy Vice-Chancellor (Research).

“These experts will bring a rich and established knowledge of their respective fields to the College, expertise that has been cultured by the longstanding research excellence of Macquarie’s academic community.”

The new members of the ARC College of Experts from Macquarie are:

Professor David Coutts, Associate Dean Research for the Faculty of Science and Engineering and Professor in the Department of Physics and Astronomy

Professor Coutts is an expert in optical and laser physics including laser device development, nonlinear frequency conversion and applications of optics and lasers.

Professor Paul Haynes, from the Department of Molecular Sciences and Director of the ARC Training Centre for Molecular Technologies in the Food Industry

Professor Haynes’ research interests are in quantitative proteomics analysis across a range of biological systems, mainly focusing on plant and environmental proteomics.

Professor Annabelle McIver, from the Department of Computing
Professor McIver uses mathematics to analyse security flaws in computer systems.

Researchers from FSE have been named in the Web of Science's Highly Cited Researchers 2019 list, which recognises the most highly regarded scientists and social scientists when it comes to research influence among their peers.

This year's list identifies researchers – including 23 Nobel laureates – across 60 countries who produced multiple papers ranking in the top one per cent by citations for their field and year of publication.

Six Macquarie University staff are named on this year's list, cementing the University's place among Australia's most respected research institutions.

Professor Colin Prentice, honorary chair of ecology and evolution, is recognised in the Environment and Ecology category. Professor Prentice's work centres on understanding how plants react to changes in climate and other aspects of the physical environment.

Eminent plant ecologist Distinguished Professor Ian Wright is named in the Plant and Animal Science category. Professor Wright was made a Fellow of the Australian Academy of Science earlier this year and well known for using concepts from economics to understand plant evolution and plant ecological strategies.

Professor Hendrik Poorter from the Department of Biological Sciences was highly cited in the Cross Field category.

Deputy Vice-Chancellor (Research) Professor Sakkie Pretorius says the impressive number of Macquarie University researchers appearing on the Highly Cited Researchers list each year is reflective of the University's global impact in the sector.

"Macquarie University continues to produce research that is advancing the frontiers of knowledge worldwide. I congratulate these six researchers for this well-deserved recognition of their world-leading work, which is having world-changing impact," he says.

Other Awards and Grants

Dr Yee Lian Chew was awarded $387,551 to lead a project in the Department of Biological Sciences looking at how neural networks change and influence behaviour. The research aims to uncover new insights on neural circuit plasticity, which will advance discovery in neuroscience and robotics.

The dynamics of slender fibres suspended in viscous fluids has applications to healthcare and fertility, through understanding how sperm or bacteria swim, and in

industry for the creation of cheap lightweight materials. A project by Dr Lyndon Koens from the Department of Mathematics and Statistics will develop models for these complex suspensions with a grant of $312,566.

Dr Wenjie Ruan from the Department of Computing was awarded $418,998 for a project that aims to develop robust and interpretable deep learning models to support home-based health monitoring and care for the elderly.

A grant of $355,325 will support research into how bacteria steal iron from their hosts, a project led by Dr Francesca Short from the Department of Molecular Sciences. The project will develop a new genomics-based technology for defining bacterial gene regulation networks, then apply this to understand the networks controlling a family of iron-stealing molecules called siderophores.

Dr Jia Wu from the Department of Computing received $427,068 to develop an early prediction system to forecast possible outbreaks of malicious messages in social networks, before they have a chance to propagate. The findings have applications in preventing cyberfraud, online rumour-mongering, and financial loss by assisting Australia's government and industry infrastructure in fighting malicious online messages.

Dr Andrew Care from the Department of Molecular Sciences was awarded a Priority-driven Collaborative Cancer Research Grant from Cancer Australia. Dr Care's project is aimed at engineering an innovative natural nanoparticle (called a 'Protein Nanocage') that can selectively target and disrupt copper levels inside neuroblastoma, causing tumour cell death. Neuroblastoma is the most common solid tumour in young children, with a less than 50 per cent survival rate.

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2019 Research Highlights

RESEARCHERS UNITED ON INTERNATIONAL ROAD MAP TO INSECT RECOVERY

Biology's Marie Herberstein and Lizzy Lowe are among a group of more than 70 scientists from 21 countries who have created a road map to insect conservation and recovery, published in Nature Ecology & Evolution early in January Their

strategies cover everything from urgent ‘no-regret’ solutions to long-term global comparisons.

