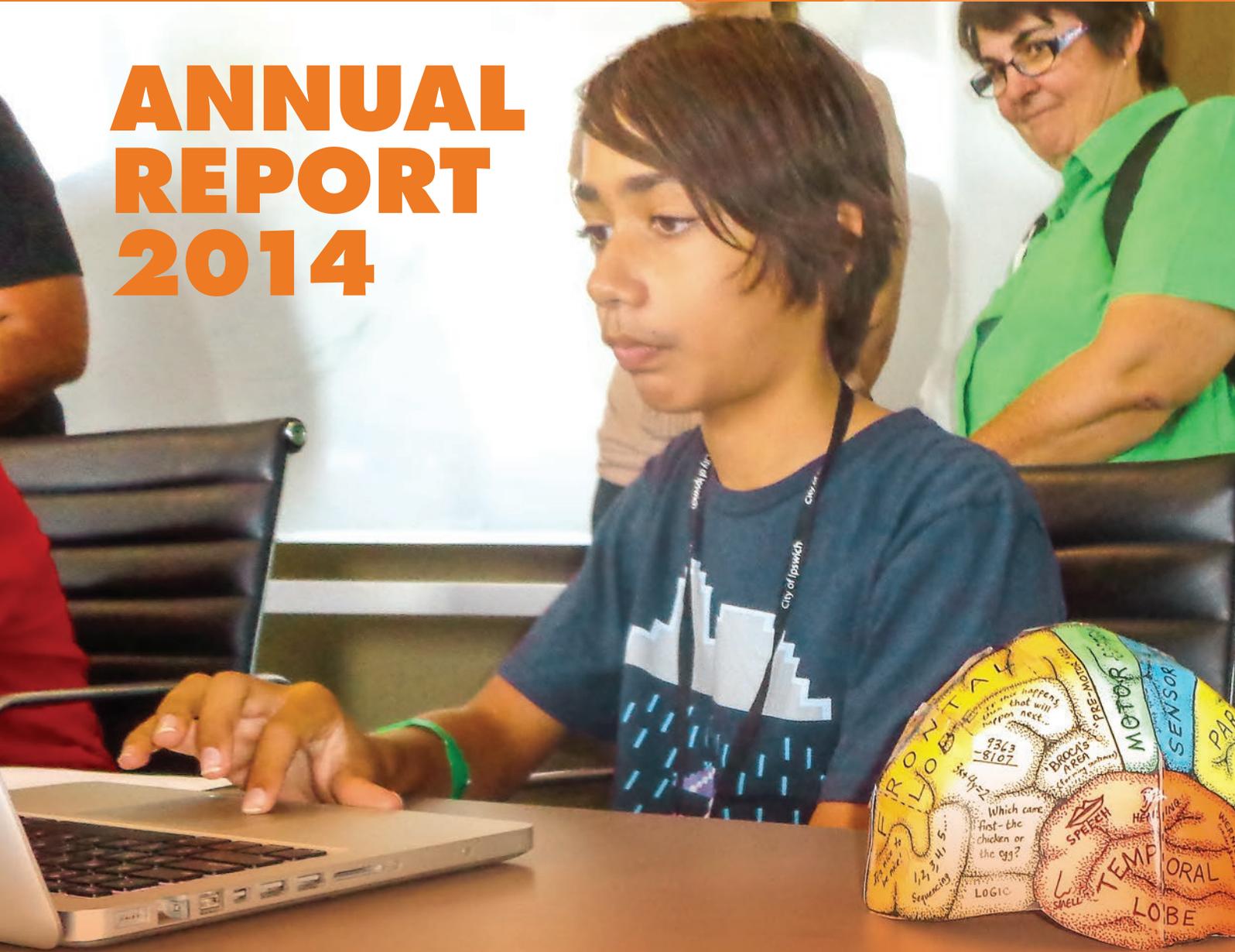




SCIENCE OF LEARNING
RESEARCH CENTRE

ARC Special Research Initiative for Science of Learning

ANNUAL REPORT 2014



IMPROVING LEARNING OUTCOMES



25 CHIEF INVESTIGATORS
9 NODES
1 VISION

**TO IMPROVE
LEARNING
OUTCOMES**

VISION

an organisation
that makes a

POSITIVE impact

on **LEARNING OUTCOMES**

through the

**PROMOTION &
IMPLEMENTATION**

of **SCIENTIFICALLY-VALIDATED**

LEARNING & TOOLS both
STRATEGIES & NOVEL and **EXISTING**

GOALS

UNDERSTAND the neural mechanisms that underpin learning and develop robust methods to

MEASURE outcomes in order to identify and develop evidence-based strategies that

PROMOTE learning

Use cross-disciplinary
COLLABORATIONS
between neuroscience, education, cognitive psychology and practicing teachers to accelerate research outcomes in learning

DEVELOP 1: tools and strategies that promote learning in formal and informal settings, and
2: resources for educating students and teachers about how the brain learns

TRANSLATE research outcomes into the classroom by incorporating new knowledge into pre-service teacher training and professional development programs

TRAIN future researchers and teachers with an understanding of neuroscience, psychology and education who will continue to scrutinise and develop new learning strategies in a constantly evolving environment

Collaborating Organisations



Partner Organisations



Government of South Australia
Department for Education and
Child Development



Carnegie Mellon University



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USING RESEARCH FROM
**NEUROSCIENCE,
EDUCATION,
AND COGNITIVE
PSYCHOLOGY**

TO DEVELOP EVIDENCE-BASED STRATEGIES
EVALUATE EXISTING STRATEGIES
DISPEL LEARNING MYTHS

IMPROVING LEARNING OUTCOMES

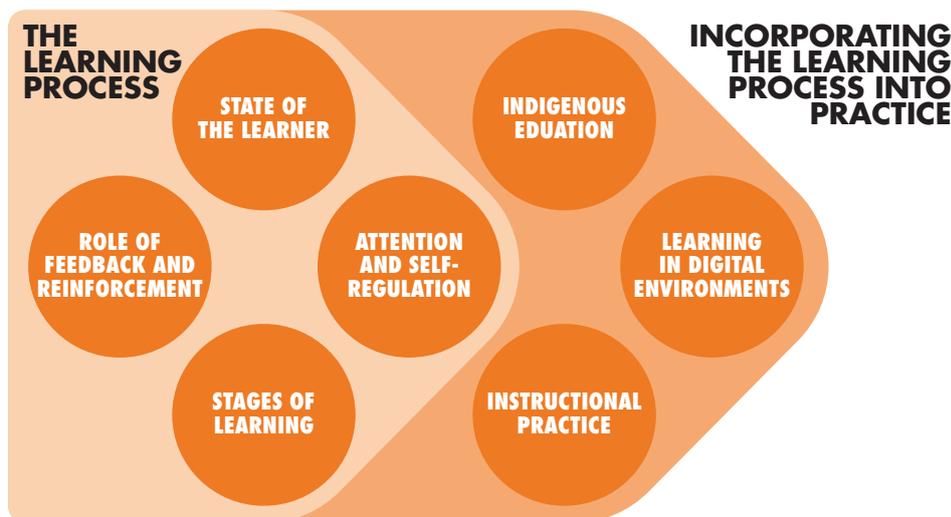
The Science of Learning Research Centre (SLRC), established in 2013, is a Special Research Initiative of the Australian Research Council, administered by The University of Queensland.

The SLRC brings together 25 of Australia's leading researchers in neuroscience, education and cognitive psychology from across the country, collaborating in programs to better understand learning, using innovative experimental techniques in the laboratory and classroom.

Knowledge gained from this research feeds into the Centre's overarching goal of developing evidence-based strategies and tools to assess and evaluate learning outcomes, evaluating existing strategies and dispelling learning myths. This knowledge will be shared with educators and policy makers to enhance teaching and learning outcomes.

The Centre's research is broadly organised into seven programs, with three overarching themes—Understanding Learning, Promoting Learning and Measuring Learning—running across and uniting each of the programs. The programs fall broadly within two categories: the learning process, and incorporating the learning process into practice.

The seven programs of research within the Centre are:



Research programs are being conducted in the molecular neuroscience research laboratory, in the school classroom and in two specially constructed classrooms: the Learning Interaction Classroom at the University of Melbourne, designed to study learning interactions; and the Educational Neuroscience Classroom at The University of Queensland, designed to monitor neurological and physiological activity during learning and making use of human brain imaging facilities.

This report summarises the performance of the SLRC for 2014 and outlines the Centre's plans for meeting its strategic objectives in 2015.



LEARNING

ABOUT

LEARNING

SO THAT WE CAN IMPROVE

LEARNING

DIRECTOR'S REPORT

It was an honour to take up the position as Director of the SLRC at the start of 2014 with the departure of Professor Ottmar Lipp from The University of Queensland to take up a position at Curtin University in Perth. Professor Lipp did a fantastic job in establishing the SLRC and he continues to play a role in the management of the SLRC as leader of the Understanding Learning theme and as a member of the Executive.

The SLRC is a 'big ideas' centre, integrating findings from neuroscience, education and cognitive psychology. As the Centre has matured, its research has evolved into seven programs inextricably woven together by the themes of Understanding Learning, Measuring Learning and Promoting Learning. At the heart of the SLRC are the Educational Neuroscience Classroom at The University of Queensland and the Learning Interaction Classroom at the University of Melbourne, which serve as the links between experiments in the classroom and laboratory based experiments to understand learning. The classrooms came on line in 2014 with both facilities generating data using experimental paradigms not previously possible.

Ensuring the SLRC is relevant to educators is high on our list of priorities. To this end, in 2014 we implemented a number of new initiatives. Under the guidance of Professor Cindy Shannon, Pro-Vice Chancellor (Indigenous) at The University of Queensland, who joined the SLRC Advisory Board at the start of 2014, we conducted a think-tank on Indigenous learning. As a result of recommendations from the think-tank, the Centre now has an Indigenous Learning Consultation Group and has appointed an Indigenous Research Fellow who will unite the research being undertaken in communities in Queensland, Northern Territory and Victoria.

One of the goals of the SLRC is to deliver translational outcomes. In June 2014 Associate Professor Annemaree Carroll joined the Executive Committee, tasked with the role of coordinating research translation. Working closely with Professor John Hattie and Centre members from across various nodes, Associate Professor Carroll is overseeing the development of new curriculum, and content, to add to pre-service teacher training, Masters coursework programs and professional development—thus addressing both future and current educators.

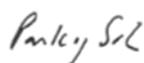
We continue to work closely with education departments across a number of states as well as the teaching community, and are extremely grateful for their support. This year SLRC researchers delivered 24 seminars, workshops and professional development in schools and the Centre hosted 17 workshops and seminars in schools across the country.

As the Centre continues to evolve, 2015 is shaping up to be another big year, with the launch of the *Nature Partner Journal*—"NPJ-Science of Learning", and a Science of Learning Symposium scheduled for April and sponsored by Macmillan Press.

It is through the dedication and commitment of numerous people that the Centre has evolved from its original 25 Chief Investigators. I would like to thank all of the SLRC members—Chief Investigators, Partner Investigators, postdoctoral fellows, research assistants, students and support staff—for bringing this Centre to life and making it a truly cross-disciplinary, multi-nodal unit. The ready engagement and support of the teacher community to support our activities has been particularly heartening. This interest was evident in the large number of applicants (90) for the teacher intern position funded by the Queensland Department of Education, Training and Employment. I am especially grateful for the support of the Australian Research Council and all of our Collaborating and Partner Organisations for their ongoing commitment to the Centre.

