PUSHING FRONTIERS

A LEADING LIGHT IN LIFELONG LEARNING
CONNECTING THE SCIENCE OF LEARNING WITH THE ART OF TEACHING

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A LEADING LIGHT IN LIFELONG LEARNING

CONNECTING THE SCIENCE OF LEARNING WITH THE ART OF TEACHING

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LEARNING NEVER STOPS

In today’s Singapore, about four working-age adults support one person aged 65 years or older. By 2030, it is predicted that there will be just two people working for each retiree.

As one of the most rapidly ageing countries in the world, Singapore is facing enormous challenges to its economy and society as a whole. At NTU, we are taking this challenge head on, by re-skilling older workers to help them extend their productive years.

Not surprisingly, training 60-year-olds is different from training 20-year-olds. For this reason, NTU researchers are studying how learning changes as we age. This new discipline of neuroeducation, which draws from neuroscience, psychology and education, harmonises findings in brain research with pedagogical methods such as self-directed learning, also known as fascination-based learning.

This edition of Pushing Frontiers highlights NTU’s advances in cognostics, an interdisciplinary field that aims to understand how the brain masters complex tasks such as learning. In particular, researchers at NTU’s Centre for Research and Development in Learning are using neuroscientific tools in connection with behavioural studies to inform learning pedagogies.

These studies are done in collaboration with education specialists at NTU’s National Institute of Education, Singapore’s renowned teacher-training institution. By employing contemporary developments in technology-enhanced learning, researchers there are turning decades of experience in pre-tertiary education into insights that can be applied to tertiary education at NTU and beyond.

We also look at NTU’s latest academic extension, the College of Professional and Continuing Education, which—in collaboration with Singapore’s SkillsFuture programme—delivers courses to help Singapore’s working adults stay relevant in a fast-paced economy.

With our diverse portfolio of research on education and learning, and motivated by the mantra that learning never stops, NTU aims to rise to the challenge of providing education and lifelong training to young and old alike.

Prof Lam Khin Yong
Acting Provost, Chief of Staff and Vice President (Research)
Nanyang Technological University
Singapore
All for a Better Life

NTU researchers have received competitive grants to prolong lifespan and improve the wellbeing of the sick.

The Skin Research Institute of Singapore (SRIS)—a partnership between NTU, the Agency for Science, Technology and Research (A*STAR) and the National Healthcare Group (NHG)—has operated as a virtual entity since 2013.

Led through the NTU Institute for Health Technologies, by Prof Russell Gruen of NTU’s Lee Kong Chian School of Medicine and Prof Teoh Swee Hin of the School of Chemical and Biomedical Engineering—and in collaboration with Prof Birgit Lane from A*STAR’s Institute of Medical Biology and NTU Adjunct Prof Steven Thng from NHG’s National Skin Centre—the initiative has received S$24.7 million (US$18.2 million) in funding over two years to build and operate a clinically integrated research environment for skin research at NTU’s medical campus. Known as SRIS Phase 2@Novena, it involves researchers from several schools at NTU who will contribute to the development of tools, devices, therapies and clinical management strategies in skin care.

Having identified new drug targets in drug-resistant tuberculosis, a research team led by Prof Gerhard Grüber from the School of Biological Sciences, together with his NTU colleagues, Assoc Profs Kevin Pethe and Roderick Bates, and scientists from A*STAR and the National University of Singapore, has received up to S$5 million (US$3.7 million) in funding from Singapore’s National Research Foundation. The grant will allow the research team to evaluate enzyme inhibitors targeting the vital respiration machinery in dormant mycobacteria, as well as study the inhibitors’ synergistic effects in combination with other antibacterials, in a tailored drug discovery chain that includes preclinical testing.

Assoc Prof Kevin Pethe has received substantial funding from Singapore’s governmental agencies to develop new antibiotics for the notorious pathogen, methicillin-resistant Staphylococcus aureus (MRSA)—the leading cause of hospital-acquired bacterial infections. The research is based on his discovery that MRSA bacteria are unable to synthesise the essential vitamin thiamine, commonly known as Vitamin B1.

Analysing our environment for toxic compounds will soon be less expensive, thanks to a new ultra-sensitive point-of-use infrared laser spectroscopy analyser invented by Prof Wang Qijie and his colleagues from NTU’s Schools of Electrical and Electronic Engineering, Physical and Mathematical Sciences, and Materials Science and Engineering. Supported by a grant of about S$7 million (US$5.1 million) from Singapore’s National Research Foundation, the analyser permits real-time environmental monitoring and detection, and can also be used for quality control in the pharmaceutical industry and in medical diagnostic devices.

Aiming to enhance the quality of the final days of terminally ill patients and the emotional wellbeing of their families, Asst Prof Andy Ho from NTU’s School of Social Sciences has received more than S$500,000 (US$370,000) from Singapore’s Ministry of Education to develop a novel Family Dignity Intervention programme for augmenting palliative care services that includes psychosocial, emotional and spiritual support and links terminally ill patients at two hospices in Singapore with specially-trained psychotherapists.

In August 2017, Asst Prof Ho developed an experiential learning programme on death, titled “I died today”, where psychology students reflect on their lives, write a self-eulogy, and experience their own “funeral”, encouraging them to live with purpose and compassion.
As societies age and waistlines expand, diabetes mellitus type 2 has become a major global health issue. In older patients with late-onset type 2 diabetes, the disorder can cause damage to organs such as the kidneys and eyes, as well as the cardiovascular and nervous systems, leading to high rates of hospitalisation and mortality.

To better understand the complex metabolic changes associated with late-onset diabetes, an international team led by Prof Bernhard Boehm from NTU’s Lee Kong Chian School of Medicine conducted a study on a large cohort of late-onset type 2 diabetes patients. Using high-throughput ultra-performance liquid chromatography-mass spectrometry, they profiled the metabolites in patient urine samples, and compared the metabolic profiles of late-onset patients to those of earlier-onset patients.

Together with colleagues from the Singapore Phenome Centre at NTU and Germany’s University of Ulm, the research team identified four novel metabolite biomarkers whose levels were increased in the cohort of late-onset patients.

The information gleaned from the study will help physicians to tailor therapies to the late-onset group, the researchers say.

The study “Metabolite profiling in identifying metabolic biomarkers in older people with late-onset type 2 diabetes mellitus” can be found in Scientific Reports (2017), DOI: 10.1038/s41598-017-01735-y.

Using cryo-electron microscopy (cryo-EM), a technique that won its inventors the 2017 Nobel Prize in Chemistry, researchers at the NTU Institute of Structural Biology have determined protein structures at unprecedented resolution.

In a study published in Nucleic Acids Research as a breakthrough article, Asst Prof Sara Sandin and her colleagues determined the structure of nucleosome core particles—small protein-DNA complexes that are important for DNA organisation and key cellular processes such as gene expression.

“Using the novel Volta phase plate cryo-EM technique provided significant contrast enhancement that hugely increased detection of molecules in ice,” says Asst Prof Sandin. “The 3.9 Å resolution allowed us to clearly identify individual particles and even substructures such as amino acid side chains, as well as the conformations of free DNA molecules.”

The team’s breakthrough could make it possible to determine DNA-binding protein complexes and other challenging intracellular biological structures at near-atomic resolution, the researchers say. Two brand-new state-of-the-art scanning and transmission electron microscopes equipped with Volta phase plates and direct electron detectors are currently being installed at NTU for that purpose.

The article “3.9 Å structure of the nucleosome core particle determined by phase-plate cryo-EM” was published in Nucleic Acids Research (2016), DOI: 10.1093/nar/gkw708.
BEHAVIOURAL SCIENCE

A FAMILIAR FACE

In this internet age, creating an avatar for online gaming or social media accounts is commonplace. However, not much is known about how users relate to their avatars.

Together with collaborators from Korea, Assoc Prof Jung Younbo and Dr Seo Young-nam from NTU’s Wee Kim Wee School of Communication and Information conducted an experiment with 25 participants from a South Korean university.

The participants were shown a random series of eight images for one second each, including a photo and an avatar image of themselves, photos and avatar images of a famous person, an ideal face, and an unfamiliar face. The study subjects related strongly to their photo and avatar image, and more distantly to the other images.

“The individuals felt a higher sense of self-presence when they were exposed to the virtual representation wearing their own faces—regardless of photo or avatar image—than to the ones with other faces. Interestingly, the discrepancy between our survey results and neurological results indicates that even if we do not treat avatars as our equals at a conscious level, our brains certainly do at a subconscious level,” says Assoc Prof Jung.

Designing avatars that mirror users’ facial and physical features will be important as companies employ avatars to engage users, the researchers say.