The aim is to start insect recovery as quickly as possible, says project initiator Prof. Jeff Harvey from the Netherlands Institute of Ecology (NIOO-KNAW) and VU Amsterdam. “From all over the world, there is growing evidence that insect species are suffering from multiple human-induced stress factors: habitat loss and fragmentation, pollution, invasive species, climate change and overharvesting.

As scientists, we want to gather all available knowledge and put it to action together with land managers, policy makers and everyone else involved.”

Nowhere is this more important than in Australia. Macquarie University’s Marie Herberstein explains that, “As the Australian bushfire crisis is showing us, we need a coordinated global strategy to implement immediate- to long-term measures for insect recovery.

“In Australia, the bush fires are likely to have resulted in substantial overall losses of insect numbers and possibly losses of entire species.”

The roadmap is based on achieving targets over different timescales. More than 70 experts from all continents joined the effort. Herberstein was among the researchers from Australian universities, along with Macquarie’s Lizzy Lowe.

Insect abundance, diversity and biomass are frequently under pressure. It affects all functional groups: from predators to pollinators. This is not a problem that can be considered in isolation – the effects will be wide-ranging. The authors stress that “insects are vitally important in a wide range of ecosystem services of which some are indispensible for food production and security, as in pest control.”

The steps to be taken are divided into immediate, mid- and long-term actions. First of all, there are a number of actions described as “no-regret solutions”. These can be taken immediately and won’t be affected by any new knowledge we uncover. They will benefit all insects, not just single species.

Second, we must urgently establish priorities about which species, areas and issues most need our attention.

In the medium term, we need to plan new experiments to establish which stress factors cause what effects, and gain knowledge in understudied areas. At the same time we need to dig through existing insect collections, like those held in museums. This can provide an essential base reference to fill in gaps in our diversity data of

the past.

Long term actions could include forming public-private partnerships and sustainable financing initiatives to restore and create places habitat for the insects. Combined with a global monitoring program where people all use the exact same methods and sites, over longer timescales. In that way, we can compare the well-being of insects worldwide, and rule out possibly disruptive inconsistencies.

The extensive group of scientific experts involved in the road map stresses that insect declines are a serious threat, one that society cannot postpone addressing any longer. Harvey says, “Most importantly, we hope that end-users and land managers now can use this road map in for instance farming, habitat management and urban development as a template for true insect recovery.

Essentially, we are thinking strategically, and this is a new approach. Now and down the road, all to reverse insect declines.”

Lowe stresses that taking action is necessary and urgent. “Insects are such important contributors to our ecosystems that we can’t afford to keep ignoring their conservation. We’ve created a road map, including solutions such as reducing pesticide use and pollution, that will help maintain healthy insect populations into the future.”

JAVA WAS THE SITE OF *HOMO ERECTUS’S* LAST STAND

New dating of a river terrace location in Central Java called Ngandong has finally established the true age for an important site in the story of human evolution. This site on the banks of the Solo river, discovered in 1931-33, contained twelve *Homo erectus* skull caps and two lower leg bones. These fossils are the youngest, most advanced form of the human species, and represent an important evolutionary change. Until now the nature of the burial sediments has made precisely dating the evidence difficult.

But 90 years after the remains were discovered, a new suite of analyses, generating 52 new ages for the Ngandong evidence, has confirmed that *Homo erectus* went extinct in the middle of the last interglacial phase, when warmer rain forested environments were widespread. This research has wide implications for the complex story of human evolution in this region, and helps to establish the time in which *Homo erectus* occupied east Java, who they interacted with, and – potentially – why they went extinct.

Watch here

Associate Professor Kira Westaway explains her team's new research which shows that Homo Erectus and at least two other species of early humans were living in Southeast Asia well before modern humans left Africa.

The new findings have been published in *Nature*.

The site, originally excavated by Dutch geologists Oppenoorth and ter Haar in 1931-1933, has long been a source of frustration for scientists attempting to establish a satisfactory age for the remains, despite the significance of the site for understanding human evolution.

Excavations at Ngandong.

Previous attempts to date the site returned very young ages (53-27,0000 years) and much older ages (143-500,000 years). These earlier studies had issues with the true provenance of the material, a lack of association between the fossils and material being dated, and the leaching of uranium from the fossils being dated, all creating uncertainties.

“After many unconvincing attempts to date the site over the years we knew we needed to try a different approach” says joint lead author of the study, Macquarie’s Associate Professor Kira Westaway.