With best wishes,

Pankaj Sah



RESEARCH PERSONNEL, TRAINING_{AND} DEVELOPMENT

**25 CHIEF
INVESTIGATORS**

**2 PARTNER
INVESTIGATORS**

**28 RESEARCH HIGHER
DEGREE STUDENTS**

**26 POSTDOCTORAL
RESEARCHERS**

"Strength lies in differences, not in similarities"

—Stephen R. Covey

CHIEF INVESTIGATORS



DR TIMOTHY BREDY
The University of Queensland



ASSOCIATE PROFESSOR ANNEMAREE CARROLL
The University of Queensland



PROFESSOR DAVID CLARKE
The University of Melbourne



ASSOCIATE PROFESSOR ROSS CUNNINGTON
The University of Queensland



ASSOCIATE PROFESSOR PAUL DUX
The University of Queensland



PROFESSOR ROBYN GILLIES
The University of Queensland



PROFESSOR MERRILYN GOOS
The University of Queensland



PROFESSOR PATRICK GRIFFIN
The University of Melbourne



PROFESSOR JOHN HATTIE
The University of Melbourne



ASSOCIATE PROFESSOR ROB HESTER
The University of Melbourne



PROFESSOR TIANZI JIANG
The University of Queensland



PROFESSOR GREGOR KENNEDY
The University of Melbourne



DR SIEK-TOON KHOO
Australian Council for Educational Research



PROFESSOR OTTMAR LIPP
Curtin University



PROFESSOR LORI LOCKYER
Macquarie University



PROFESSOR JASON MATTINGLEY
The University of Queensland



PROFESSOR JOHN PEGG
University of New England



PROFESSOR DAVID REUTENS
The University of Queensland



PROFESSOR PANKAJ SAH
The University of Queensland



PROFESSOR SVEN SILBURN
Charles Darwin University



PROFESSOR COLLETTE TAYLER
The University of Melbourne



DR SUE THOMSON
Australian Council for Educational Research



DR MICHAEL TIMMS
Australian Council for Educational Research



PROFESSOR RUSSELL TYTLER
Deakin University



PROFESSOR MARTIN WESTWELL
Flinders University

PARTNER INVESTIGATORS

Professor Brian Butterworth University College London
Professor Diana Laurillard Institute of Education, London

POSTDOCTORAL RESEARCHERS AND STUDENTS

Graduate students and postdoctoral researchers add an essential dynamic to the Centre, bringing a wealth of experience from their diverse backgrounds. These students include school principals, a psychiatrist and a cognitive neuroscientist who has just completed a postdoctoral position at Hitachi developing new tools to measure brain activity.

Sixteen new postdoctoral researchers distributed across all nodes of the Centre were recruited to the SLRC in 2014 taking the total number to 26. Of these, 19 are within 5 years of completing their PhD.

There were a total of 28 research higher degree students enrolled across the Centre in 2014, one of whom graduated. In addition to their primary advisor, these students are mentored by a Chief Investigator from another node or discipline who is aligned to their program of research. All except for one of the research higher degree students were enrolled in PhD courses.

SLRC researchers supervised a total of 13 Honours students who graduated in 2014. These students were predominantly from the disciplines of psychology and neuroscience. This distribution across disciplines reflects the structure of training in education, where a Master of Educational Studies coursework program or a PhD are more commonly undertaken than an Honours course.

Several Chief Investigators taught Masters by coursework courses, including the Masters of Neuroscience at the Queensland Brain Institute (Sah), the Masters course “Designing Technology-based Curriculum” at Macquarie University (Lockyer) and the Master of Educational Studies in The University of Queensland School of Education (Carroll). As part of the Masters of Neuroscience course taught by Professor Pankaj Sah, students learnt of the importance of synaptic plasticity to learning memory formation and neural development, through formal lectures and during their 3-month laboratory rotations. Dr Tim Bredy hosted a Masters of Neuroscience occupational trainee from Holland for six months, studying the consolidation of memory.

Postdoctoral Researchers

Dr George Aranda	Deakin University
Dr Amael Arguel [†]	Macquarie University
Dr Jeff Bednark [†]	The University of Queensland
Dr Rachel Buckley [†]	The University of Melbourne
Dr Sarah Buckley [†]	Australian Council for Educational Research
Dr Man Ching Esther Chan [†]	The University of Melbourne
Dr Caroline Cohrsen [†]	The University of Melbourne
Dr Anita D'Aprano [†]	The University of Melbourne
Dr Sacha DeVelle	Australian Council for Educational Research
Dr Florence Gabriel [†]	Flinders University
Dr Kelly Garner [†]	The University of Queensland
Dr Marcus Gray	The University of Queensland
Dr Susan Harding [†]	The University of Melbourne
Dr Helen Harper	Charles Darwin University
Dr Hilary Hollingsworth	The University of Melbourne
Dr Jason Lodge [†]	The University of Melbourne
Dr Lars Marstaller [†]	The University of Queensland
Dr Natasha Matthews [†]	The University of Queensland
Dr Greg McPhan	University of New England
Dr Frank Niklas [†]	The University of Melbourne
Dr Mariya Pachman [†]	Macquarie University
Dr David Painter [†]	The University of Queensland
Dr Kate Reid [†]	Australian Council for Educational Research
Dr Ursula Schwantner [†]	Australian Council for Educational Research
Dr Xiaoxun Sun [†]	Australian Council for Educational Research
Dr Ling Tan	Australian Council for Educational Research

Started in 2014

[†]Early career researcher (received PhD less than 5 years ago)

Dr Sarah Buckley

Australian Council for Educational Research

Sarah is a psychological and educational researcher interested in the role of motivation and emotion in learning. Sarah completed her PhD in 2009 at the University of Melbourne where she investigated mathematics anxiety and motivation in relation to peer relationships using longitudinal social network modelling. As part of her role in the Centre, Sarah is working with Dr Sue Thomson (ACER), Professor Ottmar Lipp (Curtin), Professor Merrillyn Goos (UQ) and Dr Kate Reid (ACER) examining the experience of mathematics anxiety for pre-service primary teachers. Sarah says "Working as part of a team at the SLRC is a wonderful opportunity to collaborate with people from different areas, with different perspectives, which has great benefits for the research that we are doing."



Dr Jason Lodge
The University of Melbourne

Jason is a psychological scientist with more than a decade of experience teaching in universities. His primary research interests are in the translation of neuroscience and psychological science to develop resources and approaches for enhancing teaching practice. He has a particular focus on applications involving educational technology in higher education and vocational training. Jason is working with Professor Gregor Kennedy (UM), Professor Lori Lockyer (Macquarie), Professor Ottmar Lipp (Curtin), Associate Professor Rob Hester (UM) and Dr Mike Timms (ACER) on an investigation of the role of confusion in technology-mediated learning. Jason commented, "I feel very fortunate to have the opportunity to be immersed in an innovative multidisciplinary culture in the SLRC. The Chief Investigators are leaders in their respective fields and it's a privilege and an inspiration to have the chance to collaborate with them."



Dr Rachel Buckley
The University of Melbourne

Rachel is a cognitive neuroscience postdoctoral researcher working with Associate Professor Rob Hester in the School of Psychological Sciences at the University of Melbourne. Her research interests span a range of areas including the role of performance monitoring and error-making in learning, the adaptation of learning behaviour in confusing environments, and the influence of metacognition on memory processes. She recently completed her PhD focusing on the predictive outcomes of subjective memory complaints in healthy adults. As part of the 'confusion group' Rachel is investigating confusion-related outcomes in learning, collaborating with Professor Gregor Kennedy (UM), Professor Lori Lockyer (Macquarie) and Drs Jason Lodge (UM), Amael Arguel (Macquarie) and Mariya Pachman (Macquarie). Together with Associate Professor Hester she is investigating the neural correlates of confusion using functional MRI paradigms. "The SLRC gives me the opportunity to communicate with education researchers, understand their research, and determine how we can complement and enhance their questions using neuroscience. There are no other platforms like the SLRC in Australia that break down the barriers between education and neuroscience in this way, and I think that is the strength of this collaborative research centre," she said.



Dr Helen Harper
Menzies Institute, Charles Darwin University

Helen is a linguist and educator with research interests in classroom interactions—what teachers say to students and how students respond—and the impact of these interactions on students' learning. Helen has lived in the Northern Territory for two decades and has specialised in developing approaches to teaching literacy, particularly to Indigenous students. She is now based at the Menzies Centre for Child Development and Education in Darwin. In her current project she works with middle school science teachers who teach students from remote Indigenous communities. Her study involves analysing authentic classroom interactions and measuring students' progress through linguistic analysis of their oral and written explanations. Helen says, "Our piece of the puzzle is to work at the pointy end of education and improve learning in real classrooms with some of the most disadvantaged kids. Through our collaborations with researchers across the Centre we will be able to further dissect and reconstruct the puzzle. This will have important implications for training teachers to work effectively with Indigenous students."



Dr Greg McPhan
University of New England

Greg's research background is in the area of science education and his research interests encompass the development of understandings, and teacher quality. He completed his PhD studies in 2005 at the University of New England. During his PhD he investigated students' developmental understanding of chemistry concepts using a cognitive structural model and concept maps. As part of his role in the Centre, Greg is working with Professor John Pegg (UNE), Professor Martin Westwell (Flinders), Professor David Reutens (UQ) and Dr Marcus Gray (UQ) investigating the neural correlates of problem solving in mathematics, particularly where conceptual development or the development of higher-order processing skills, knowledge and understanding are concerned. Of particular interest to Greg is the neuro-scientific basis of cognitive models, and of aligning the structural complexity of key learning skills in mathematics and science with brain functioning data.



Research Higher Degree Students

Angela Bender	The University of Queensland
Scott Bolton	The University of Melbourne
Amanda Bourgeois	The University of Queensland
Cameron Brooks	The University of Queensland
Megan Campbell	The University of Queensland
Yuan Cao	The University of Queensland
Paula de Barba	The University of Melbourne
Greg Donoghue	The University of Melbourne
Jacinta Duncan	The University of Melbourne
Kelly Garner	The University of Queensland
Michell Hall	The University of Queensland
Luke Hearne	The University of Queensland
Jared Horvath	The University of Melbourne
Dan Jazby	The University of Melbourne
Pavle Jeric	Macquarie University
Andrew Jones	The University of Melbourne
John Kuszniczuk	The University of Melbourne
Camilla Luck	Curtin University
Stephanie MacMahon	The University of Queensland
Sandra Milligan	The University of Melbourne
John Morris	The University of Queensland
Adrian Norman	Macquarie University
Natalie Rens	The University of Queensland
Greg Scott	University of New England
Clare Scoular	The University of Melbourne
Chase Sherwell	The University of Queensland
Tim Smith	The University of Queensland
Lauren Sperotto	The University of Queensland

Graduated in 2014

As ACER is not an educational institution it is unable to enroll students; however, its researchers are involved in the supervision and mentoring of SLRC students.

Greg Donoghue

The University of Melbourne

Before entering the field of educational neuroscience, Greg Donoghue worked in Victoria, in the Police Department, investigating serious crimes against children. It was this work which led him to his research interests in child protection, wellbeing and the science of learning. After completing his Master of Education at the Melbourne Graduate School of Education, he commenced his PhD under the supervision of Professor John Hattie (UM) and Associate Professor Rob Hester (UM), investigating children's foundational beliefs, and how these impact learning and wellbeing outcomes.

He is using insight-independent interventions including EEG and cognitive bias modification to measure and manipulate these beliefs. By far the best part of being in the SLRC, according to Greg, is the unique opportunity to collaborate with so many capable and intelligent scholars – so much so that he says he may never want to leave.



Adrian Norman
Macquarie University

Adrian is interested in the area of self-regulated learning in massive open online courses (MOOCs). Before commencing his PhD in 2012 he worked as a freelance E-Learning consultant and video producer for a range of clients in different sectors such as finance and health services. Becoming part of the centre has provided him with the opportunity to network with other researchers in the same field. Adrian says the best thing about being part of the SLRC is the diverse academic community—educators, neuroscientists and cognitive psychologists— all with the sole aim of better understanding how we learn. Adrian plans to submit his PhD thesis in early 2016 and is currently working on a longitudinal study investigating the experiences of early career teachers.



Camilla Luck
Curtin University

Camilla is interested in the interaction between associative learning and cognition, especially in the learning of complex behaviours like fear. In particular, she is interested in whether the acquisition and extinction of fear requires learning by experience or whether learning via instructions is sufficient to alter fear. After completing her Honours in 2012 at The University of Queensland, Camilla commenced her PhD with Professor Ottmar Lipp (Curtin) in 2013. “The best thing about being part of the SLRC is the opportunity to be part of a team working on so many different aspects of learning and seeing how such a diverse focus can translate into outcomes in the classroom,” says Camilla.