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AUGMENTED REALITY

TUNING OUT THE DISTRACTION

Ambient noise is increasingly recognised as a major detriment to health and well-being, especially in densely populated cities where residential areas are often close to industrial and construction sites.

To help urban designers plan public spaces with improved aural comfort, a team from NTU’s School of Electrical and Electronic Engineering developed a software system that allows users to simulate soundscapes—3D acoustic environments that can be perceived by humans.

Using augmented reality headsets coupled to the soundscape-creating software system, study subjects can listen to sound objects, sound interactions and masking effects, and evaluate the soundscape.

“This data can be used by urban designers to develop sound objects and masking techniques that are able to mitigate noise,” says team leader Prof Gan Woon Seng. “The system will help urban planners and real estate developers to design spaces that reduce noise pollution and improve the aural comfort of residents,” he adds.

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The research is one of five projects that won a total of S$14 million (US$10.3 million) in Singapore’s Land and Liveability National Challenge. The findings were published as a conference paper titled “3D Audio AR/VR capture and reproduction setup for auralisation of soundscapes” at the 24th International Congress on Sound and Vibration in July 2017.
ECONOMICS

IDEAS FUEL GROWTH

Economists have long debated the question of which of the four principal transmission channels of financial development—ideas production, savings, fixed investment, and secondary and tertiary education—plays the biggest role in economic growth.

Previous research had largely focused on the channels of savings and investment, neglecting human capital and research and development as potential major drivers of growth.

Providing a different viewpoint is Assoc Prof James Ang from NTU’s School of Social Sciences, who constructed a unique macroeconomic data set based on 140 years of records from 21 member countries of the Organisation for Economic Co-operation and Development (OECD).

Assoc Prof Ang found evidence that the production of ideas followed by secondary and tertiary education are the channels through which financial development influences economic growth the most.

His findings suggest that researchers should focus on these two channels when looking at how financial development can boost economic growth.

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SMART CONSTRUCTION SYSTEMS

LIFTING HOME CONSTRUCTION INTO THE FUTURE

Imagine semi-automatic cranes with microchips, sensors and cameras that are controlled remotely and guided by 3D-building information models. These cranes, which represent the future of home construction, are part of a new integrated model-based smart construction system that could streamline the entire construction pipeline.

The Smart and Semi-Automated Precast Elements Logistic Management and Installation System, as it is called, was invented by a team of researchers led by Assoc Prof Robert Tiong from NTU’s School of Civil and Environmental Engineering.

At its core, the 3D-Building Information System enables consultants, contractors, pre-casters and construction material suppliers to share and keep track of project deadlines, delivery schedules, project requirements and budgets. The Smart Tracking System monitors radio-frequency identification-tagged construction materials on their way from precast manufacturers to the construction site, enabling virtual logistics management.

Finally, by making use of real-time GPS tracking and lifting paths, cameras and a network of smart sensors across the construction site, the Smart Crane System automates quick, precise and safe hoisting of precast elements and other building materials to their desired location.

The system has already been tested on a building site in Singapore, and will be enhanced with funding from NTU’s commercialisation arm, NTUitive. Together with industry partners, the team behind the Smart Crane System & Building Information Modelling system won the 2017 Building Information Modelling Gold™ Award (project category) from Singapore’s Building & Construction Authority.
The 2015 magnitude 6.0 Sabah earthquake took relatively earthquake-free Malaysia by surprise, triggering landslides on Mt Kinabalu that killed 18 hikers on its flanks and injured many more.

“As far as we know, this was the first earthquake of this magnitude to strike Mt Kinabalu in the instrumental records,” says Dr Wang Yu, a Research Fellow at NTU’s Earth Observatory of Singapore, who in the weeks following the rupture conducted a study on the region’s geology.

Dr Wang pinpointed the tectonic fault that triggered the earthquake to a location directly beneath Mt Kinabalu, which explained the widespread crumbling of the mountain’s steep surface. “The earthquake ruptured directly underneath the mountain, causing strong shaking and, ultimately, deadly rockfalls,” he says.

By mapping the 200km-long fault system along Sabah’s northwestern coastline, the team found evidence that the fault segments could give rise to earthquakes larger than magnitude 7.0, albeit with a low frequency of once every several thousand years. Based on their new data, they also estimate that earthquakes greater than magnitude 5.0 could occur every 20 years, and those greater than magnitude 6.0 every 150 years.

“Now that we know there is an active fault system in the region that can produce large earthquakes, it is imperative that people and governments take steps to minimise damage and the loss of lives,” Dr Wang concludes.

The study “The 2015 Mw 6.0 Mt Kinabalu earthquake: an infrequent fault rupture within the Crocker fault system of East Malaysia” can be found in Geoscience Letters, DOI: 10.1186/s40562-017-0072-9.

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Studying millennia-old coral microatolls on the Indonesian island of Belitung, an international research team led by Dr Aron Meltzner and Assoc Prof Adam Switzer from NTU’s Earth Observatory of Singapore found that sea levels in Southeast Asia oscillated by up to 60cm over the course of a few centuries about 6,500 to 6,800 years ago.

By analysing recordings from two sites on Belitung Island and from a third site in South China, the team detected two separate time periods—about 6,750 years and 6,600 years ago—when sea levels were about 60cm above that of an intermediate period about 6,700 years ago.

Though they have yet to pinpoint the specific climatic conditions behind these historic sea level fluctuations, the researchers note that an extra 60cm rise in sea levels—on top of the globally predicted rise—would have a considerable impact on surrounding shores.

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Details of the study “Half-metre sea-level fluctuations on centennial timescales from mid-Holocene corals of Southeast Asia” can be found in Nature Communications (2017), DOI: 10.1038/ncomms14387.
INNOVATION

SHAKEN, NOT STIRRED
Have you ever seen an outfit or accessory on TV that you would like to add to your wardrobe? That might soon be possible with a simple shake of your mobile phone.

Called Hey! Shake, the new app is able to recognize items in footage with the help of sound patterns encoded in the audio track. Linked to a cloud server, the app then pulls related content from the web, connecting the user to vendors.

Invented by Assoc Prof Wen Yonggang, Director of the Innovation Lab at NTU’s School of Computer Science and Engineering, and developed by NTU spin-off company Cloud Wings with the help of NTU’s commercialisation arm, NTUitive, the interactive app offers new opportunities for product placement in movies and TV shows.

The app is available on Apple’s App Store and the Google Play Store, where it was ranked the “hottest” app when it debuted in August 2017. The technology is compatible with all display screens, such as those at train stations, bus stops and movie theatres and on public transport.

“As long as there is a display screen and speakers, our technology can work seamlessly,” says NTU alumnus Xia Ye, who heads product and business development at Cloud Wings.

Other applications of the technology include the option to purchase virtual coupons that can be redeemed at brick-and-mortar shops.

GIVING WASTE A SECOND LIFE
Methods that remove and recycle organic pollutants from industrial wastewater are usually complex and costly. Thanks to a new material invented by Prof Zhang Hua from NTU’s School of Materials Science and Engineering, the recycling of wastewater may soon become cheaper, more efficient and sustainable.

The researchers developed a carbon fibre aerogel that can absorb organic waste such as industrial oils, food oils, solvents and chemicals from water. The aerogel can absorb waste of up to 190 times its own weight and remove up to 99% of the waste from the water. In many cases, the processed wastewater can be released directly into sewers or the sea.

The technology is also eco-friendly, since the organic waste can be recycled and the aerogel is manufactured from cellulose-based waste material like cotton wool or paper in a process known as pyrolysis.

Twenty times cheaper than commercial alternatives, the technology has received early-stage investment from NTU’s commercialisation arm, NTUitive, and is being commercialised by NTU spin-off EcoWorth Tech in collaboration with two multinational companies.
As computer software get increasingly complex, sluggish data processing has become a pressing concern for industries everywhere. With the help of collaborators overseas, Asst Prof Anupam Chattopadhyay from NTU’s School of Computer Science and Engineering has discovered a new way to make memory chips perform computing tasks.

Using a state-of-the-art memory chip known as redox-based resistive switching random access memory (ReRAM), the researchers built a prototype circuit that combines information storage and data processing. While current devices and computers have to transfer data from the memory storage to the processor unit for computation, the new circuit saves time and energy by eliminating these data transfers, speeding up computing devices by a factor of two or more.

In addition, while all current computer processors in the market are based on a binary system—composed of the two states 0 and 1—the new circuit processes information using a ternary number system consisting of three states (0, 1, 2). Because ReRAM uses different electrical resistance to store information, the number of states could even be increased, potentially speeding up computing tasks beyond current limitations.

The ReRAM circuit is a breakthrough in terms of speed and efficiency, and the elimination of processors may lead to new design possibilities in consumer electronics and wearable technology. The researchers now hope to engage industry partners to advance their ReRAM-based ternary computing technology.