“Previous studies fixated on the evidence itself, so instead we viewed the fossils as a piece of a much larger puzzle, and tried to understand how they fitted into the wider valley and region.”

The joint Indonesian-Australian-American team applied a regional approach to dating the site and interpreted the evidence within the wider landscape of Central Java. The site is in a river deposit that represents a rung on a ladder of floodplain steps called terraces. Their study took into account how the Solo River system was

created (landscape context), how the terraces were formed (terrace context), and how the fossils were deposited (fossil context).

By dating stalagmites in caves, they were able to establish when the mountains to the south rose up and diverted the Solo River into the Kendeng Hills, creating the Solo river terraces. They then, for the first time, dated the entire sequence of river terraces, so the age of the site would be constrained by the terraces above and below Ngandong. Finally they re-excavated the site to discover and date the original bone bed found by the Dutch.

“Finding the original bone bed was crucial for this study. That way there could be no confusion or doubt that the material we dated was directly associated with the original *Homo erectus* discovery” says Yan Rizal from the Institute of Technology, Bandung, joint lead author of the study.

“It was great feeling to finally see that deposit clearly, and know we could finally draw a line under the story of *Homo erectus*”.

The researchers applied a barrage of dating techniques to all three contexts: the stalagmites in the cave, the river terrace sediments around the fossils, and to the associated mammal teeth found within the bone bed. The result was 52 new ages, indicating that the river deposit and fossils were laid down between 117-108,000 years ago.

“This site has been shrouded in uncertainty since it was first excavated” says Westaway. “We used a range of dating techniques from different institutions to establish a robust chronology that, after 90 years, will finally put an end to this inconclusiveness about the age and significance of the 12 *Homo erectus* skull caps”

“We were lucky to have some of the best dating facilities in the world at our disposal, including the equipment that dated the famous ‘Hobbit’ fossils of Southeast Asia, the human teeth from Lida Ajer cave in Sumatra and fossils from the Rising star cave in South Africa” says co-author Renaud Joannes-Boyau from Australia’s Southern Cross University.

The new age range for Ngandong finally places the site into a framework for human evolution in Southeast Asia. The Ngandong *Homo erectus* existed at around the same time as *Homo floresiensis* (Hobbits) in Indonesia and the newly-discovered *Homo luzonensis* in the Philippines, both of which have some *Homo erectus*-like features. At this age, *Homo erectus* could potentially have met other human species such as the enigmatic Denisovans, first discovered in the cold caves of Russia.

“Ngandong *Homo erectus*, *Homo* floresiensis, and *Homo luzonensis* represent three different evolutionary trajectories of Homo in island Southeast Asia, each of them

ending in extinction", says corresponding author Prof Russell Ciochon, from the University of Iowa in Iowa City, USA

"The new age range also raises important questions about the interactions between the Denisovans and the Ngandong *Homo erectus* population".

Side view of Homo Erectus skull.

HYPERVELOCITY STAR IS THE ONE THAT GOT AWAY

In an astronomical world record, scientists have discovered a hypervelocity star that escaped the dark heart of the Milky Way nearly five million years ago and is hurtling through the galaxy at more than 6 million km/h.

Watch here

Stellar finding: Researchers say it serves as an incredible example of the Hills Mechanism, proposed by astronomer Jack Hills 30 years ago. Videographer: Sophie Gidley.

Named S5-HVS1, the star, twice the mass of our own sun, was flung into space by the supermassive black hole at the centre of the Milky Way, about the time the earliest ancestors of humanity were appearing on the Earth.

It is the first strong evidence to support a 30-year-old theory that black holes can kick a star into hyper speed and ultimately out of the Galaxy, explains Macquarie University's Daniel Zucker, a leader of the international research team that identified S5-HVS1.

Very significantly, it also gives astronomers an unprecedented line of sight into what happens in the mysterious, dust-shrouded Galactic heart – including how stars can

possibly form so close to the gravitational pull of a supermassive black hole, in this case one that is 4 million times the mass of our sun.

“The centre of the Galaxy is a maelstrom of objects circling and falling into a massive black hole, Sagittarius A*, and yet there seem to be stars forming there,” says Zucker, an Associate Professor in the Department of Physics and Astronomy.

“It’s a weird, bizarre place, and very hard for us to probe because there is a lot of dust between us and it; we can see things with infrared and radio waves but not necessarily with optical light.