John Morris
The University of Queensland

John completed a first degree in neuroscience at Oxford before studying medicine at Guy’s Hospital in the United Kingdom. He subsequently trained as a psychiatrist at the Royal Free Hospital, before becoming a Clinical Research Fellow at the Functional Imaging Laboratory in Queen Square, where he studied emotional processing in the human brain using fMRI and PET. After moving to Australia, he joined Professor Pankaj Sah’s laboratory at the Queensland Brain Institute (UQ) studying partial reinforcement of fear conditioning in both animals and humans. John completed his PhD in 2014 and in 2015 will commence as a postdoctoral researcher in the SLRC and has a particular interest in how the brain deals with uncertainty and unpredictability during learning. He is keen to investigate how our understanding of the basic neuropsychology and neurophysiology of learning can be used to make a practical difference to teaching and learning in the classroom. “I think the best thing about being a member of the SLRC is being able to work with colleagues from other disciplines to make this a reality,” John said, echoing sentiments from other researchers on the integrative nature of the SLRC.

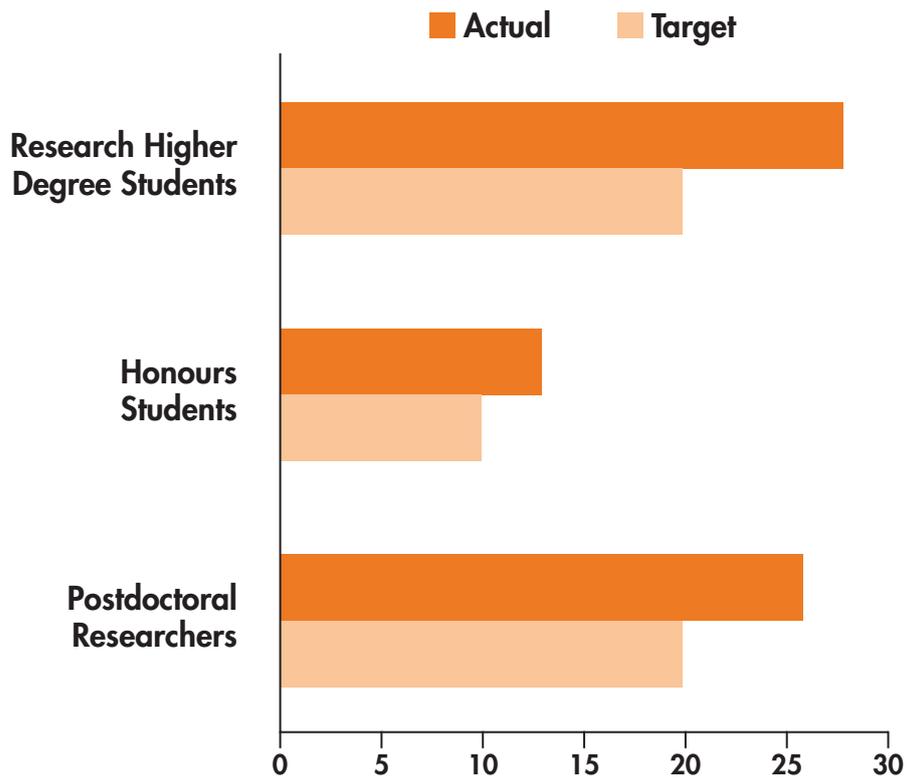


Cameron Brooks
The University of Queensland

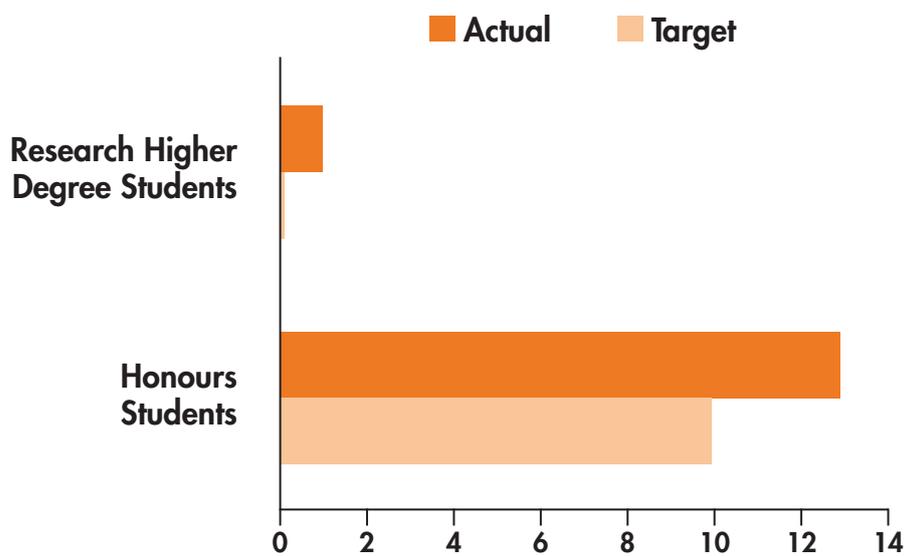
Cam’s research is focused upon the design and implementation of a feedback matrix that facilitates young adolescent students using feedback to improve their learning outcomes. He has been working with Associate Professor Annemaree Carroll (UQ) and Professor Robyn Gillies (UQ) since the beginning of 2013. Before commencing his PhD, Cam was a classroom teacher and Acting Deputy Principal. Becoming part of the Centre has provided him with the opportunity to network and discuss ideas and findings with researchers from other disciplines. Cam enjoys the breadth of expertise offered by SLRC members, and says “The best thing about being in the Centre is the opportunity to meet and work with a group of highly experienced experts in research.” Cam is scheduled to complete his PhD in early 2016.



Personnel working on core program research



Graduating Students



TRAINING AND DEVELOPMENT

One of the goals of the SLRC is to train the next generation of researchers to have a broad understanding spanning neuroscience, cognitive psychology and education who will continue to scrutinise learning strategies in a constantly evolving environment. The Centre achieves this goal by providing professional training and development for all research staff and mentoring programs for early career researchers.

Professional development and training

The SLRC ran a total of 10 training sessions tailored to Centre researchers throughout the year. In addition to this 26 students, researchers and Chief Investigators attended 18 training and professional development courses.

With the opening of the two experimental classrooms, workshops were hosted at each facility, and training in the use of equipment and analysis techniques was provided. At each of the Big Days Out in March and August presentations were given on the classrooms, the specific areas of research and the tools and methodologies involved. At the August Big Day Out in Adelaide, students and early-career researchers also participated in a workshop on communicating research presented by Mikaeli Costello, Director of Communications and Advancement at the Queensland Brain Institute, and Dr George Aranda, who specialises in the use of social media to communicate science.

SLRC Training Sessions

February	Introduction to the Educational Neuroscience Classroom Dr Natasha Matthews <i>held at Australian Council for Educational Research, Melbourne</i>	March	What we know from neuroscience Professor Pankaj Sah <i>held at Big Day Out, Melbourne</i>		
May	Neuroscience 101 Associate Professor Ross Cunnington <i>held at Social-cultural group meeting, Melbourne</i>	May	UQ MBI Matlab for Neuroscience Workshop Associate Professor Ross Cunnington <i>held at Queensland Brain Institute, Brisbane</i>		
August	Communications workshop Mikaeli Costello Dr George Aranda <i>held at Big Day Out, Adelaide</i>	August	SOLO: Structure of the Observed and Learned Outcome Professor John Pegg <i>held at Big Day Out, Adelaide</i>	August	Imaging 101 Professor David Reutens <i>held at Big Day Out, Adelaide</i>
September	Studiocode training Carmel Mesiti Cameron Mitchell <i>held at Learning Interaction Classroom, Melbourne</i>	October	Student engagement workshop Prof Mary Ainley Dr Ling Tan <i>held at Australian Council for Educational Research, Melbourne</i>	November	Eye tracking workshop Dr Kelly Garner <i>held at Educational Neuroscience Classroom, Brisbane</i>

Mentoring

In addition to the mentoring that all students and early career researchers receive from their primary supervisors, the SLRC has put in place 3 formal mentoring programs:

- **Educator mentorship**

The SLRC is privileged to have 5 teachers, including 3 school principals, studying within the Centre. On completion of their studies most of these teachers will return to the school, many in leadership roles. Professor John Hattie and Associate Professor Annemaree Carroll provide mentoring to this group.

- **Program mentorship**

The SLRC has seven programs running across its three themes. Within each program students and early career researchers are paired with a Chief Investigator from another node and/or discipline who is their program mentor.

- **Theme mentorship**

The three theme leaders, Professor John Hattie, Professor Ottmar Lipp and Dr Mike Timms each provide mentorship to the students and early career researchers in their themes of Promoting Learning, Understanding Learning and Measuring Learning, respectively.

SLRC Chief Investigators mentor in excess of 105 students and early career researchers, including 5 summer and winter research placements, 2 people involved in student placement programs, and 41 Honours and PhD students within the Centre.

Developing students and early career researchers

Dr George Aranda and Ms Mikaeli Costello's workshop on communicating research had everybody thinking at the Big Day Out at Flinders University in Adelaide



The year ahead

The SLRC already has three new students enrolled to do a PhD in 2015 including an international student who will be jointly supervised by Professors Sah and Hattie and Associate Professor Annemaree Carroll. He will spend part of his time working at the University of Melbourne as well as The University of Queensland. A new student will be recruited to work on a collaborative project between the SLRC and Hitachi, developing improved techniques to measure brain function during learning.

A teacher from the Queensland Department of Education, Training and Employment will join the Centre in 2015 as part of an internship program sponsored by the Department. The intern will have the opportunity to benefit from the mentoring and training programs offered by the Centre.

RESEARCH
3 THEMES
1 GOAL

**TO IMPROVE
LEARNING
OUTCOMES**

*“Research is to see what everybody else has seen,
and to think what nobody else has thought”*

—Albert Szent-Gyorgyi

The first full year of operation of the SLRC saw the emergence of a number of research programs. In the second half of 2014 the Executive Committee reviewed the research structure of the Centre, identifying seven programs of research running across the three existing themes: Understanding Learning, Measuring Learning and Promoting Learning. The Advisory Board in its December meeting endorsed the revised structure. Moving forward, the Centre comprises the three original research themes, each theme spanning the seven research programs.

RESEARCH THEMES

Understanding Learning

Professor Ottmar Lipp

Curtin University

Understanding the learning process is at the core of the Science of Learning Research Centre. Experimental neuroscientists, cognitive psychologists and educationalists are investigating the learning process in both humans and non-human animal models to gain a better understanding of the basic mechanisms that mediate learning. This new knowledge is being translated into practice to promote learning outcomes in real world settings such as school classrooms.

Understanding Learning is one of the three themes that form the pillars of the SLRC. The theme covers projects as diverse as the investigation of cellular mechanisms and cell circuits that mediate learning in rodents, the Educational Neuroscience Classroom-based investigation of the effects of mathematics anxiety on the behavioural and physiological responses to a mathematics test in pre-service teachers of primary school education, and the assessment of attentional and emotional self-regulation in students during a regular lesson in a school classroom setting. It brings together researchers from different backgrounds, who use a wide range of methodologies, in the pursuit of a common aim – understanding the learning process as it occurs. This approach has seeded a number of collaborations, which are now well developed and have progressed to the data collection stage.

Highlights of the activities within the theme

- Research within the theme is progressing well and has already yielded outcomes in terms of journal publications and PhD/Honours student graduations. Projects within the theme provide a fertile training ground for PhD students and post-doctoral researchers.
- The two experimental classrooms, the Learning Interactions Classroom located in the Graduate School of Education, the University of Melbourne, and the Educational Neuroscience Classroom, located in the School of Psychology, The University of Queensland, are now operational. Pilot studies for several projects within the theme have been completed in each and have yielded valuable information for the conduct of further studies.
- The Big Day Out meeting in Adelaide in August, 2014, which involved presentations on educational theories of human learning as well as neuroscientific methodologies including brain imaging, sparked a number of discussions among researchers from different disciplines which have led to applications of funding for new collaborations within the SLRC as well as for the provision of new research infrastructure from outside sources. This will, for instance, contribute to the implementation of a Science of Learning Laboratory within the School of Education at Macquarie University.



Measuring Learning

Dr Mike Timms

Australian Council for Educational Research



The development of new techniques for accurately measuring learning, both qualitatively and quantitatively, is essential for studying the learning process and in the development and validation of practices that promote learning.

During 2014 researchers in the Measuring Learning theme have developed their skills and experiences of measuring learning by training in new techniques and via collaborative work on several projects. Professor David Reutens gave an overview of the various imaging techniques and how these can be used to measure changes in brain function during learning at the Big Day Out in Adelaide in August. He compared the spatial and temporal resolution available when using functional magnetic resonance imaging (fMRI), positron emission tomography (PET) and computed tomography (CT).