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The findings are described in the article “Multistate memristive tantalum oxide devices for ternary arithmetic”, published in Scientific Reports (2016), DOI: 10.1038/srep36652.

CYBER SECURITY

A SAFE AND SECURE INTERNET

Viewed as the “Swiss Army knife” of cryptography, hash functions form the backbone of security applications in industries such as telecommunications, banking and access control. They are also used in everyday devices such as personal computers, mobile phones and smart cards.

The main security goal of a hash function is to prevent anyone from generating two inputs mapping to the same output—a so-called “collision”. Despite a new method developed in 2005 that showed it is possible to generate collisions at much shorter time scales, until recently the less-secure cryptographic hash function standard SHA-1 (Secure Hash Algorithm 1) remained the industry norm.

In 2016, researchers from NTU and the Netherlands, led by Nanyang Asst Prof Thomas Peyrin from NTU’s School of Physical and Mathematical Sciences, managed to generate and detect the first free-start collision for SHA-1 (a slightly easier version of a normal collision), prompting companies such as Google, Mozilla and Microsoft to announce that they would reject SHA1-based certificates earlier than planned and move to more secure alternatives such as SHA-2.

This move proved to be timely as shortly after the announcement, based on the advances by the NTU-Netherlands collaboration, a Google-led research team was able to compute a full collision.

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The findings are described in the article “Freestart Collision for Full SHA-1”, published in EUROCRYPT 2016, DOI: 10.1007/978-3-662-49890-3_18.
A LEADING LIGHT IN LIFELONG LEARNING

CONNECTING THE SCIENCE OF LEARNING WITH THE ART OF TEACHING

The Centre for Research and Development in Learning (CRADLE@NTU) is advancing evidence-based education to transform the learning landscape in Singapore and beyond.
Our prodigious ability to learn has enabled humans to achieve astounding feats; by accumulating knowledge and passing it down from generation to generation, we have built entire civilisations, reshaped our planet and even gone into space.

For millennia, this learning was largely informal and unstructured—instruction reserved for society’s elite. Then came the Industrial Revolution, and with it mass education, which, in the spirit of the times, took on a factory-like mode of operation.

But much has changed in the two hundred years since then. Learners are now no longer seen as future factory workers or passive vessels to be filled with information, but active participants who must acquire critical thinking skills. Learning, likewise, has had to adapt.

Leading the charge is the Centre for Research and Development in Learning (CRADLE@NTU), a research centre established in late 2014 to raise the quality of education using research-based findings.

“We see ourselves as a platform, and invite all researchers interested in pedagogy and learning to join us,” says Prof Annabel Chen, Acting Director of CRADLE. “Whether you are from cognitive neuroscience, education, psychology or computer science, we welcome you to come together and work with us to build new paradigms to answer the most urgent questions in the science of learning.”

A PEEK INTO THE BILINGUAL BRAIN

Noting that there are many well-established research disciplines studying how learning can be improved, Prof Chen says that the emerging field of learning science is focused on where the different fields overlap. “What we are interested in is the nexus between different disciplines—transdisciplinary research that combines knowledge from education, psychology, neuroscience and technology.”

CRADLE has provided seed funding to support such interdisciplinary collaborations. One of these is with experts in the Science of Learning Institute at Johns Hopkins University in the US. NTU’s Nanyang Asst Prof Suzy Styles, a developmental psycholinguist, is working with Johns Hopkins’ Prof Barbara Landau to investigate language acquisition of infants in a multilingual environment.

In collaboration with Johns Hopkins’ cognitive neuroscientists like Prof Brenda Rapp and Prof John Desmond, Prof Chen and Dr Beth O’Brien from the Office of Education Research at NTU’s National Institute of Education (NIE) are studying reading networks in bilingual adults with the plan to investigate the neural mechanisms of reading difficulties in dyslexia.

In her own research, Prof Chen looks at the impact of dyslexia in the brain networks of bilingual learners. The findings could be a cornerstone in linking upstream brain imaging studies with downstream classroom interventions, helping to elucidate how bilingual reading networks are impacted by dyslexia and to identify more efficient intervention strategies.

“The unique thing about education in Singapore is that children are taught to be bilingual, and children with different mother tongue languages all learn together in the same classroom,” Prof Chen explains.

“We see ourselves as a platform, and invite all researchers interested in pedagogy and learning to join us.”

Prof Annabel Chen, Acting Director of CRADLE
“But certain languages are closer together than others. For example, Malay and English are very close phonologically, but Chinese is very distant to both. What happens in the brain when an English-Malay bilingual child has dyslexia, and is it different from what happens in an English-Chinese bilingual child? The better we understand dyslexia in children and the earlier we can detect it and intervene, the better the outcomes can be.”

In Singapore, the education system has the advantage of deep connections between the three main players: the Ministry of Education, NTU’s NIE and the schools themselves. At NIE—Singapore’s main teacher development institute—the faculty not only teach student teachers how to teach but also carry out extensive research into improving learning for their students.

“Taking part in research ensures that teachers are at the forefront of best practices. By carrying out research in the schools, there is a direct impact in the classrooms. At the same time, the information of what works on the ground with the schools and teachers is fed back to Singapore’s Education Ministry, which can inform policy,” Prof Chen says.

“This way, the Ministry, NIE and schools form a ‘golden triangle’ where everybody works together to improve learning in the classrooms of Singapore.”

A UNIQUELY NTU EDUCATION

Given the lasting impact that early childhood and primary and secondary, or K-12, education can have on the development of the brain, it is no surprise that much of the research in the science of learning has focused on that critical phase. However, researchers at CRADLE are also forging ahead in the relatively less well-understood areas of university education and adult learning.

“You can think of CRADLE as a broker, bringing the different fields together,” says Assoc Prof Tan Seng Chee, Acting Co-Director of CRADLE. “Not only does CRADLE tie the different departments at NTU together, but we also form the link between K-12 education and tertiary education and even to adult education.”

“At NTU, we are very fortunate to have NIE,” adds Prof Chen. “Efforts across the University were further strengthened when the late Prof Lee Sing Kong, after stepping down as Director of NIE, helped to establish CRADLE as its Founding Director. The goal was to improve teaching at the university level.”

“The initial motivation was to ask the question of what an ‘NTU’ education is, and what would make graduates from NTU unique. Subsequently, we also wanted to know if the proposed changes were effective in helping students learn better,” she continues.

For example, researchers from CRADLE worked with a teaching team from the Asian School of the Environment to modify a course taught in a traditional format with lectures to a technology-enabled format using interactive questions and group work. After three years of monitoring how
students responded to the changes, the researchers found that student-approval ratings for the course improved from 55% to 92%.

“At CRADLE, we are not trying to prescribe the way lecturers teach, but work alongside them to improve instruction.” Assoc Prof Tan says. “This example illustrates how technology-enhanced or technology-enabled learning is not about a one-off conversion but involves a lot of research along the way. We are trying to effect change not just in the form of delivery, but also in the belief in what effective learning is.”

KEEPING SENIORS EXCITED

Another notion that CRADLE researchers are trying to overturn is that the ageing brain can no longer learn. “Neuroscience shows us that is not true; we still have plasticity as we age and certain lifestyle activities can act as a scaffold, helping the brain adapt.” Prof Chen says.

In particular, exercise is known to improve cognition by increasing the levels of dopamine in the brain. Cognitive training, which can be thought of as “exercise for the brain”, has likewise been shown in research studies to improve cognitive processes, she continues.

“No many studies have looked at this, but it is possible to get the best of both worlds. We devised a very simple exercise-based programme with cognitive components to do just that. Called ExCITE, which stands for ‘exercise and cognition integration for enhanced healthy living’, the training programme aims to optimise cognitive functions during ageing,” Prof Chen says.

At the moment, the ExCITE programme has been piloted in young adults and a few older adults, showing promising improvements in cognitive performance, Prof Chen shares. The research team, led by NIE sports psychologist Asst Prof Masato Kawabata, is formalising the prototype, with follow-up brain imaging studies also planned.

This research on activities that can prevent cognitive decline also has implications for adult learning, adds Prof Chen. In 2016, CRADLE signed a Memorandum of Understanding with the Institute of Adult Learning, the research arm of a governmental initiative called SkillsFuture Singapore, to collaborate on research in improving teaching and learning in adults in Singapore.

CHANGING THE LANDSCAPE

Through these partnerships with local and international institutions, CRADLE is trying to remodel Singapore’s entire educational landscape for the better, Prof Chen says. This inclusive view of learning has helped them scope the types of research to conduct, from basic research in neuroscience to applied research in realistic environments.