Historic escape: An artist’s impression of S5-HVS1’s ejection by Sagittarius A, the black hole at the centre of the Galaxy. The black hole and the captured binary partner to S5-HVS1 are seen far away in the left corner of the picture, while S5-HVS1 is in the foreground, speeding away from them. Credit: James Josephides (Swinburne Astronomy Productions).

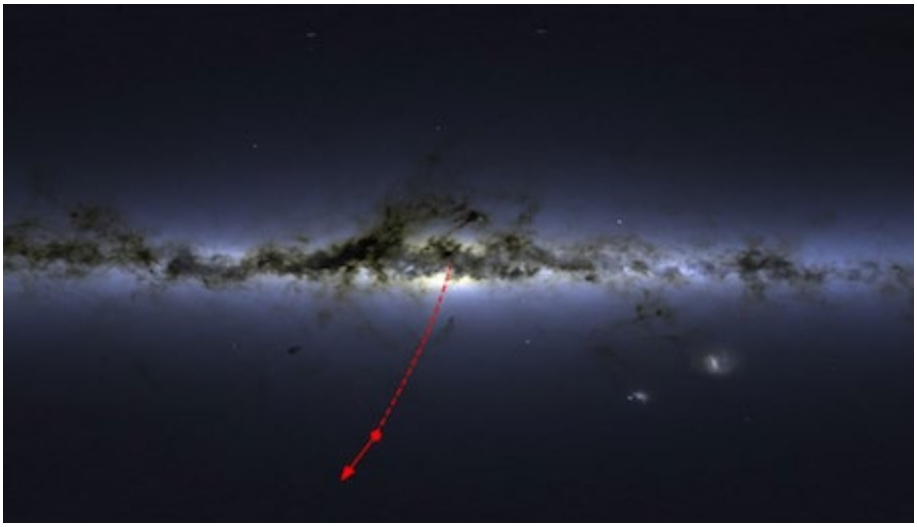
“Now we’ve got a star that seems to have formed within the region and has escaped from it and, at 29,000 light-years from Earth, is now close enough for us to study in relative detail.

“And it seems to be perfectly normal, so that should tell us something about how stars are being formed near the Galactic centre and about the conditions there.”

“Normal” means S5-HSV1 is a main sequence star, like our own and most other stars, that is still fusing hydrogen at its core. At 500 million years old, S5-HSV1 is halfway through its life span. For the 495 million years before its dramatic expulsion from Sagittarius A*, it would have been in a binary system with another star, the two of them orbiting each other in a Galactic dosey doe until coming too close to the black hole.

At that point, the Hills Mechanism proposed by Jack Hills in 1988 kicked in, with the black hole capturing one star of the pair and hurling the other into space at a velocity of 1800 kilometres a second.

“It has to do with the gravitational binding energy,” Zucker says of Hills’ theory. “In a binary system, a very massive object takes the place of the other star in the binary, then the remaining star is flung out. It’s like switching dance partners, but where the initial partner is thrown out at high speed. If the object replacing one of the stars is way, way, way bigger, then it will give an enormous kick to the one that’s escaping, and that is what’s happened in this case.”
The first hypervelocity star was identified in 2005, and fewer than 30 have been observed since.



Hurtling heavenly body: The location of the star on the sky and the direction of its motion. The star is flying away from the Galactic centre, from which it was ejected 5 million years ago. Credit: Sergey Koposov.

The fastest of them all, S5-HVS1 (moving at 1700km/s relative to the Galactic centre), was discovered with the Anglo-Australian Telescope at Siding Spring Observatory near Coonabarabran, in the NSW Central West, as well as with data collected by the European Space Agency’s Gaia space observatory.

To put S5-HVS1’s speed in perspective, our own sun moves in its orbit around the Milky Way at about 220 kilometres a second.

The data that led to its discovery were being amassed as part of the ongoing Southern Stellar Stream Spectroscopic Survey – or S5 – which is observing the streams of stars on the edges of the Milky Way that have been formed by orbiting dwarf galaxies and star clusters torn apart by the Galaxy’s tidal forces.

"As a side project”, Zucker says, “Professor Sergey Koposov of Carnegie Mellon University in Pennsylvania was examining spectra from the S5 survey to look for

stars with high radial velocities. He was very surprised to find that one star - which he dubbed S5-HVS1 - was moving away from us at a speed of over 1000 km/s!"

Other members of the S5 leadership team include Kyler Kuehn, from Macquarie-based Australian Astronomical Optics and Lowell Observatory, Ting Li from Carnegie Observatories and Princeton University, and Geraint Lewis from the University of Sydney.