Throughout the year, research teams across the Centre continued to work on projects that involved measuring different aspects of learning including measurement of attention, anxiety, automaticity, cognitive control processes, collaboration/collaborative problem solving, confusion, engagement, emotional state/emotional regulation, “mirroring” and response to feedback/impact of hints.

Research groups in the Measuring Learning theme held regular meetings every few weeks involving researchers from various institutions including the Australian Council for Educational Research, the University of Melbourne, Macquarie University, Deakin University, Curtin University, The University of Queensland; and investigators at Partner Organisations, the University of London and North Carolina State University. Researchers in the theme are developing research designs and methods that combine approaches from educational research, cognitive psychology and neuroscience, making it possible to measure learning in fine grain under laboratory conditions as well as at larger grain sizes in more classroom-like settings, and to make connections between these two ends of the educational neuroscience research spectrum.

2014 highlights include

- In June five researchers attended the 7th International Educational Data Mining conference in London where they attended workshops on Epistemic Network Analysis (ENA), Graph-based Educational Data Mining (G-EDM) and Cluster Analysis. They also attended conference paper sessions and two researchers presented their paper on a method to measure student attention from log data gathered in intelligent learning environments.
- Researchers attended a training session at the SLRC’s Learning Interactions Classroom where they learned how to gather and analyse data using biometric wristbands.
- Researchers attended a training session at the SLRC’s Educational Neuroscience Classroom where they learned how to set up an experiment using eyetracking equipment, gather data and do basic analyses using custom software.

Promoting Learning

Professor John Hattie

The University of Melbourne

The ultimate goal of the SLRC is to promote learning outcomes, incorporating new knowledge of the learning process – obtained through improved and novel measurement tools – into practice.

Indigenous education

A group of Chief Investigators and leading Aboriginal researchers attended a workshop in October on a paper written by Australian Council for Educational Research's Tony Dreise, entitled "Background, Scoping and Discussion Paper on the topic of science of learning from Indigenous perspectives." The aims were to gain stronger insights into the distinction between universal quality teaching techniques for all learning environments and specialist quality teaching techniques for Indigenous contexts; to employ a wider lens to Indigenous learning science than is provided by neuroscience alone, by taking into account psychological, social, historical, economic, intergenerational and cultural considerations; and to illuminate the efficacy of particular interventions and approaches to learning being investigated in the SLRC. Various projects relate to this theme, including specific programs: incorporating joint attention and feedback for pre-school and schoolchildren; the value of learning measured in remote communities; the impact of a second chance intervention (Abercedarian); progressing learners through sequential stages of learning; validation of the ASQ3-TRAK developmental screening tool for use with Australian Aboriginal children; the effect of adult prompts and feedback on children's learning and development; and literacy, metalinguistic knowledge and dialogic teaching in Indigenous and other authentic educational contexts.

Learning in digital environments

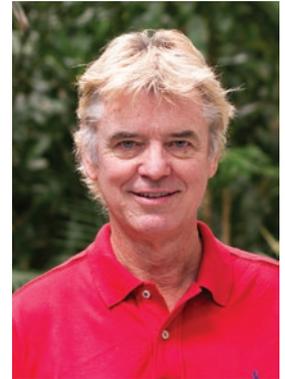
The last 20 years has seen an exponential increase in the use of digital technology for learning. In this program researchers will develop methodologies for monitoring learning behaviour in digital environments and identify the key attributes necessary to deliver optimal learning outcomes, taking into account particularly our knowledge of feedback and attention in the learning process. Projects underway in 2014 include: learning in digital environments; learner processing of feedback in intelligent learning environments; measurement methodology in digital learning environments; modelling hint effectiveness in digital learning environments; and predicting learner confusion for enhanced feedback and self-regulation.

Instructional practice

Researchers in the Centre are working closely with teachers and their classes to understand how our knowledge of learning processes is being adapted for instructional practice, such as collaborative learning, use of multi-modal representations, feedback and attention; and to validate and advance these practices. Specific projects that commenced in 2014 include: Literacy, metalinguistic knowledge and dialogic teaching in Indigenous and other authentic educational contexts; using joint attention sequencing to promote expressive language learning; how students solve problems through coordinating multimodal representations—reasoning and learning through constructing representations in science; dyadic and small group interactions in mathematics and science; teacher learning, teacher knowledge, selective attention and decision-making; the role of knowledge-based frameworks and active knowledge creation during collaborative inquiry science in the middle-years; and understanding and promoting interdisciplinary research.

Highlights for the year include:

- Professor Hattie delivered the Vernon-Wall lecture at the British Educational Psychological Association presenting, the first results from the synthesis of meta-analyses and studies (based on approximately 15 million students), and has since presented the findings at more than 12 conferences/workshops throughout the world.
- At the Big Day Out in Melbourne in March Professor David Clarke gave a presentation to the Centre on the videoing facilities in the Learning Interaction Classroom. He gave several examples of how the videoing capability can be used to dissect and reconstruct particular learning events in various settings such as during group work and in the use of multi-modal representations.



RESEARCH PROGRAMS

The Learning Process

State of the learner

The state of a person affects their level of learning achievement. This program investigates the effect of emotional states such as anxiety, belief states and empathy on learning outcomes and develops and tests specific interventions.

Role of feedback and reinforcement

Feedback is one of the most powerful influences in achievement but it is also among the most variable in its influence. Researchers are investigating the effect of feedback and reinforcement paradigms on learning outcomes. Knowledge gained in this program is being used to develop guidelines for the delivery of feedback in various scenarios, including classroom and digital environments.

Attention and self-regulation

Attention and self-regulation have been hypothesised to play key roles in learning and classroom performance. This program characterises attentional processing and self-regulation and how these processes influence learning. It also aims to understand how these processes can be enhanced through feedback and cognitive training.

Stages of learning

We know that if a student does not have a good grasp of the basics they will not succeed as a task becomes more difficult. One major challenge in learning is knowing when a student is ready to move on to the next concept and how to progress a student from one stage to the next. Such knowledge will inform pedagogical practice by improving understanding of how basic knowledge use is transformed from a slow and effortful process to a rapid, habitual and automatic process within the brain.

Incorporating the Learning Process into Practice

Indigenous education

The SLRC Indigenous education program spans learners of all ages—from early childhood to adult. Specific programs incorporating joint attention and feedback for preschool and school children are being developed and the impact on learning measured in remote communities. The impact of a second chance intervention, progressing learners through sequential stages of learning, will be investigated in adult learners.

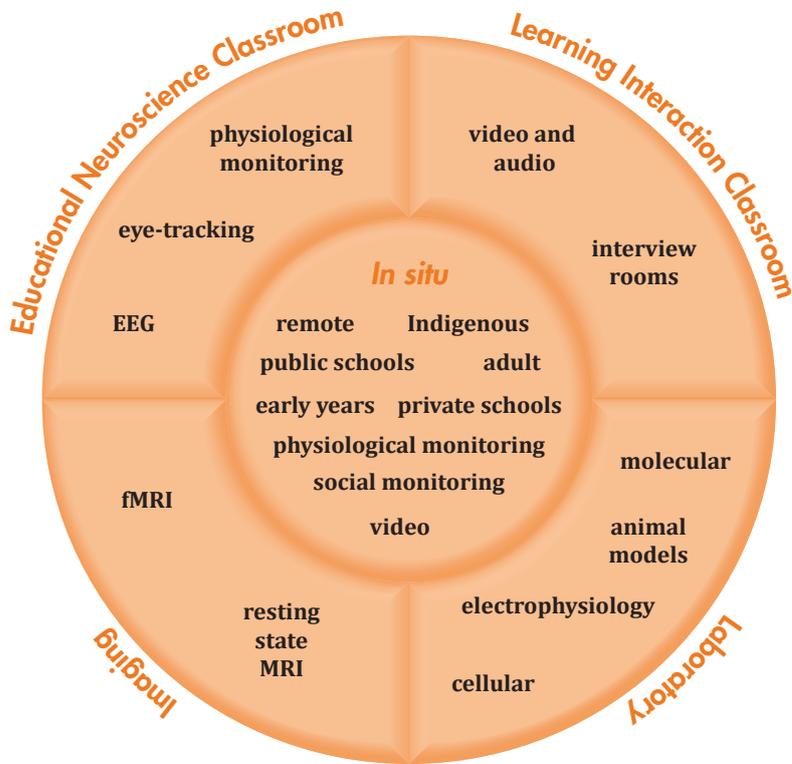
Learning in digital environments

The last 20 years has seen an exponential increase in the use of digital technology for learning. In this program researchers are developing methodologies for monitoring learning behaviour in digital environments and identifying the key attributes necessary to deliver optimal learning outcomes. In particular, in developing new methodologies researchers are taking into account new knowledge of feedback and attention in the learning process.

Instructional practice

Researchers in the Centre are working closely with teachers and their classes to understand how our new knowledge of the learning processes can be accommodated in instructional practice, such as collaborative learning, use of multi-modal representations, feedback and attention. This knowledge is being used to validate and further advance these practices.

RESEARCH INFRASTRUCTURE



The SLRC infrastructure makes it possible for researchers to study learning at various levels of granularity from in situ in the school classroom to the cellular level within the laboratory. The ability to study learning at various degrees of magnification, whilst at the same time monitoring authenticity in a natural classroom setting, greatly enhances the strength of the research.

In situ

The SLRC is observing, trialling and validating strategies for learning in the classroom in early childhood, primary, secondary and tertiary settings across Australia, including rural Indigenous communities. In 2014 the Centre worked with teachers and students from more than twelve schools across four states and territories including Victoria, Queensland, the Northern Territory and South Australia.

Investigating how students solve problems in science

Children at Holy Spirit School, Bray Park, Queensland are helping SLRC researchers investigate how students use different representations, while engaged in cooperative problem-solving activities.

"The project is focusing on how teachers teach students to use the different multi-modal representations in the science unit and how the students use these representations during their small cooperative group activities," Professor Russell Tytler from Deakin University's School of Education explains.

Some of the questions being addressed by the research include:

1. What approach does an exemplary teacher adopt when using representational tools during cooperative inquiry science?
2. What are the effects of different representational tools on students' conceptual understandings, dialogic processes, motivation, and learning?
3. How do these literacy resources and social processes affect learning at the individual level?
4. What physiological states of alertness and arousal during learning activities are associated with the best outcomes?



This study is unique in that not only are the interactions of teachers and students being videoed, but physiological measures of alertness and arousal during teacher-student interactions and small group discussions are also being recorded.

"The measures of heart-rate and skin conductance give an index of the physiological level of arousal which has a well-known U-shaped relationship with optimal cognitive performance," explains cognitive neuroscientist Associate Professor Ross Cunnington from The University of Queensland.

Professor Robyn Gillies from The University of Queensland's School of Education adds, "We hope to be able to identify and develop classroom strategies and competencies for teachers using different multi-modal representations when teaching science, and at the end of the day, to enhance students' interest in science as a way of understanding their world."

"The students have adapted effectively to the filming and collection of data for the science lessons and there has been no negative impact on their learning. The research staff have been very professional and supportive to myself and the students in this type of learning environment. The children all realise the importance of the project and feel privileged to be involved in this type of research," explains Year 5 teacher Mr Bernie Griffith.

Learning Interaction Classroom

Classroom Director – Professor David Clarke (The University of Melbourne)

The **Learning Interaction Classroom** is a unique, cutting edge facility located in the Melbourne Graduate School of Education at the University of Melbourne. Physically structured like a conventional classroom, this complex facility offers researchers the opportunity to engage in fine-grained analyses of classroom interactions at an unprecedented level of detail. Lessons given in the classroom may be recorded through up to sixteen video cameras and thirty-two audio channels. High Definition video data, computer or tablet screen capture and high quality audio files are all synchronised at the time of capture allowing for comprehensive recording of all aspects of classroom practice and efficient retrieval and viewing of different angles and different elements of the recorded learning interactions.

The Classroom technical team of Cameron Mitchell and Peter “Reggie” Bowman has provided advice to a wide range of SLRC projects with regard to technical design of a variety of new research projects. Ongoing collaborations with industry partners in the development of entirely new software tools for video data generation, analysis and management match the increasing scale and detail of these research projects. The team recently conducted two StudioCode workshops at the new facility to introduce Centre members to this sophisticated data analysis tool.