“The upstream research that we conduct not only flows towards more applied situations but is also influenced by findings and research being conducted downstream. For example, cognitive neuroscientists are typically not aware of what the questions are in education, so we need to be informed by the experts in education,” says Prof Chen.

Up till the founding of CRADLE, Singapore did not have the research capabilities to probe these questions in an integrated way, she continues. The role of CRADLE, she says, is to encourage interdisciplinary conversations and facilitate collaborations between all researchers who are interested in improving education and learning.

“Prof Lee Sing Kong had a vision to create this research capacity for Singapore.” Prof Chen shares. “It is our hope that we can see this vision fulfilled.”

“At CRADLE, we are not trying to prescribe the way lecturers teach, but work alongside them to improve instruction.”

Assoc Prof Tan Seng Chee, Acting Co-Director of CRADLE
HELPING WORKING ADULTS REMAIN RELEVANT IN A TIME OF UNCERTAINTY

In the past, a bachelor's degree was a ticket to a relatively stable career. Working adults today cannot assume that what they learnt in university will support their entire career. Like the Red Queen in Lewis Carroll’s *Alice Through the Looking Glass* who has to keep running just to avoid falling behind, working adults must continuously update their professional proficiencies to remain relevant in society.

Recognising the value of lifelong learning, the Singapore government has placed significant emphasis on advancing adult education and professional development among working adults. In line with this national agenda, NTU’s College of Professional and Continuing Education (PaCE College) was officially launched in May 2016 to upgrade and renew the skillset of Singapore’s workforce.

“The core mission of PaCE College is to enable advanced skills acquisition for lifelong learning,” says Prof Ting Seng Kiong, the founding Dean of PaCE College. “By offering continuing education programmes to equip Singaporean professionals, managers and executives with updated knowledge and skills, we allow them to keep pace with the rapid
According to Prof Ting, it all boils down to the way Singaporean society currently views lifelong learning. “The major challenge to lifelong learning is that it is still lacking in our present culture—most working adults do not see the need to acquire additional skills to prepare themselves for future changes,” he says. “We have to make learning a way of life, and to achieve this, learning must be made enjoyable instead of intimidating.”

To orchestrate this change in mentality, researchers at NTU’s Centre for Research and Development in Learning (CRADLE) are delving into the behaviours and psyches of adult learners to complement the efforts of PaCE in promoting lifelong learning. “Working adult learners need a combination of flexibility and structure,” notes Dr Peter Looker, who heads the Teaching, Learning and Pedagogy Division of CRADLE. “Flexibility is particularly needed in terms of time constraints, but structure is also needed to keep people engaged and on track.”

To provide both the flexibility and structure to entice professionals to make upskilling a priority, PaCE College is wielding the very tool that warranted its existence—technology.

**THE EVOLVED CLASSROOM**

With the advent of the internet, the four walls of a physical classroom have been broken down. Information is simply a click away, and learning can take place even in the absence of a teacher. “Nobody can predict upcoming trends, so we should be prepared to learn something different whenever necessary,” says Prof Ting. “Learning should be a part of life—do not wait until you have no choice but to learn a new skill.”

Drawing on NTU’s deep technical know-how in established and emerging technologies, PaCE College offers 55 undergraduate-level courses, eight graduate-level courses and 63 short courses, in addition to in-house training and part-time degree programmes. The majority of these courses revolve around the engineering and computer sciences, like data analytics and cloud computing, reflecting the current and future needs of Singapore’s economy, though courses on finance, leadership skills and graphic design are also available.

“There is a great demand for power engineers, civil engineers and specialised information technology personnel,” says Prof Ting. “From the employer’s point of view, they want to hire someone with the right skills. PaCE plays the role of facilitator: we find out what skills or courses are in demand and make them accessible to working adults.”

To take the pulse of Singapore’s job market, the College has successfully created a market-sensing feedback loop by keeping channels of communication open with government agencies, industry partners and even alumni employers. With this insider knowledge into job market trends, PaCE can then identify skills shortages that cause certain job positions to be particularly hard to fill, and adjust its curriculum accordingly.

**MATCHING DEMAND AND SUPPLY**

For Research and Development in Learning (CRADLE) are delving into the behaviours and psyches of adult learners to complement the efforts of PaCE in promoting lifelong learning. “Working adult learners need a combination of flexibility and structure,” notes Dr Peter Looker, who heads the Teaching, Learning and Pedagogy Division of CRADLE. “Flexibility is particularly needed in terms of time constraints, but structure is also needed to keep people engaged and on track.”

To provide both the flexibility and structure to entice professionals to make upskilling a priority, PaCE College is wielding the very tool that warranted its existence—technology.

**A PARADIGM SHIFT IN MINDSET**

The adage goes that you can “lead a horse to water, but you can’t make it drink”. Even with the smorgasbord of courses available at PaCE College, adult learners may still be hesitant to go back to school.
Learning sciences researchers at NTU’s National Institute of Education are challenging long-held assumptions about teaching and learning.

PREPARING STUDENTS FOR TOMORROW’S CHALLENGES

Whether it is maintaining a high literacy rate or coming in top three in the Programme for International Student Assessment (PISA) ranking year after year, Singapore is renowned for its world-class education system. Achieving such high standards is no accident, but the result of effective teachers who are well trained with continuous professional development and informed by education research.

As Singapore’s teacher training institute, the National Institute of Education (NIE) plays an integral role in ensuring the country’s sustained educational success. Here, innovative research conducted by the Learning Sciences and Technologies Academic Group and the Learning Sciences Lab helps to usher in new pedagogical thinking and practice.

“Our learning sciences researchers play the roles of agents of educational change rather than mere observers of educational phenomena in classrooms and schools,” says Prof Tan Oon Seng, Director of NIE.

WHERE THEORY AND PRACTICE MEET

In Singapore’s education system, schools adopt their teaching material and best practices from the Ministry of Education’s (MOE) policies and guidelines, while NIE, an autonomous institute within NTU, trains educators and conducts research to improve pedagogy.

In particular, NIE’s learning sciences researchers maintain a very close collaborative relationship with Singapore schools, allowing the researchers to receive valuable feedback from both educators and students, and come up with new learning designs, which involve...
designing units of learning, learning activities or the learning environment. “The success and failures of the iterations of learning designs enable researchers to better understand the theoretical underpinnings of the designs,” Prof Tan says. “This in turn improves the learning design and further impacts educational practice.”

“In this way, our learning sciences researchers can work towards transforming practice as well as informing educational theory.”

Besides being in touch with the local schools, the learning sciences researchers also work closely with their peers abroad. In 2016, NIE co-hosted the 12th International Conference of the Learning Sciences, which was held in Asia for the first time. In the same year, the Learning Sciences and Technologies Academic Group collaborated with academics from the Open University of the UK to produce a report on Innovating Pedagogy.

THE TECH TRANSFORMATION OF CLASSROOMS

One key research focus for the NIE team is the impact of technology on pedagogy. When NIE was founded almost 70 years ago as the Teacher’s Training College, the notion that smart networks or high-tech gadgets would someday be used as learning materials was unthinkable. Today, a number of the Institute’s ongoing projects and initiatives leverage the latest technology.

“In preparing future-ready learners, we need MAD and BIG pedagogical shifts,” says Prof Tan. “MAD refers to learning with multiple perspectives, authenticity of real world learning and dialogue instead of just didactics. BIG is an acronym for big-picture thinking in problem solving, inquiry where people learn to ask lots of questions out of curiosity, and grit where learners develop strong resilience and emotional intelligence. Technology with its possibilities now allows us to do these MAD and BIG pedagogical shifts.”

“For instance, sensor technology has increased the range and granularity of data that can be collected to analyse learning, providing opportunities to transform our paradigms of assessment,” he adds. “Learning sciences also has much to offer in terms of scaling and sustaining learning interventions by doing extended time design-based research, case studies, system-level analyses and meta-analyses.”

An example is NIE researcher Dr Jennifer Tan’s work on WiREAD, a web-based collaborative reading and learning analytics environment that functions like a social media platform. Using WiREAD, students can share their views on lesson packages and reflect more critically on their classmates’ and their own responses, thereby honing their critical-thinking skills. The system, which is able to track student engagement and visually represent their progress, has been trialled in five secondary schools.

As the first lab of its kind in Asia, the Learning Sciences Lab will transform learning using such interdisciplinary approaches that cut across methodologies and scales of educational theory and practice, explains Prof Tan. “As the Lab continues to build its reputation internationally, it will fulfil its potential to become one of the few research centres that show how learning sciences can impact the world.”

LEARNING THROUGH FUN AND GAMES

To ensure that all teachers are empowered to effectively use technology in the classroom, every pre-service teacher is required to take an NIE module that teaches them how to integrate infocommunications technology (ICT) into the different disciplines, says Prof Tan.