"It goes to show, when you go out to do a survey of the sky, in addition to the science that comes from what you're planning to do, you can also have serendipitous discoveries of interesting things that just pop out of the data," Zucker says.

He says it's highly unlikely the hurtling star will collide with another heavenly body, considering the galaxy is mostly empty space. Ultimately, it will shoot out of the Milky Way and into deep space – a very long time from now, given it will take about 180 years to travel one light year.

"And who knows what will happen with it then."

Collaboration and Innovation

The Faculty of Engineering is now hosting the first occupant of its Engine Room, a start-up engineering space that uses Macquarie University's Incubator distributed model approach. A new partnership with FLEDGE Innovation Labs will provide opportunities for Macquarie students to access medical technology industry expertise while developing impactful and community-minded medical products.

FLEDGE provides project-based learning experiences where aspiring MedTech entrepreneurs can develop real products under the leadership and guidance of FLEDGE mentors, supported by an extensive network of experienced med-tech advisors.

"Macquarie University is extremely proud to welcome FLEDGE as its partner and we look forward to leveraging the many opportunities that this partnership will provide for the benefit of the community and our students," said Professor David Wilkinson, Deputy Vice-Chancellor (Engagement).

Forty-five students
(25 from Macquarie) have already been instrumental in developing some of FLEDGE's innovative social impact projects, including:

- VitaMon™: real-time monitoring of vital signs for hospital inpatients. It is being developed to monitor ECG, respiration, SpO2, temperature, cuff-less blood-pressure, location and kinematics in real-time. Coupled with an AI expert system, VitaMon™ will alert carers if a patient's vital signs deteriorate, enabling early intervention.
- VR-4-CP: Non-contact Virtual Reality interfaces and immersive content for people living with cerebral palsy, acquired brain injury, spinal cord injury, stroke and neuro-muscular disorders. This project involved collaboration with a Macquarie Arts undergraduate living with Cerebral Palsy and a Macquarie Computer Science PhD student.
- RESPI (Respiration Enhancement & Support for Preterm Infants): Reducing the mortality rate of preterm infants in resource-limited countries. Two Macquarie students completed their PACE Work Integrated Learning internships on this project.

Arrivals and Advertisements

The Department of Earth and Environmental Sciences welcomes Ms Isra Ezad as a Postdoctoral Research Fellow, and Dr Vera Horigue as an MQ and WIOMSA Postdoctoral Fellow

Dr Ramil Nigmatullin has joined the Department of Physics and Astronomy as a Postdoctoral Research Fellow in Noise Resilient Quantum Simulations

The Department of Mathematics and Statistics welcomes Dr Christian Thomas as a Senior Lecturer in Applied Mathematics.

All the above appointments date from 2 January 2020

Mr Zhigang Lu as joined the Department of Computing as a Post-doctoral Research Fellow on 6 January 2020.

The School of Engineering welcomes Dr Sara Dellami as a Senior Lecturer in Electrical Engineering, from 13 January 2020

Dr Zhu Sun took up a position in the Department of Computing as Lecturer in Computing on 20 January 2020

I trust you will join me in welcoming our new colleagues.

A number of positions are currently advertised. They are:

- Lecturer in Engineering Management - Academic, continuing position
- Test Software Engineer, Professional, fixed term position
- Postdoc for Future Fellowship "Robust Quantum Control in the Noisy Intermediate-Scale Quantum Era" - Academic, fixed term
- Research Associate - TerraneChron® Data and Geochemical Development Scientist - Academic, fixed term
- Associate Professor in Software Engineering - Academic, fixed term

Events

Educating for Success Conference 2020

Learning and Teaching is kicking off 2020 with an interactive and participative conference-style event called Educating for Success: 2020, held on Thursday 6 February.

Key themes that will be discussed:

1. Learner Engagement
2. Feedback and Assessment for Success
3. Technology Enhanced Learning

Professor Kira Westway will be a speaker at the conference, discussing Technology Enhanced Learning.

Refreshments and a light lunch will be provided.

Please join us by registering by the 31 January here.

Connect with us

If you have comments, questions or research news you think might be of interest to the rest of Faculty, I'd love to hear from you. Drop me a line at fse.execdean@mq.edu.au.

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Website: science.mq.edu.au
Faculty on Twitter: @MQSciEng

Bernard on Twitter: @mans_bernard

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