Researchers involved in the following projects have most recently made use of the Science of Learning Research Classroom: (1) Making sense of feedback in a digital environment; (2) Assessment of students' emotions during interaction with computer-based collaborative problem solving; and (3) Motivation and autonomous learning in online environments: a preliminary study.

Making sense of feedback in a digital environment

Researchers in the SLRC are investigating feedback in digital learning environments—how learners process and make sense of it? The study uses behavioural and neural research methods such as observation, computer log data, eyetracking, biometric data and EEG to understand the neural responses to feedback when students are using intelligent learning environments.

Intelligent learning environments developed by researchers at Partner Organisations North Carolina State University and Carnegie Mellon University are being used in this study. Dr Mike Timms explains, “The intelligent learning environments that we are using in this study track student progress as they work through tasks in science and maths, providing feedback when the system judges that it is needed. What we are interested in is whether students are actually noticing and attending to the feedback that the system provides. Designers of such systems take care to craft helpful and informative feedback, but there are a lot of factors, such as individual differences among learners, that can interfere with the use of that feedback. If the student is not processing the feedback that is offered, then they will not benefit from it. It is that process that we are examining in this study.”

The study has just completed the first phase of the research in which year 7 and 8 students participated in 31 sessions to use Crystal Island, a 3-D game-like environment in which students investigate the causes of diseases, and Maths Tutor, in which they tackled problems involving fractions. The cognitive laboratory sessions took place in the Learning Interaction Classroom where video data, screen capture and biometric wristband data were collected.

“We can track students’ alertness and stress levels by measuring changes in their heart rate and skin sweating that are controlled by the brain. The biometric wristbands are a non-invasive way of measuring alertness and stress levels in students whilst they are engaged in learning activities” explains The University of Queensland researcher Associate Professor Ross Cunnington. Data from the wristbands and the other sources are being analysed and preparations will then be made for the second phase of the study that will take place in the Educational Neuroscience Classroom facility at The University of Queensland in 2015.

At the end of the study researchers hope to have developed and tested a model of how students attend to, process and act upon feedback offered to them in intelligent learning environments. Understanding this sequence in more detail will allow researchers to develop guidelines for the design of effective feedback systems in intelligent learning environments.



Educational Neuroscience Classroom

Classroom Director – Professor Jason Mattingley (The University of Queensland)

The **Educational Neuroscience Classroom**, located in the School of Psychology at The University of Queensland, brings together state-of-the-art equipment for the measurement of brain activity, eye movements, physiological responses (such as heart rate and breathing rate) and behaviour. This is a multi-modal approach to assess factors that contribute to successful learning. The design of the virtual classroom allows for up to four research participants (adults or children) to be tested simultaneously.

Dr Natasha Matthews, the Classroom Research Manager, oversaw the establishment of this unique research facility in 2014. Dr Matthews was also instrumental in providing training and support for Centre members intending to use the facility. Specifically, she provided researchers with the theoretical and practical bases for using the equipment in the classroom, including how to optimise the design of experiments to answer research questions aimed at understanding the cognitive-neuroscientific mechanisms of learning. Dr Matthews delivered a presentation on this topic to research groups based in Melbourne. As part of her role in providing technical training, Dr Matthews also delivered tutorials in Brisbane on how to collect data and analyse the results.

Some of the research projects ongoing in the Educational Neuroscience Classroom are: (1) Components of contextual effects on hippocampal-mediated learning; (2) Feedback in virtual learning environments; and (3) Neural markers of attentional readiness.

Neural markers of attentional readiness

This project is a cross-disciplinary collaboration between cognitive neuroscientists Professor Jason Mattingley, Associate Professor Paul Dux, and Dr Natasha Matthews, and education academic Associate Professor Annemaree Carroll. The aim of the project is to identify neural markers of attentional readiness for learning in adults and children. Previous research has shown that our ability to successfully remember and pay attention to new information depends upon the current state of neural oscillations in the brain. If the amplitude of these oscillations is high, then the amount of information that can be followed or remembered is reduced. By contrast, if the oscillation amplitude is low, information is better followed and remembered.



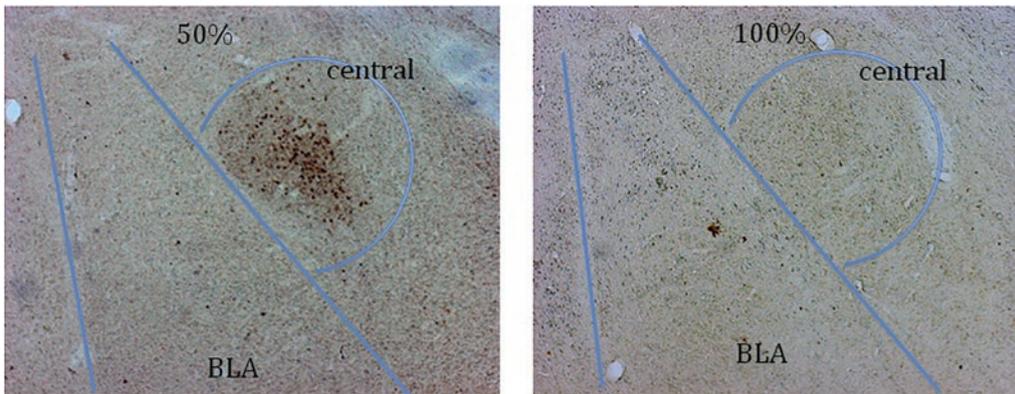
Phase 1 of the project will be conducted in the Educational Neuroscience Classroom and will make use of the unique resources available in this facility. Electroencephalography (EEG) will be used to record ongoing changes in the amplitude of brain oscillations underlying attentional readiness, while research participants perform an education-relevant task—in this case mathematics problems that progressively increase in difficulty. In addition, eye-tracking will be used to monitor how pupil diameter (a proxy measure of attentional effort) also changes with both the difficulty of the mathematics problems and attentional readiness. The aim of Phase 1 is to determine how attentional readiness impacts upon our ability to engage in mathematics tasks, and to develop predictors of future mathematics performance.

The aim of **Phase 2** is to improve attentional readiness using various forms of cognitive training. The effectiveness of this training will be tracked using EEG and eye-tracking methods, again utilising the Educational Neuroscience Classroom.

In **Phase 3**, researchers will translate what they have learnt about the relationship between attentional readiness and learning to “real-world” classroom environments in participating schools, with the aim of improving attentional focus and learning in the classroom.

Molecular laboratory

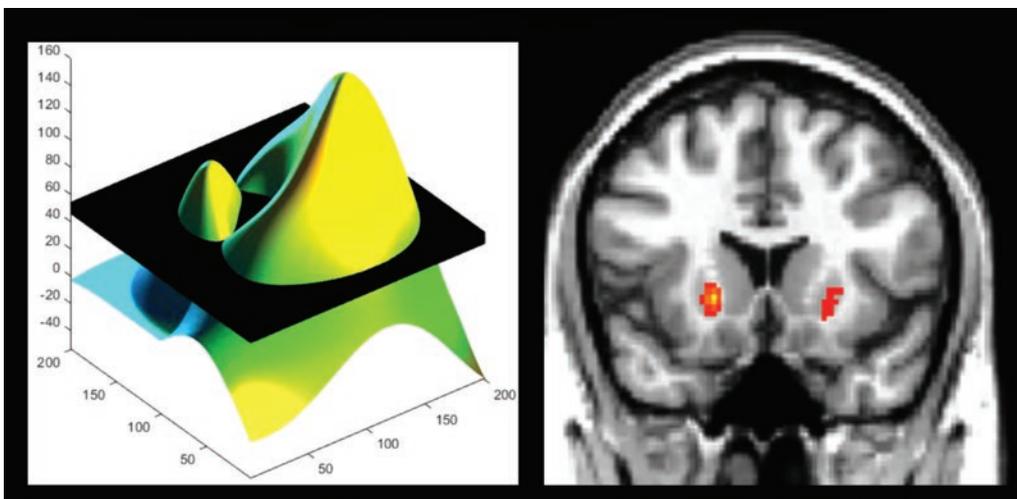
Changes in the brain during learning are being identified and measured at a molecular level at The University of Queensland.



Partial Reinforcement Extinction Effect (PREE): Sections of rat amygdala showing neuronal activity one day after acquisition of learning (Pavlovian conditioning) during an extinction session. Active cells are shown by staining for p-ERK, a protein involved in synaptic plasticity. Rats receiving unpredictable, partial (50%) reinforcement during learning had much greater activity in lateral central amygdala than rats receiving predictable, consistent (100%) reinforcement. This is known as the partial reinforcement extinction effect (PREE).

Imaging

Functional magnetic resonance imaging (fMRI) is being used to monitor changes in brain activity and structure at an anatomical level.



Insight, reflex and reflection: This research focuses on two fundamental features of learning; the acquisition of knowledge automaticity, and on the subtle transfer between explicit and implicit learning systems centered in the hippocampus and basal ganglia.

Insight, reflex and reflection

Insight may occur by reflection or by reflexive recall; both are important mechanisms which develop throughout primary and secondary education. As students continue to learn, problems which were initially solved by conscious problem solving (reflection) can be solved automatically, allowing new and more complex



learning to occur. Understanding how this fundamental balance of reflective versus reflexive problem solving is achieved in the brain is important. By applying computational modelling to neuroimaging data, this research will advance knowledge of how activity in specific neural circuits underpin the basic mechanisms of learning. This highly inter-disciplinary project carried out through the SLRC brings together expertise in education, psychology, neuroscience and neurology. Core researchers include Dr Marcus Gray and Professor David Reutens from the Centre for Advanced Imaging at The University of Queensland, Professor John Pegg and Dr Greg McPhan from The National Centre of Science, ICT, and Mathematics Education for Rural and Regional Australia (SiMERR) at the University of New England, and Professor Martin Westwell from the Flinders Centre for Science Education in the 21st Century (Science21), at Flinders University.

Early learning study

Child-initiated and adult-mediated conversation, playful interactions and learning through involvement are integral to young children's development. This SLRC Early Learning Study (ELS), through three focused sub-studies, sets out to explain the effects of particular types of adult-child engagement on young children's development, and also proposes to validate measures of very young children's development in remote Aboriginal communities using the Learning Interaction Classroom.



ELS one is a field study being conducted in Alice Springs to clarify, in the teaching-learning process, the relative contributions of teachers' contingent prompts, teachers' contingent feedback, and young children's contingent responses as contributors to child outcomes. This leg of the project is being led by Professors Collette Tayler (UM) and Sven Silburn (CDU).

ELS two is a study of the functioning of ASQ3-TRAK developmental screening instrument to determine if the tool measures and detects developmental problems accurately in the remote Aboriginal population and to undertake standardisation with scoring norms established for this population. Dr Anita D'Aprano (UM) is working on the implementation and analyses of this research. This will determine what the normal distribution of results from this test would be in the remote Australian Aboriginal population.

ELS three is a laboratory study to test the efficacy and effects of a specific pedagogical strategy that is based on joint attention, where the adult joins their attention to the child's, and will be carried out in the Learning Interaction Classroom in Melbourne.

Knowing when confusion sets in

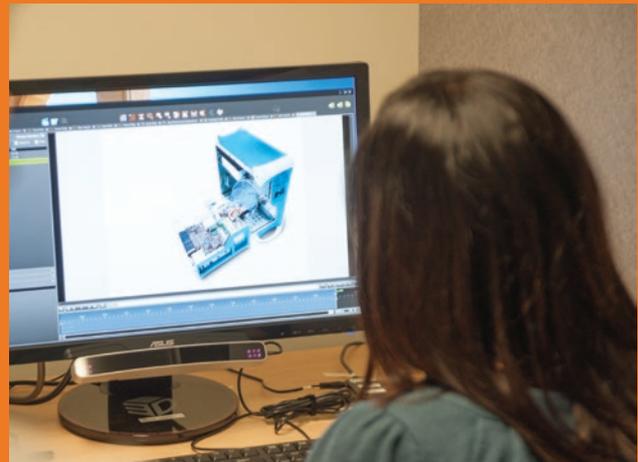
At what point do learners become confused while engaging with complex online learning tasks? Can confusion be predicted? And what are the consequences of confusion for further learning? These are some of the questions being addressed in the Feedback and Reinforcement program.

While confusion can be overcome by learners and be a precursor to productive learning, SLRC researchers are particularly interested in non-productive confusion that leads to lack of progress, anxiety and maladaptive responses from the learner.