“This module has been consistently informed and updated by research output from the learning sciences, including studies on game-based learning, multi-user virtual environments and technology for assessment,” he adds.

Take, for instance, Assoc Prof Chee Yam San’s internationally acclaimed work on digital game-based learning. In a game called Space Station Leonis, students assume different roles to manage a space station. Through a total of nine levels of gameplay and teacher-facilitated discussions for each round, they learn about governing principles and citizenship, gaining knowledge that can be applied to subjects like social studies, as well as real-world situations such as managing group dynamics.

FUTURE-READY LEARNERS

Implementing these research-backed innovations is the next challenge. Prof Tan says, and may require teachers to change their established beliefs. For example, learning sciences research has debunked the notion of learners being either purely visual, verbal, auditory or kinaesthetic, among others.

“Learning sciences are well aligned with some of the grand challenges of the future of learning and will continue to contribute to transformative pedagogies for schools and building teacher capacity for innovative teaching practices,” Prof Tan says.

“The Learning Sciences Lab will continue its trajectory to be the centre of excellence for the study of innovative pedagogies and learning designs that can prepare students in Singapore schools to be future-ready.”

“Our learning sciences researchers... work towards transforming practice as well as informing educational theory.”

Prof Tan Oon Seng
Director of NIE
This suggests that the language-processing areas of the brain are automatically involved during colour perception, thus providing the first neuroimaging support for the Whorf hypothesis that language directly affects perception.

Our follow-up study, in which study participants needed to find a patch with a slightly deviating colour tone among over half a century ago, American linguist Benjamin Lee Whorf proposed that language affects perception and thought. Although Whorfian effects have been found in behavioural studies, no studies on the brain have been conducted so far to investigate how learning and the use of language influence brain activity associated with perception.

One of the research interests of our lab is to locate the language function in the brain and understand how these language-related locations interact with brain regions related to other functions such as perception and cognition. Using state-of-the-art functional magnetic resonance imaging (fMRI), we showed that brain regions mediating language processes participate in neural networks that are activated by the perception of colour.

In our brain imaging experiments, we asked participants to perform a discrimination task on colour patches without requiring them to label the colour name of the patches. Interestingly, we found that brain regions associated with word-finding processes were strongly engaged while performing the task (Figure 1).

The ABCs of the brain
How does learning a new language change the brain?

By Alice Chan

Assoc Prof Alice Chan is a cognitive neurolinguist in the Linguistics and Multilingual Studies programme and Principal Investigator in the Neurolinguistics and Cognitive Science Lab at NTU’s School of Humanities.


Figure 1: Our study shows that two language regions (the left posterior superior temporal gyrus and inferior parietal lobule) play a crucial part in colour perception. Activated areas of the brain are shown in fMRI images (A) on the surface and (B) in cross-sectional views, respectively. Figure reproduced from [4], copyright 2008, National Academy of Sciences, USA.

This suggests that the language-processing areas of the brain are automatically involved during colour perception, thus providing the first neuroimaging support for the Whorf hypothesis that language directly affects perception.

Our follow-up study, in which study participants needed to find a patch with a slightly deviating colour tone among...
12 otherwise identical patches and name the number of the respective deviating patch (Figure 2), showed further evidence that the brain region responsible for naming colours was activated during a colour-searching task.

More importantly, we found that enhanced activity in regions of the visual cortex that are responsible for colour perception coincided with enhanced activity in language-related regions. These results suggest that language may serve as a form of top-down control, modulating the activity of perceptual brain areas such as the visual cortex.

Figure 2: Study participants were shown these 12 colour patches and asked to name the number of the patch that differed in colour (number 2). Figure reproduced from [3].

Figure 3: Language learning provides mental stimulation through the training of memory and cognitive control. Shown here is brain activity measured by electroencephalography in study participants before and after language learning (yellow- and red-coloured regions reflect areas of higher neurological activity).

STAYING YOUNG BY LEARNING NEW LANGUAGES

One of the key challenges Singapore faces is an ageing society. Previous studies have shown that speaking more than one language can delay the onset of dementia by a few years. Here, we aim to apply our understanding of the influence of language on perception and cognition to evaluate language learning as a means to counter the negative effects of ageing, for instance, in memory capacity and cognitive control.

In our previous fMRI studies, we found that language learning is highly correlated to activity in the left fusiform gyrus and caudate nucleus—regions thought to mediate executive control functions and resolve competition that arises between the first language and a new language that is being learned.

In an ongoing project using another brain imaging technique called electroencephalography, we asked participants to learn a new writing system. Intriguingly, after only one week of training, we found that brain waves related to writing-to-speech-sound mapping in our young adult participants had changed (Figure 3). These imaging studies suggest that adult brains are still plastic and that learning a new language changes the brain not only in language-related areas but also in other cognitive control areas.

We are now designing and examining the feasibility of a community-based language training programme for older adults. Apart from giving older adults the opportunity to expand their linguistic repertoire, it is hoped that these interventions will ultimately aid them in maintaining healthy and active lifestyles, thereby impacting society at large.
Game development for everyone

Learning to master artificial intelligence through game development

By Ong Yew Soon and Jaime Rubio Hervas

The threshold for developing digital games is rather high today because computer programming often involves a steep learning curve. This means that many innovative games never get realised, as many creative people lack the programming skills necessary to turn their ideas into reality.

In addition, even games that are commercially available—with good visual effects and compatible for use on mobile devices—do not come equipped with artificial intelligence (AI).

To make game development accessible to everyone, companies have developed tools to help the general public learn basic programming logic for creating simple games. However, these tools are generally not very useful for creating serious games.

INTUITIVE AND SIMPLE GAME DESIGN

Our team at the Data Science and Artificial Intelligence Research Centre (DSAIR) at NTU has embarked on the research and development of a next-generation programming language, with the goal of developing a system-independent, programming-free game authoring platform.

The product of this research, the game development studio IntelliK, equips users with the necessary tools to design and develop different types of games in an easy and efficient manner.

IntelliK uses elemental operations, which, when combined, provide users with an intuitive graphical editor. The integrated environment allows users to seamlessly define and create different kinds of game objects, logics, interfaces, control scripts and AI tools through fourth-generation visual programming.

An AI generator tool helps users to quickly define and embed different kinds of AI in their games using a visual interface. In addition, games created using IntelliK can be designed for various mobile devices and operating systems.

DELVING INTO THE TECHNOLOGY

IntelliK pays special attention to the use of AI technologies, including expert systems, decision and behaviour trees, fuzzy rules, state machine, and neural and deep networks. Researchers can use IntelliK to easily verify, validate and compare different AI algorithms by integrating the algorithms into the platform and validating them in real time through game play. Beyond AI, researchers can use IntelliK to collect real-time data from developers or gamers for data analysis.
Additionally, IntelliK allows users to make use of AI tools to create novel forms of games and interactions between users and the gameplay, a feature that could potentially revolutionise the gaming industry given the large number of smartphone users today.

APPLICATIONS IN EDUCATION AND HEALTHCARE

IntelliK can be employed in a number of different industries, and it also complements Singapore’s Smart Nation initiative.

One of the most direct applications of IntelliK is in the education sector, where the platform can be used to develop learning tools for coding and AI. Where traditional teaching methods may fail to maintain students’ interest in coding and AI-related concepts, IntelliK’s attractive visual script editor can be used to teach the basic principles of machine learning and AI to young people. Some of these features have already been tested and validated for primary school-age children and as a teaching tool in NTU’s computer science classes.

Beyond education and academia, the wellness and healthcare industry also stands to benefit. Serious games can seamlessly be developed using IntelliK with a variety of applications such as customised therapies, general wellness and health education, or health monitoring and disease prevention, using the embedded AI and data collection and analysis tools.

In summary, IntelliK provides those without much coding experience the opportunity to create their own interactive stories and games. One of the most attractive features of the platform is that a wellspring of new applications is likely to come from its users as they apply IntelliK in novel and creative ways.
A major driving force behind NTU’s rapid transformation into a research-intensive university, Prof Bertil Andersson has headed the University for over ten years—first as Provost and then as NTU’s third President.

A visionary leader, Prof Andersson helped to establish the Lee Kong Chian School of Medicine, a bold partnership with Imperial College London, and build new capabilities in environmental and earth sciences, including the Asian School of the Environment. He also furthered NTU’s scope in the humanities, social sciences and educational research as well as in arts, design and media.

Before joining NTU, Prof Andersson was Chief Executive of the European Science Foundation in France, President of Linköping University in Sweden, and Chairman of the Nobel Committee for Chemistry.

In addition to more than 15 honorary doctorates, the latest from the University of Exeter, the accomplished biochemist has been conferred the prestigious Austrian Wilhelm Exner Medal and Singapore’s Meritorious Service Medal for his exceptional leadership and service to NTU and Singapore.

In this interview with Pushing Frontiers, Prof Andersson reflects on his journey at NTU—one that he considers a privilege to have experienced.
Q: Which of your achievements at NTU are you most proud of?
A: I am most proud of the holistic transformation of the entire University. Today, we are not just a research-intensive institution; we are transforming education, including developing completely new pedagogical models. We have also widened our academic portfolio and greatly expanded NTU’s infrastructure, including the construction of some iconic buildings.

I am also proud of all the people we have recruited, especially the young investigators who constitute around 5% of the faculty but contribute up to 40% of the articles in high-impact journals, which include Nature and Science. To me, that is the NTU of tomorrow.

In rankings, NTU is now ranked first in Asia and 11th in the world (in the QS Asia University Rankings 2018 and the QS World University Rankings 2017, respectively), as a reflection of all our achievements.

Q: What is the role of the arts and humanities at a university that has traditionally focused on engineering and science?
A: Adding humanities and social sciences in an engineering-oriented university like NTU is introducing the glue that joins technology with communities. One example would be behavioural research, which looks at the interplay between language and computer science for internet applications.

We have also moved into environmental social science to relate to environmental issues from a societal perspective. We use the campus as a green test bed for research that examines the interplay between cars and pedestrians with autonomous vehicles, including ethical questions of machine decision-making that would mimic a human response.

We should also do more in social science and business. What is the economic model in Industry 4.0 and in a society where robots are doing most of the work? These are topics where humanities and social sciences should be engaged at a university like NTU.

Q: You have said that managing a university is both a science and an art. In what way is it an art?
A: With education, research, humanities, engineering, science, students, parents, and political and industry stakeholders, a university is a very heterogeneous organisation. I think it’s quite an art to make everyone happy in such a place. And it will only become more complex as the demands for lifelong learning of a diverse cohort complicate the delivery of courses for very different educational aspirations.

Q: What is the secret behind NTU’s success in establishing itself as a world-class research university?
A: There is no secret—our success is our people, especially the way we have been able to recruit top scientists, and the mix of nationalities that comes here. Singapore being East and West at the same time makes it a very unique place, with English as a common language being fundamental to its appeal.

We are very established in engineering, with materials science, computer science and electrical engineering placed among the top ten spots in some rankings, thanks to our world-class highly-cited faculty. Our young chemistry department is now in the top three in some global rankings.

Q: How did you promote interdisciplinary research?
A: Interesting research in recent years is happening at the interfaces between disciplines. That’s where the system of traditional universities, which are built on disciplinary entities such as schools, becomes a limitation.

One way to open up the system laterally is to create thematic research centres, like the Energy Research Institute at NTU, where engineers and physicists work together on renewable energies, or the Nanyang Environment and Water Research Institute, which brings together civil engineers and biologists. Similar to many other global universities—applying best international practice—we have created a matrix where thematic research cuts across the schools’ disciplines.

Q: What new research grounds can NTU break into with its new life sciences cluster?
A: One is plant science, which we are now working to include in the School of Biological Sciences. Plants are able to produce a huge variety of molecules that chemists are still unable to copy in the lab. Exploring the rich biodiversity of plants will be very interesting for Singapore and NTU. In Southeast Asia, one of the most biodiverse regions of the world, we are sitting on a gold mine of substances with pharmacological and nutritional value that we have yet to discover. Plant research would also interface with Chinese medicine, which is already part of the School’s educational and research portfolio.

The other area is brain research, often described as the biggest challenge for the 21st century. Here, we want to better understand how we learn and remember—an area explored at NTU’s Centre for Research and Development in Learning—as well as the physiological and pathological processes involved in diseases like dementia and Alzheimer’s. Today we know everything about the heart and liver, but the human brain is still a mystery.

Q: You have been the driving force behind the campus master plan and the stunning physical growth of the campus. Is there a link between a university’s infrastructure and its excellence?
A: Infrastructure and excellence are connected in many dimensions, especially with more than 16,000 students and 1,000 professors and researchers living on our main campus, frequently named among the most beautiful in the world.

It is essential to create a variety of spaces for interaction—some formal and others informal—that promote discourse, since discourse leads to scholarship. In this way, we encourage interdisciplinary interactions and spur creativity and innovation.

We have iconic buildings—old ones like the Chinese Heritage Centre and new ones such as The Hive, the centrepiece of
NTU’s dual-campus medical school, set up jointly with Imperial College London, includes a 20-storey Clinical Sciences Building in Novena, Singapore’s medical district. Credit: NTU.

“Our success is our people, especially the way we have been able to recruit top scientists, and the mix of nationalities that comes here.”
The Falling Walls Foundation, established on the 20th anniversary of the fall of the Berlin Wall, brings people together to ask the question: “Which walls in science will fall next?” A trustee of the foundation, Prof Helga Nowotny has asked the same question throughout her own path-breaking career.

An expert in social sciences and a pioneer in the field of science, technology and society, Prof Nowotny is Nanyang Visiting Professor at NTU’s College of Humanities, Arts, and Social Sciences (CoHASS) and the recipient of an honorary doctorate from NTU for her outstanding contributions to academia and public service, which includes developing NTU’s social sciences curriculum.

Her position as an intellectual leading light in Europe is undisputed: Prof Nowotny is Professor Emerita of Science and Technology Studies at ETH Zurich (Swiss Federal Institute of Technology), and a founding member and past President of the European Research Council (2010–2013). She is also currently Chair of the European Research Area Council Forum Austria and Vice-President of the Council for the Lindau Nobel Laureate Meetings.

Here, Prof Nowotny shares her views on how the arts, humanities and sciences can join forces in shaping the future of society.
How can the trio of social studies, humanities and arts contribute towards pushing the frontiers of knowledge?

The world today is in the grip of the turbulence generated around the latest scientific-technological developments and renewed geopolitical tensions.

Many societies are experiencing fragmentation and confusion, often expressed in the quest for identity in a globalised world. It is mainly in this respect that the social sciences, humanities and arts can contribute by raising new questions and, especially in the arts, by experimenting in interactive ways with ordinary citizens.

We have the ability to relate the past to the present and the present to possible alternative futures. By covering an enormous range of human experience, and by co-producing science and technology with society, we have the potential to sharpen awareness in society of where we are going and what kind of society we want to live in.

Your recent research includes themes such as disruption, chaos, uncertainty and critical complexity. How have these themes influenced the arts, humanities and social sciences?

An interesting feature of these phenomena is that many of them are known and well defined in the natural sciences, while they exist in a more fluid form in society.

Part of my fascination stems from exploring possible parallels. In the social world it is us humans who experience and partly generate, but also have to cope with, uncertainty, complexity and messiness. My hope is that the inclusion of knowledge from the social sciences will ultimately lead to the emergence of new bridges of mutual understanding.

In 1994, you helped coin the term “Mode 2”, which describes a new mode of applying research to solving specific problems, as compared to “Mode 1” research, which occurs in disciplinary silos. Have you seen a shift towards Mode 2 research over the years?

Over the course of almost 15 years, the drift from Mode 1 to Mode 2 has been vindicated worldwide, even if the term itself is not used. We had tried to understand, identify and diagnose an underlying trend that we sensed was emerging. This was immediately recognised by policymakers and funding agencies everywhere.

As Nanyang Visiting Professor, you have been involved in research, education and curriculum development, as well as faculty mentoring. What has been the focus and objectives of these different lines of engagement?

My engagement at NTU’s College of Humanities, Arts, and Social Sciences (CoHASS) is multiple. For example, when I talk to the excellent junior faculty, I try to give advice on how their potential and current research interests can be combined into research grant applications.

I also give public lectures and seminars that cross disciplinary boundaries. And, together with colleagues in the natural sciences, I am working on establishing the field of science, technology and society in CoHASS.

You have been instrumental in NTU’s involvement in the Falling Walls Lab and Conference. Why do you think competitions like the Falling Walls Lab are important for researchers and research institutions like NTU?

The Falling Walls competition is important, first of all, to the young researchers who participate and meet like-minded and innovative young people from different disciplinary or cultural backgrounds with whom they share experiences and ambition.

It is also good for NTU and the other universities in Singapore because it provides a fermentation ground for good ideas and for cultivating the entrepreneurial spirit. The competition thus strengthens Singapore as a place in which academia and industry meet, in a bottom-up mode and at an early stage.
From uttering our first word to adopting new technologies at the workplace, learning never stops throughout our lives. Here, we put the spotlight on four NTU researchers who study how people of all ages learn.

Having won a national research grant of more than S$7 million (US$ 5.2 million)—the largest amount ever awarded to a project in the humanities and social sciences in Singapore—Nanyang Asst Prof Suzy Styles is embarking on an ambitious five-year research project that aims to find out how babies master multiple languages at the same time.