Through a series of empirical studies in laboratory-based settings and in the Learning Interaction Classroom and the Educational Neuroscience Classroom, the team is establishing whether predictive models of learner confusion can be established for complex online learning tasks.

Building on their prior research on technology-enhanced learning, Professor Gregor Kennedy (UM), Professor Lori Lockyer (Macquarie), and Dr Mike Timms (ACER) are employing electronic learning environments that permit fine grained assessments of students' learning as they engage with increasingly complex materials. Professors Ottmar Lipp (Curtin) and Rob Hester (UM) are investigating whether changes in cortical (EEG) or peripheral (heart rate, electrodermal response) biomarkers are predictive of confusion and learner error in these environments.

This research will aid understanding of the relationship between behavioural, cognitive and physiological markers of student learning and facilitate the prediction and design of appropriate responses to student confusion. This foundational work will form the basis for two inter-related streams of research which will focus on (i) understanding when and how to provide feedback to students who flounder in complex online learning environments so that they can remain on task and (ii) understanding when and how scaffolds can be provided to students in complex online learning environments so that self-directed learning is promoted and non-productive confusion is minimised.



The year ahead

With the Educational Neuroscience Classroom and Learning Interaction Classroom now fully operational and many new collaborations established, 2015 promises to be a year of significant research output. Theme leaders will run workshops for the respective themes during the course of the year. Research updates will be presented at the Big Days Out in May and August. This provides an opportunity to monitor the progress of research across the various programs, provide valuable feedback and ensure programs are on track and appropriately resourced.

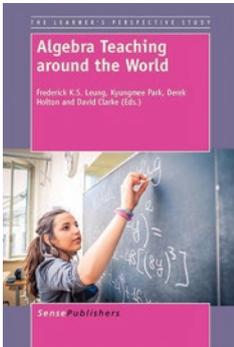
RESEARCH OUTPUT

“Information wants to be free”

—Stewart Brand

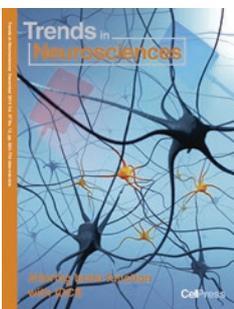
PUBLICATIONS

In 2014 the Centre produced 84 publications, 6 of which were co-authored by Chief Investigators from different nodes and/or disciplines. SLRC research featured in 41 peer reviewed journals and 32 conference publications. Researchers contributed to 10 book chapters and co-edited 1 book. Highlights of the year include



Leung, F., Park, K., Holton, D., & **Clarke, D.J.** (Eds.) (2014). *Algebra Teaching around the World*. Rotterdam: Sense Publishers. This book is one in a series co-edited by Professor David Clarke that focuses on the learner's perspective.

Professor Clarke is using the Learning Interaction Classroom to investigate how social-cultural interactions affect the learner's perspective.



Filmer, H.L., **Dux, P.E.**, & **Mattingley, J.B.** (2014). Applications of transcranial direct current stimulation for understanding brain function. *Trends in Neurosciences*, 37, 742-753.

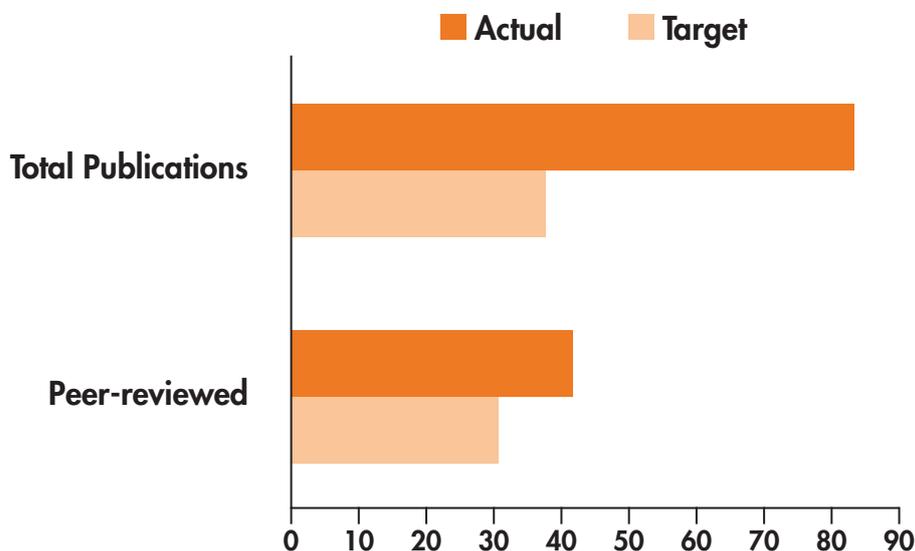
This publication by two SLRC chief investigators featured on the cover of Trends in Neuroscience.

Li X., Wei W., Zhao Q., Widagdo J., Baker-Andresen D., Flavell C.R., D'Alessio A., Zhang Y. and **Bredy T.W.** (2014). Neocortical Tet3-mediated accumulation of 5-hydroxymethylcytosine promotes rapid behavioral adaptation. *Proceedings of the National Academy of Sciences*, 111(19), 7120-5.

This study of the epigenetic mechanisms involved in the regulation of gene expression underlying learning and memory by Dr Tim Bredy published in Proceedings of the National Academy of Sciences was recommended by Faculty of 1000.

A full list of publications is in Appendix 1.

Research Output



COMMUNICATING SCIENCE

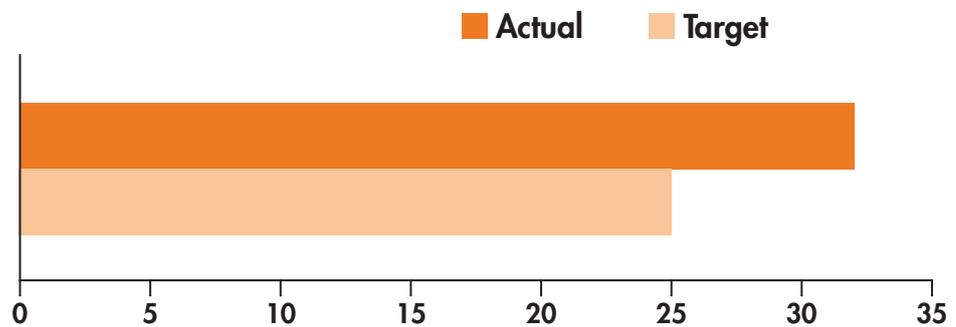
Invited talks, papers and keynote lectures

Centre researchers delivered over 80 presentations at national and international conferences, 32 were at major international conferences.

Major conferences included:

- 12th International Cognitive Neuroscience Conference, Brisbane, Australia. Held at the Brisbane Convention and Exhibition Centre, the conference attracted over 600 delegates. Four SLRC researchers gave lectures at this conference, including Professor Jason Mattingley who delivered a keynote lecture.
- 38th Conference of the International Group for the Psychology of Mathematics Education and the 36th Conference of the North American Chapter of the Psychology of Mathematics Education, Vancouver, Canada. Professor David Clarke presented his multi-authored examination of mathematical tasks and the student at an invited research forum.
- 30th International Congress of Clinical Neurophysiology, Berlin, Germany. Associate Professor Ross Cunnington was an invited speaker at the Congress that had over 2,000 attendees.
- The 9th Conference of the International Test Commission, San Sebastian, Spain. Professors John Hattie and Patrick Griffin delivered a keynote presentation on the measurement of learning.

Number of invited talks/papers/keynote lectures given at major International events



Commentaries

SLRC research featured in all forms of media: television, newspaper, radio and on-line. The SLRC Quarterly Bulletin is distributed electronically to over 500 recipients.

February

Associate Professor Annemaree Carroll – Australian Educator - Mind over matter
SLRC Quarterly Bulletin – Q1

March

Dr Jason Lodge - Campus Review - Online study debate rages
Dr Jason Lodge - Campus Review - A new look at how to teach and learn
Dr Jason Lodge – The Conversation- The campus is dead: long live the campus?

April

Professor David Clarke – Herald Sun - Classroom technology to track student every move
Professor David Clarke – 774 ABC Melbourne – Interview with Red Symons
Dr Jason Lodge - ABC Local Radio, South Australia - Interviewed live on air as expert commentator on national educational policy
Dr Jason Lodge - The Guardian - Students: bring your own technology to uni. Asking students to use their own tech in lectures could save money, but will it damage attention spans?
Dr Jason Lodge – The Guardian – As laptop scheme ends what next for families and learning?

May

Professor David Clarke – Channel 7, Melbourne – World first trial revolutionising learning
Dr Jason Lodge - ABC Radio National, Life Matters with Natasha Mitchell, Nation-wide - Interviewed live on air as expert commentator on learning and technology
Dr Tim Bredy – Brisbane Times – Cure for Phobia
SLRC Quarterly Bulletin – Q2

June

Dr Jason Lodge – The Conversation – Higher ed changes will lead to higher fees, more online delivery

July

Professor Martin Westwell – ABC radio, North and West South Australian – On work with schools in Port Augusta an Quorn
Professor John Hattie – The Australian – Goodbye, Mr Tomlinson

August

Professor John Hattie – Grande Prairie Daily Herald-Tribune – Aussie research teaches GP teachers
Professor Ottmar Lipp – ABC Online - Science Week: Psychologists research how people can overcome phobias

August continued

Professor Ottmar Lipp - Capital City Daily – Freaky phobias
Professor Ottmar Lipp – Capital City Daily – Wiggle phobia
Professor Gregor Kennedy – The Conversation – MOOCS: learning about online learning one click at a time
SLRC Quarterly Bulletin – Q3

September

Dr Jason Lodge – The Conversation – What is the point of assessment in higher education anyway?
Professor Ottmar Lipp – Curtin FM – Phobias
Professor Pankaj Sah – The Project – Memory and learning

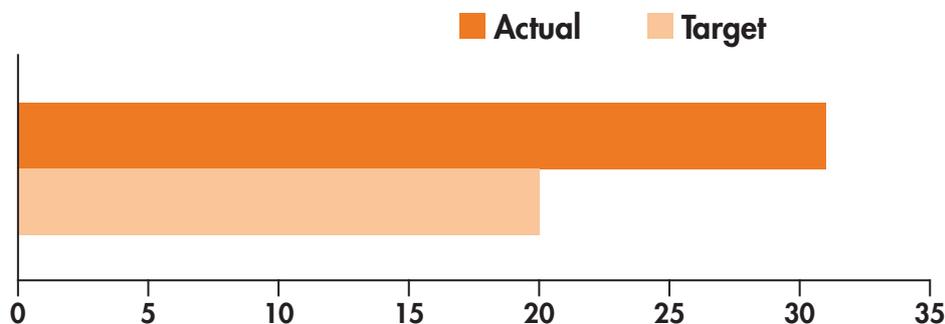
October

Dr Jason Lodge - Triple J Hack, Triple J Network (national) - Consulted as expert commentator on test anxiety and effective learning strategies

November

Professor Ottmar Lipp – ABC radio, Ballarat – What grabs a person’s attention
Professor Brian Butterworth – ABC Science Show with Robyn Williams – Counting fish
SLRC Quarterly Bulletin – Q4

Commentaries about the program’s achievements



The year ahead

There are already over 10 papers in review and in press, which will be published in 2015. A special edition of a Nature Publishing Group journal will be published in the second half of the year featuring new research and reviews by SLRC researchers.

In April the SLRC is hosting a symposium which will cover three main themes – neuroscience and learning, learning in the digital age and trends in policy which will be attended by education policy makers from around the country.

**INTERNATIONAL,
NATIONAL AND
REGIONAL**

**LINKS AND
COLLABORATIONS**

“Alone we can do so little; together we can do so much”

—Helen Keller

INTERNATIONAL VISITORS

The SLRC hosted 17 visitors across its nine nodes.