“There is a gap in our knowledge because research into language acquisition was mostly conducted in societies where babies grow up hearing just one language,” says Asst Prof Styles.

The first part of the project, which is also supported by seed funding from NTU’s Centre for Research and Development in Learning (CRADLE), will focus on studying how daily immersion in multiple languages and vernaculars shapes language capabilities and the brain.

The team will collect tens of thousands of hours of speech recordings from 500 Singaporean households, analysing them with automatic speech processing algorithms developed by Assoc Prof Justin Dauwels from NTU’s School of Electrical and Electronic Engineering.

Based on these baseline findings, the researchers will then work with Asst Prof Luca Onnis, a researcher in Linguistics and Multilingual Studies at NTU’s School of Humanities, to evaluate how language use in the babies’ homes relates to the way they adapt to changes in the acoustic environment.

Subsequently, the team will collaborate with psychologist Dr Beth O’Brien from NTU’s National Institute of Education (NIE) and neuroscientist Prof Annabel Chen, the Acting Director of CRADLE, to study the development of auditory language processing systems in slightly older children (between pre-kindergarten and first year of elementary school) as they transition from developing oral language skills to acquiring reading skills and literacy.
From 2009 to 2014, there was a nationwide effort to develop students’ competencies in collaborative and self-directed learning through infocommunications technology (ICT). This mammoth project involved 110 schools, more than 7,000 students and 5,000 teachers. But how best to measure the project’s success?

Enter Assoc Prof Tan Seng Chee, who develops tools and methods to evaluate technology-enabled learning (TEL) projects such as Singapore’s third ICT in Education Masterplan (mp3). Assoc Prof Tan led a research team to evaluate the mp3 project, and is translating the insights he gained to teaching outcomes at universities.

“My personal interest is using computer-supported collaborative learning for knowledge-building,” says Assoc Prof Tan, who is the Acting Co-Director of CRADLE@NTU and Associate Dean of the Office of Graduate Studies and Professional Learning at NIE.

“Contributing and interacting through these online forums also give students ownership of their learning and increase their motivation to explore inquiry topics of their choice.”

Working with NTU’s main TEL-developing unit, the Centre for IT Services, as well as the Teaching, Learning and Pedagogy Division. Assoc Prof Tan and his team are investigating various case studies across NTU schools that apply technologies to improve the quality of teaching.

Data gathered on these platforms, such as the ways students interact and how their ideas are integrated, can help researchers better understand students’ behaviour patterns when interacting with various online learning materials, providing clues on how to improve TEL materials and learning productivity.
“Technologies for the common user need to be useful, safe, useable and less frustrating,” says Prof Theng Yin Leng, a professor at NTU’s Wee Kim Wee School of Communication and Information (WKWSCI), whose mission is to design better technologies that benefit individual users as well as communities.

Prof Theng was instrumental in the set-up of COVE—short for COgnition and BehaVioural SciencEs—a laboratory at NTU that provides controlled experimental settings to study how people respond to different sensory perceptions, as well as how computer-mediated communication and social media influence individuals and groups.

Supported through a national initiative for research in active ageing, the Acting Executive Director of NTU’s Ageing Research Institute for Society and Education has developed an interactive exergaming platform targeted at older adults that requires users to be physically active and to interact and bond with others in the community. Called Virtual Exercise Therapist System, the platform has been used by more than 400 older adults in a national programme, providing valuable data on users’ needs that will help to advance interactive technologies.

To better the lives and wellbeing of elderly citizens in a more holistic way, Prof Theng also plans to build a caregiving ecosystem that covers general healthcare, rehabilitation and emergency response, including helping elderly people in daily chores and providing them healthy meals. In collaboration with NTU’s College of Professional and Continuing Education and NTU’s Centre for Research and Development in Learning, she is looking at possibilities for training and qualification of caregivers, for instance, as certified health caregivers, to provide the required manpower for the patient care management ecosystem.

Prof Theng also holds other portfolios such as Founding Director of the Centre for Healthy and Sustainable Cities at WKWSCI, and Research Director for Arts, Humanities, Education and Social Sciences in the University President’s Office.
When he first joined NIE in 2001, Prof Tan Oon Seng introduced the concept of problem-based learning in its education psychology module. Now its Director, Prof Tan is internationally renowned for his research in problem-based learning—a student-centred pedagogy in which students learn about subjects through engagement with real-world problems.

At NIE, Prof Tan developed a model of teacher education for the 21st century—termed V’sK—which puts three values at its core: learner-centred thinking, teacher personality development, and social collaborative learning.

Other initiatives and projects he spearheaded include the NTU-NIE Teaching Scholars Programme (TSP), which offers future teachers interdisciplinary training and innovative pedagogical knowledge, and the Centre for Research in Child Development. The TSP has become a premium programme at NTU, taking in some of the best students passionate about joining the teaching profession.

Prof Tan also heads the Singapore team for the Global Education Innovation Initiative. The Harvard Graduate School of Education-led project studies key programmes across different parts of the world to discover and analyse different approaches to 21st century education.

“Education is about granting freedom, giving faith and hope to every learner, and helping all to fulfill their life potential regardless of their stations in life,” he says, adding that school leaders must think out of the box and always aim to view the bigger picture in order to lead future-ready schools.

“When facing the uncertainties of the 21st century, teachers and students need to have grit and resilience to embrace the many challenges, and grow holistically,” he shares.
Opeining up new possibilities for mankind, light-emitting diodes (LEDs) have been used to disinfect drinking water for millions of people around the world, said 2014 Physics Nobel Laureate and co-inventor of the blue LED, Prof Hiroshi Amano, at the 9th International Conference on Materials for Advanced Technologies (ICMAT). Held in June 2017, the conference covered innovations in nanotechnology and emerging materials. It was organised by the NTU chapter of the Materials Research Society Singapore and drew more than 2,300 experts, including Nobel Laureates Prof Sir Konstantin Novoselov (Physics, 2010) and Prof Sir James Fraser Stoddart (Chemistry, 2016).

While Chinese philosophy has a history spanning thousands of years, it continues to be relevant in today’s inter-connected world, as showcased at the 20th International Society for Chinese Philosophy (ISCP) Conference. Jointly organised by NTU’s Philosophy Programme, the Confucius Institute at NTU and the International Society for Chinese Philosophy in July 2017, the event featured 250 presentations by scholars from 20 countries and 125 global institutions.

In July 2017, fans of Irish literature flocked to the College of Humanities, Arts, and Social Sciences at NTU to discuss the influence of Irish writers on modern literature around the world at a convention arranged by the International Association for the Study of Irish Literatures (IASIL) with support from NTU’s English division and the Centre for Liberal Arts and Social Sciences. The week-long meeting played host to over 150 participants from more than 20 countries. Held in Asia for the first time, it was co-funded by NTU, the Embassy of Ireland in Singapore, and The Ireland Funds Singapore, a chapter of global philanthropic network The Ireland Funds.

More than 400 leading economists congregated at NTU for the 6th Singapore Economic Review Conference. Organised by The Singapore Economic Review, a leading economic journal in Asia whose editorial team is based at NTU, the conference addressed the challenges of navigating the economic and political upheavals facing the world today. During his keynote address, Prof Edward Lazear, former chief economic advisor to President George W. Bush, discussed how economics can influence government policy.

Make an elevator pitch about your innovations and inventions in three minutes—that's the premise of the sophomore Falling Walls Lab Singapore event. Singapore's edition of the internationally renowned competition inspired by the fall of the Berlin Wall in 1989. More than 20 talented researchers, entrepreneurs and professionals vied for the two top spots to represent Singapore at the global finals in Berlin in November 2017.

Game changer: PhD student Kaushik Parida from NTU’s School of Materials Science and Engineering convinced the jury with his idea of a talking hand puppet that translates sign language into speech, winning the 2nd prize in the Falling Walls Lab Singapore competition. Credit: NTU.

The International Union of Pure and Applied Physics (IUPAP), hosted at NTU’s Institute of Advanced Studies since 2015, will remain on NTU’s campus for a further three years. The international organisation, founded in 1922 in Brussels to foster international research cooperation in physics that would solve global problems, also validates and places new elements in the Periodic Table of Elements, a task it shares with the International Union of Pure and Applied Chemistry.