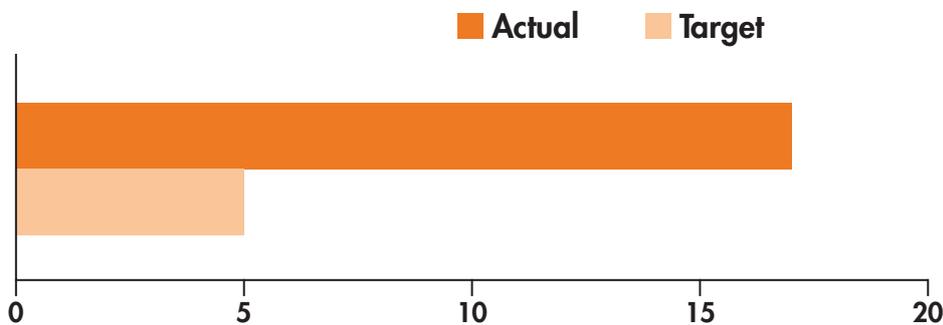
The SLRC's two Partner Investigators Professor Diana Laurillard (Institute of Education, London) and Professor Brian Butterworth (University College London) visited from the United Kingdom in the second half of the year. During their visit to Australia they spent time at The University of Queensland, the University of Melbourne, and the Australian Council for Educational Research. They generously gave workshops in both Brisbane and Melbourne for SLRC researchers and educators.

A delegation from the United Arab Emirates visited The University of Queensland in May. They spent time with the Centre Director Professor Pankaj Sah exploring potential collaborations with the SLRC. Following the visit, Professor Sah worked with Emirates College of Advanced Education to help secure funding to support a collaborative project in the science of learning in Abu Dhabi.

Professor Emmanuel Manalo from the Graduate School of Education at Kyoto University spent time with Pankaj Sah at The University of Queensland. In the past Dr Manalo has collaborated with several SLRC researchers including Professor John Hattie (UM) and Associate Professor Annemaree Carroll (UQ). The Centre is exploring potential new collaborations, including the joint supervision of a student, with Dr Manalo.

Professor David Clarke hosted Professor Markku Hannula from the University of Helsinki in the Learning Interaction Classroom at the University of Melbourne for three months from September to December. Whilst visiting Australia Professor Hannula gave seminars on the use of gaze tracking to study student attention and collaborated with Professors Clarke and Tytler on methods for capturing student interaction and attention.

Number of international visitors and visiting fellows



OVERSEAS VISITS

The science of learning is an emerging field and in the last 12 months SLRC researchers visited 23 existing and potential collaborators in over a dozen countries.

Dr Mike Timms (ACER) spent time in March at Partner Organisation North Carolina State University planning the next phase of the Learner Processing of Feedback in Intelligent Learning Environments project.

In July Dr Timms and Dr Sacha DeVelle (ACER) visited Partner Investigators Professors Brian Butterworth and Diana Laurillard in the United Kingdom to review the research plans for the Feedback study and to discuss future collaborative work. During his visit, Dr Timms also visited Professor Andy Tolmie of the Centre for Educational Neuroscience at the University of London.

Associate Professor Annemaree Carroll met with leading science of learning researchers Professor Sarah-Jayne Blackmore at the Institute of Cognitive Neuroscience, University College London and Professor Paul Howard Jones at the Centre of Mind and Brain in Educational and Social Contexts, Graduate School of Education, University of Bristol.

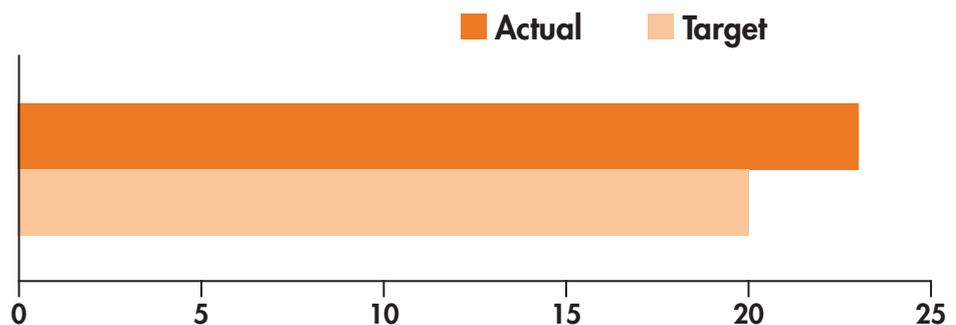
Professor Pankaj Sah spent time in the United Arab Emirates in November, visiting both the Australian Council for Educational Research office in Dubai and the Emirates College of Advanced Education in Abu Dhabi. With the assistance of the SLRC the Emirates College of Advanced Education secured funding for research into the science of learning, the SLRC hopes to build this relationship into a joint research program.

In May Professor Jason Mattingley visited Professor Hideaki Koizumi at Hitachi in Japan. The SLRC is collaborating with Hitachi to develop improved tools for correlating brain activity with learning.

In July 2014 Dr Mike Timms and Dr Sacha DeVelle met with SLRC partners Professor Brian Butterworth and Professor Diana Laurillard at the London Knowledge Laboratory, Institute of Education, United Kingdom. The meeting involved a one-day workshop to discuss the experimental methodology and steps forward for the project 'Optimising Feedback within Intelligent Learning Environments'.



Number of visits to overseas laboratories and facilities



CENTRE WORKSHOPS

The Centre held three public workshops throughout the course of the year, two in Brisbane and one in Melbourne, attended by researchers and teachers. There was also a workshop at the Learning Interaction Classroom, the topic being the *study of socio-cultural interactions in learning*.

The Wonders of Maths Workshop



Dr Stuart Kohlhagen from SLRC Partner Organisation Questacon had the audience of around 40 people enthralled during the workshop The Wonders of Maths.

The Dean of Curriculum and Scholarship at Brisbane Girls Grammar School, Mr Bruce Addison reflected, "I thought it was just a wonderful session. Wonder is so important. My science colleagues are still laughing at my scientific innocence!!!"

The SLRC is grateful to Brisbane Girls Grammar School for hosting the workshop.

Dyscalculia workshops

SLRC Partner Investigators Professors Diana Laurillard and Brian Butterworth gave two workshops, in Brisbane and Melbourne, on the rather neglected but important problem of dyscalculia. More than 50 people, comprising researchers and teachers, attended each workshop.



"The Dyscalculia workshop provided teachers with a powerful mix of theoretical and practical information. Undoubtedly, it gave us a deeper understanding of the learning needs of students with numerosity challenges, but interestingly the material was of significant value in a broader educational context," commented Samantha Bolton, Dean of Academics at St Margaret's Anglican Girls School.

The SLRC thanks St Margaret's Anglican Girls School for hosting this event in Brisbane.



Socio-Cultural Workshop

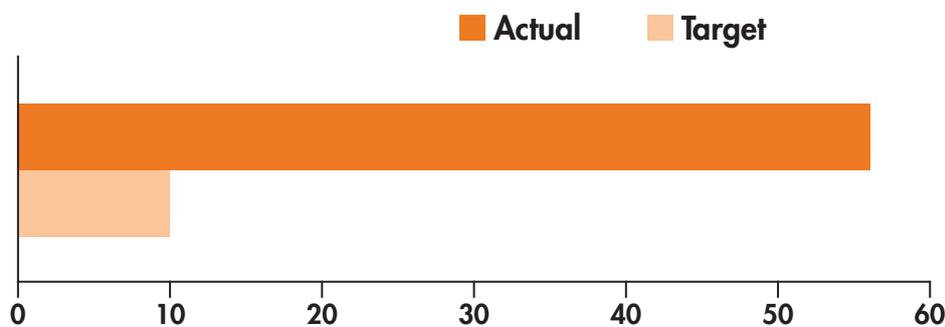
The socio-cultural workshop at the University of Melbourne gave researchers an opportunity to experience first hand the Learning Interaction Classroom, from both sides.



ORGANISATION PARTICIPATION

The SLRC is represented on a wide variety of organisations, nationally and internationally. These include UNESCO (Bangkok) Education Beyond 2015 group (Professor Martin Westwell), Victorian Curriculum and Assessment Authority (Professor Collette Tayler), South Australian Certificate of Education Board (Professor Martin Westwell), New South Wales Board of Studies, Teaching and Educational Standards (Professor John Pegg), the Australian Academy of Science’s National Committee for Brain and Mind (Professor Jason Mattingley) and the Australian Academy of Science’s National Committee for Mathematical Sciences (Professor Merrilyn Goos). In July, Professor John Hattie was appointed Chair of the Board of Directors of the Australian Institute for Teaching and School Leadership Limited (AITSL). AITSL provides national leadership for the Australian, State and Territory Governments in promoting excellence in the profession of teaching and school leadership and provides advice to the Federal Education Minister.

Organisation participation



The year ahead

The SLRC will continue to deepen its relationship with national and international partners. The SLRC’s collaboration with Hitachi Limited will be strengthened through the appointment of a joint student and Professor Sah will visit Hitachi in the first half of the year.

Professor Griffin (UM) is coordinating a collaborative project with Carnegie Mellon and the University of Memphis aimed at developing interpretive analysis templates focusing on student message language. This will include other researchers from within the Centre. Professor Griffin will also be directing a study in collaboration with the University of Luxembourg and the Organisation for Economic Co-operation and Development (OECD) in order to examine the equivalence of human to human collaboration and human to computer agent collaboration.

In addition to research theme workshops, in June the Centre will run a two-day Science of Learning Symposium specifically designed for teachers. The workshop will be replicated later in the year at other nodes.

COMMUNITY ENGAGEMENT, TRANSLATION, AND OUTREACH

*“Gaining knowledge, is the first step to wisdom
“Sharing it, is the first step to humanity”*

—Unknown

It has been an extremely busy 12 months for the SLRC as it continues to expand its engagement and outreach on a number of fronts. One of the highlights of the year was the Australian Council for Educational Research Conference where the research of SLRC Chief Investigators, students and early career researchers was on display. Professor Geoff Masters from the SLRC Advisory Board and Chief Investigators Gillies, Cunningham, Silburn and Thomson presented at sessions during the conference.

TRANSLATION

The theme for the SLRC Big Day Out in Adelaide was translation and impact. The Centre was very grateful that Dr Fiona Cameron from the Australian Research Council was able to attend, giving an extremely insightful overview of research impact, what it means and how it is measured. The day's activities were centered around discussion of the various avenues for translation and the relative impact of each of these endeavors. Topics discussed included:

- Pre-service teacher training curriculum
- Masters of Education
- Massive open online courses (MOOCs)
- Professional Development for teachers

As a result, Associate Professor Annemaree Carroll, who recently joined the Executive Committee, is leading a group of researchers within the Centre to develop material that can be integrated into a number of these initiatives.

A group based in Melbourne has been exploring different formats for the translation of work within the SLRC as well as related research in the Science of Learning field. They have trialed formats with teachers and principals, have explored developing school and tertiary courses (including MOOCs), and determined a program to deliver on these ideas in 2015. A postdoctoral researcher is being recruited to help oversee these initiatives and work with Associate Professor Annemaree Carroll on this important translational work.



The Translation Team (left to right): Mr Greg Donoghue, Associate Professor Annemaree Carroll, Mr Jared Horvath, Professor John Hattie, Ms Stephanie MacMahon

STRATEGIC PARTNERSHIPS

During 2014 two new strategic partnerships were initiated, one with Nature Publishing Group and the other with the Emirates College of Advanced Education in Abu Dhabi. Nature Publishing Group approached the Centre to explore the possibility of partnering to produce a journal devoted to the science of learning. In addition to this, Nature Publishing Group has agreed to sponsor an International symposium with the SLRC next year – this will be followed up with a special edition of Nature dedicated to the science of learning.

In November Centre Director Professor Pankaj Sah visited the Emirates College of Advanced Education in Abu Dhabi. This followed an approach from the organisation to collaborate with the SLRC. Currently the Centre is exploring suitable collaborative projects around which to build this relationship. The Australian Council for Educational Research office in Dubai is assisting in building this relationship.