Physics coup: Signed by IUPAP’s outgoing President Prof Bruce McKellar (left) and NTU President Prof Bertil Andersson (centre), the Memorandum of Understanding also sees the Director of NTU’s Institute of Advanced Studies, Prof Phua Kok Khoo (right), continuing in his role as IUPAP’s Secretary General. Credit: IUPAP.
EVENTS

TOPICAL WORKSHOP ON DARK MATTER
Organised by NTU’s Institute of Advanced Studies
13 – 15 November 2017
Venue: Nanyang Executive Centre, NTU, Singapore
ntu.edu.sg/ias/upcomingevents/DM17/Pages/default.aspx

WORKSHOP: SCIENCE, TECHNOLOGY AND INNOVATION IN THE ERA OF UNCERTAINTY
Organised by NTU’s College of Humanities, Arts, and Social Sciences
27 – 28 November 2017
Venue: Nanyang Executive Centre, NTU, Singapore
event.ntu.edu.sg/STI_policy/Pages/index.aspx

WORKSHOP ON QUANTUM RESOURCES AND CORRELATIONS BEYOND ENTANGLEMENT
Organised by NTU’s Quantum and Complexity Science Initiative and NTU’s Institute of Advanced Studies
11 – 13 December 2017
Venue: Nanyang Executive Centre, NTU, Singapore
quantumcomplexity.org/nyquantum2017/

3RD INTERNATIONAL CONFERENCE ON 2D MATERIALS AND TECHNOLOGY (ICON-2DMAT 2017)
Co-organised by NTU, NTU’s Institute of Advanced Studies, National University of Singapore and Materials Research Society of Singapore
11 – 15 December 2017
Venue: Nanyang Executive Centre, NTU, Singapore
conference.ntu.edu.sg/icon-2dmat

SPONTANEOUS SYMMETRY BREAKING, A MEMORIAL CONFERENCE FOR ROBERT BROUT
Organised by NTU’s Institute of Advanced Studies
16 – 19 January 2018
Venue: Nanyang Executive Centre, NTU, Singapore
ntu.edu.sg/ias/upcomingevents/SSB/Pages/default.aspx

CONFERENCE ON NEW FRONTIERS—PARTICLES AND COSMOLOGY
Organised by NTU’s Institute of Advanced Studies
5 – 9 March 2018
Venue: Nanyang Executive Centre, NTU, Singapore
ntu.edu.sg/ias/upcomingevents/COSMO18

INTERNATIONAL WORKSHOP: POLYEOLECTROLYTES IN CHEMISTRY, BIOLOGY AND TECHNOLOGY 2018
Co-organised by NTU’s College of Science and Institute of Advanced Studies
12 – 14 March 2018
Venue: Nanyang Executive Centre, NTU, Singapore
bit.ly/2goNDaE

JULIAN SCHWINGER CENTENNIAL CONFERENCE AND WORKSHOP
Co-organised by NTU’s Institute of Advanced Studies and the Julian Schwinger Foundation
7 – 12 February 2018
Venue: Nanyang Executive Centre, NTU, Singapore
ntu.edu.sg/ias/upcomingevents/JS18

COMPLEXITY CONFERENCE: COMPLEXITIES OF TIME
Organised by NTU’s Para Limes and Complexity Institute
19 – 21 March 2018
Venue: Nanyang Executive Centre, NTU, Singapore
bit.ly/2zr0O1w
A new institute in town will ensure Singapore keeps up to date with the latest visual technologies. Launched by NTU and German applied research institute Fraunhofer-Gesellschaft, the Fraunhofer Singapore institute will advance digital technologies under Singapore’s Industry 4.0 manufacturing paradigm, incorporating data analytics, industrial Internet of Things and automation into manufacturing processes. Industry partners include Delta Electronics and the BMW-NTU Future Mobility Research Lab.

Launch of Fraunhofer Singapore by (from left) Dr Cheong Wei Yang, Deputy CEO of Singapore’s National Research Foundation; NTU President Prof Bertil Andersson; His Excellency Dr Michael Witter, former Ambassador of the Federal Republic of Germany to Singapore; Singapore Minister for Trade and Industry (Industry) Mr S Iswaran; Prof Dieter W. Fellner, Director of German Fraunhofer Institute for Computer Graphics Research; NTU Acting Provost, Chief of Staff and Vice President (Research) Prof Lam Khin Yong; and Director of Fraunhofer Singapore, Prof Wolfgang Mueller-Wittig. Credit: NTU.

A tie-up with Camfil, a global leader in the air filtration industry, is set to improve the indoor air quality at NTU’s 200-hectare campus. Together with the Energy Research Institute @ NTU, the Swedish company will test various air filter technologies in NTU’s buildings and their effects on cognitive performance, with the longer-term goal of establishing a standard for tropical climates.

On the occasion of a state visit to Singapore by former French President Francois Hollande in March 2017, NTU signed several research and collaboration agreements with French companies and institutions. Agreements with the Alternative Energies and Atomic Energy Commission and scientific cooperation foundation SystemX will advance sustainability research. New partnerships with ENGIE Lab. Schneider Electric and Think Smartgrids Association will spur innovation from a large-scale offshore integrated power grid system developed under a national initiative led by NTU. Space technologies research will get a boost from a pact with Thales Alenia Space, Europe’s largest satellite manufacturer, which will also benefit projects at the joint laboratory, S4TIN (Smart Small Satellite Systems-Thales in NTU).
The Singapore Centre for 3D Printing (SC3DP) at NTU has partnered Singapore Technologies Aerospace to print 3D aerospace parts from metals and alloys using a technology known as Direct Energy Deposition. Separately, SC3DP will work with Germany’s Evonik Health Care Business Line, a world leader in speciality chemicals, to print 3D living tissues. With Thailand’s largest petrochemical and refining company PTT Global Chemical, SC3DP will develop new 3D printing materials for the next generation of cars.

NTU Innovation in Haifa. NTU’s new centre in Israel’s high-tech hub of Haifa, will work with leading Israeli institutions to advance research in marine sciences, maritime business, insurance and operations. It will also support entrepreneurship and stimulate broader collaboration with Israel’s industrial players, venture capitalists and angel investors.

Professionals from the wealth and asset management industries in Singapore can now receive further training at NTU’s new Wealth Management Institute (WMI@NTU), which will leverage NTU’s research and teaching capabilities, infrastructure, facilities and overseas networks to strengthen its role as Asia’s centre of excellence for wealth management education.
THE HONOUR ROLL

TOP FRENCH HONOUR

NTU’s Acting Provost, Chief of Staff and Vice President (Research), Prof Lam Khin Yong, has been conferred the rank of Knight in the French Legion of Honour (Chevalier de la Légion d’Honneur) for nurturing academic and industry collaborations between France and Singapore. The highest decoration in France, the honour recognises outstanding personalities for exemplary services rendered to France.

Profs. Lam Khin Yong (left) and Er Meng Hwa (right) receiving honorary degrees from University of Newcastle’s Deputy Chancellor, Ms Dianne Allen. Credit: University of Newcastle.

PHOTOSYNTHESIS PIONEER

Prof James Barber, Ernst Chain Professor of Biochemistry in Imperial College London and a visiting professor at NTU’s School of Materials Science and Engineering, received an Honorary Doctor of Science from NTU for his exceptional achievements in photosynthesis and his role in initiating the study of photosynthesis at the University.

GOOD VIBRATIONS

For his outstanding contributions to the field of biomolecular recognition and affinity technology, Prof Sten Ohlson from NTU’s School of Biological Sciences was presented the Pierce Award in Affinity Technology 2017 from the International Society for Molecular Recognition.

EXEMPLARY ENGINEER

NTU’s Vice President (International Affairs), Prof Er Meng Hwa, was conferred an Honorary Doctor of Engineering from his alma mater, the University of Newcastle, Australia, for his contributions to research, education, management and public service. He was previously awarded the Alumni Medal for Professional Excellence for his pioneering achievements in signal processing.

CHEMISTRY COUP

For his distinguished achievements in organic synthesis, including international academic development in the field, Prof Loh Teck Peng from NTU’s School of Physical and Mathematical Sciences was conferred the Yoshida Prize by the International Organic Chemistry Foundation.

OUTSTANDING DISSERTATION

Asst Prof Pun Chi Seng’s PhD thesis on robust stochastic control and high-dimensional statistics was awarded the Nicola Bruti Liberati Prize for being a top doctoral thesis in mathematical finance. The accolade came from the Bachelier Finance Society and the mathematics department at Politecnico di Milano in cooperation with Springer.

ABOVE THE NOISE

To highlight the problem of urban noise pollution, Asst Prof Galina Mihaleva from NTU’s School of Art, Design and Media designed a dress that lights up with blinking patterns in response to how noisy it gets. The Tranquilitie gown bagged the top prize at Paris Fashion Week in October 2016. The dress has since graced the Fashiontech Festival in Montreal, Canada, and Smart Textiles Salon 2017 in Ghent, Belgium.

Asst Prof Galina Mihaleva (left) and the Tranquilitie gown. Credit: NTU.
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