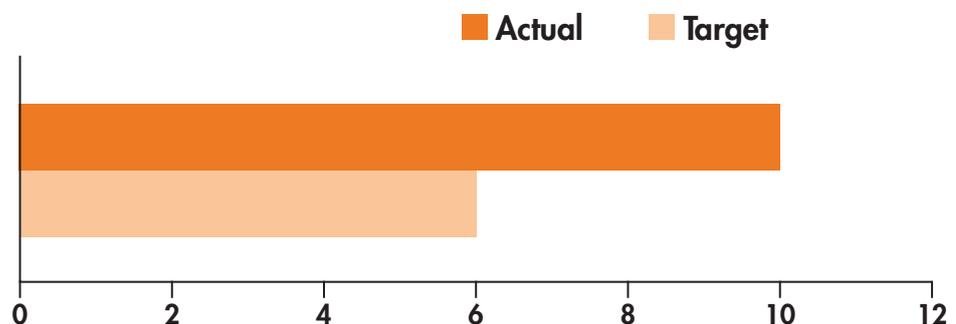
In addition to these new partnerships, the Centre continues to work closely with

- The Gumala Corporation in Western Australia (Tayler)
- United Nations Educational Scientific and Cultural Organization (UNESCO) (Bangkok) through the Education Beyond 2015 program and the ERI-net program (Westwell)
- Brisbane Catholic Education (Gillies)
- Hitachi Limited (Sah)
- Education departments in Queensland, South Australia and Victoria (Nugent, Westwell, Hattie)
- Australian College of Educators (Nugent)

Hitachi collaboration

The focus of the SLRC's partnership with Hitachi is developing more sensitive, non-invasive devices to measure physiological changes during learning. Dr David Painter, who recently completed a postdoctoral research project at Hitachi, has now joined the SLRC, working predominantly with the Educational Neuroscience Classroom. The Centre is about to recruit a member who will be co-supervised by a Research Fellow from Hitachi and a Centre Chief Investigator. The person will spend up to 12 months in Japan.

Strategic partnerships

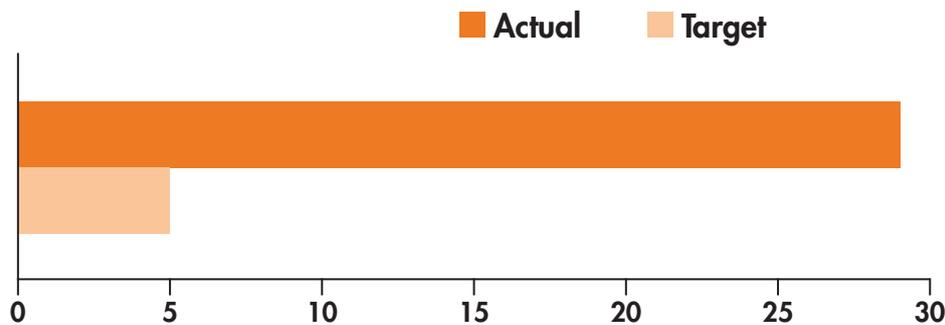


BRIEFINGS TO INFORM POLICY

Representatives of the Centre meet regularly with Partner Organisations including the Queensland Department of Education, Training and Employment, the South Australian Department of Education and Child Development and the Victorian Department of Education and Early Childhood Development to advise on the latest research outcomes. Professor John Hattie is working with the Victorian Department of Education and Early Childhood Development to increase the impact of research translation in the classroom and to be more receptive to Department research needs.

SLRC Chief Investigators are involved in 26 committees and advisory boards that directly influence education policy. In 2014 Professor John Hattie was appointed chairman of the Australian Institute for Teaching and School Leadership (AITSL). At the request of the Education Minister he has drafted a strategy document outlining a new direction for AITSL. On the international scene, Professor Martin Westwell provides briefings to UNESCO, through the Education Beyond 2015 group of which he is a member.

Briefings to inform policy



OUTREACH PROGRAMS

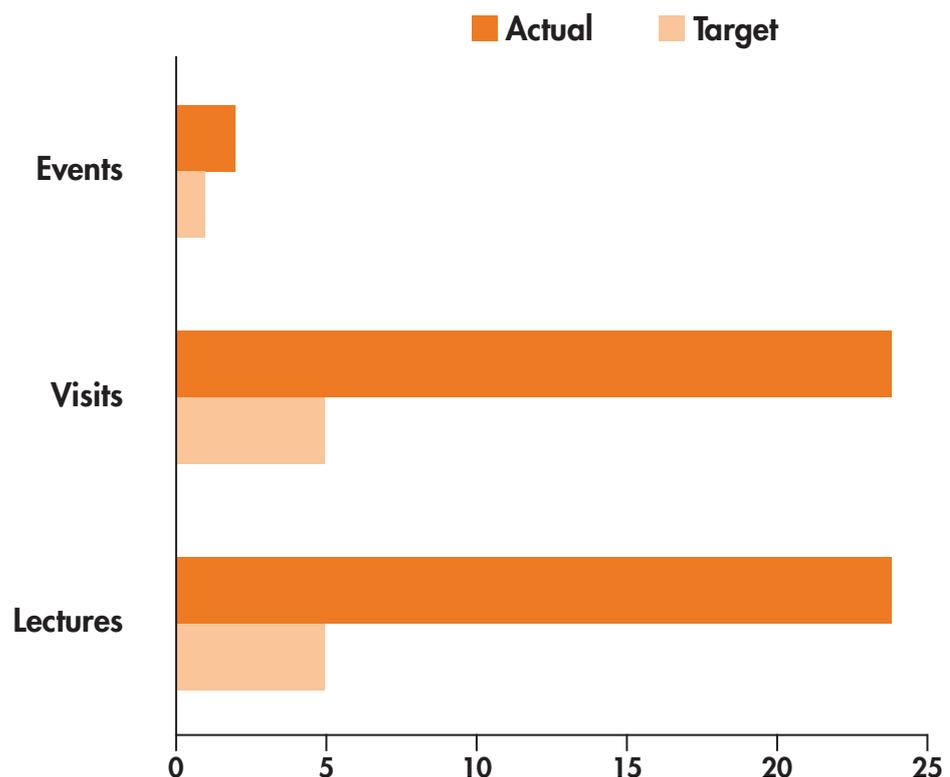
Industry Awareness

There were a total of 17 seminars given by researchers across the Centre. Both the Victorian and Queensland nodes of the SLRC held a regular seminar series which was attended by teachers, members of the respective Education Departments and education resource providers.

Members of the Centre visited 24 schools, talking about the SLRC, delivering workshops and providing professional development. Many of these presentations took a cross-disciplinary approach; for example, a neuroscientist teaming up with an educationalist to deliver a workshop on children learning through group-work.

A focus of the Centre is maintaining its relevance to educators. In June the Centre hosted a roundtable discussion with representatives from private and public schools to discuss the Centre's activities and to learn what educators want from the Centre. One suggestion, which the Centre has taken on board with great success, is the idea of taking workshops and seminars to schools. In the second half of the year the Centre hosted three separate events in local schools, all with great turnout and engagement.

Outreach - Industry



Public Awareness

The showcase of the Centre are the two classrooms, the Educational Neuroscience Classroom and the Learning Interaction Classroom. More than ten groups visited these facilities in 2014. The classrooms have also featured in several newspaper articles and television stories. A number of groups have visited the Centre, including 2 philanthropic groups.

Researchers have spoken at a range of community events, including school community forums, community, professional and business groups.

The Centre also participated in a range of public awareness events throughout the year. Two highlights were the Solid Pathways Program and an exhibit at the Ekka, the Royal Queensland Show.

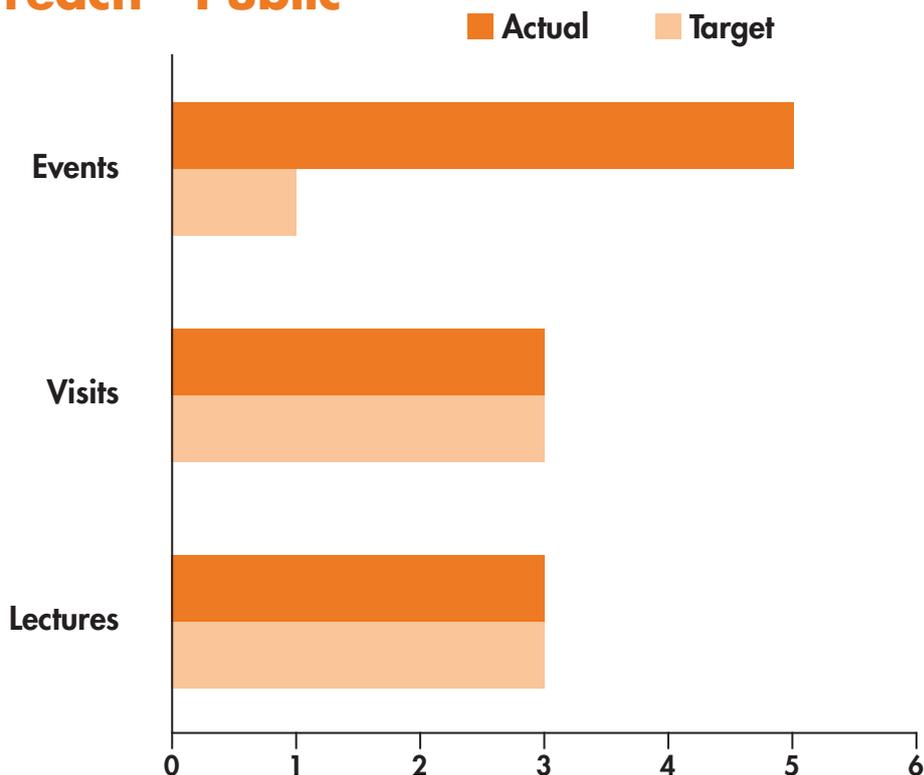
All of the seminars hosted by the SLRC are open to the public. These events are posted on the SLRC website, the SLRC Facebook page and personal invites are sent through the Centre's database. The Centre also produces a Quarterly Bulletin highlighting research activities and upcoming events. This is distributed electronically to more than 500 recipients.



Over 300 children and their parents visited the SLRC display which was part of the Street Science display at the 2014 Royal Queensland Show (also known as Ekka) in August.

Jaime Garcia (left) and Cameron Brooks (right)

Outreach - Public



INDIGENOUS ENGAGEMENT

The Centre was extremely fortunate to have Professor Cindy Shannon, UQ Pro-Vice Chancellor (Indigenous Education) join the Advisory Board at the beginning of the year. With the assistance of Professor Shannon, the SLRC hosted a Science of Indigenous Learning think-tank in October at The University of Queensland. All of the Centre's researchers working with Indigenous communities participated in the think-tank, together with Indigenous stakeholders from Victoria and Queensland. Two recommendations coming from the think-tank were the formation of a reference group for the Science of Indigenous Learning and the recruitment of an Indigenous Postdoctoral researcher and/or student to the program. Both of these recommendations have received the full support of the Advisory Board and the Executive Committee. Indigenous Research Fellow Mr Tony Dreise has been appointed to the Centre. Based at the Australian Council for Educational Research, Mr Dreise works out of the Queensland Brain Institute at The University of Queensland one day a week.

Science of Indigenous Learning Think-Tank

In October the Centre hosted a Science of Indigenous Learning think-tank. Participants brought a range of perspectives – SLRC members working in the areas of early years learning through to second chance education for adults across a range of communities, Indigenous representatives and members with experience teaching in remote communities. Key topic areas identified that the Centre has the potential to impact on were:

- The need for better measurement tools – attendance should not be used as a measure of learning success
- Understanding how Indigenous students learn

Participants

John Willis Indigenous Office UQ
Shane Drahm Indigenous Office UQ
Cindy Shannon. PVC(I) UQ
Tony Dreise Principal Research Fellow, Indigenous Education ACER
Gina Milgate Research Fellow, Indigenous Education ACER
Cameron Brooks SLRC UQ PhD student
Helen Harper SLRC Postdoctoral researcher - CDE
Collette Tayler. SLRC CI - UM
John Pegg SLRC CI - UNE
Sven Silburn SLRC CI - CDU
Pankaj Sah. SLRC Centre Director - UQ (chair)
Annita Nugent SLRC COO - UQ
Greg McPhan. SLRC Postdoctoral researcher - UNE

As part of The University of Queensland's Solid Pathways Program, throughout the year over 100 high achieving Indigenous students with ages ranging from 9 to 15 visited the SLRC. Dr Jeff Bednark gave the students a brief lesson on the multi-tasking brain. Students were then given the opportunity to test their own multi-tasking ability on an activity developed by Professor Jason Mattingley and Associate Professor Paul Dux.



The year ahead

The SLRC is pursuing a possible link to the University of Chile's Centre for Neuroscience and Cognition. Dr Mike Timms initiated this relationship in 2014 and Dr Sacha De Velle (ACER) will be visiting the Centre in 2015.

The research translation group, under the guidance of Associate Professor Anemaree Carroll, will meet on a monthly basis. A curriculum writer will be recruited to the group and tasked with the responsibility of liaising with Centre researchers to produce content for the various translation pursuits. This material will be incorporated into undergraduate courses at the University of Melbourne and The University of Queensland in Semester 2 of 2015, and Semester 1 of 2016, respectively.

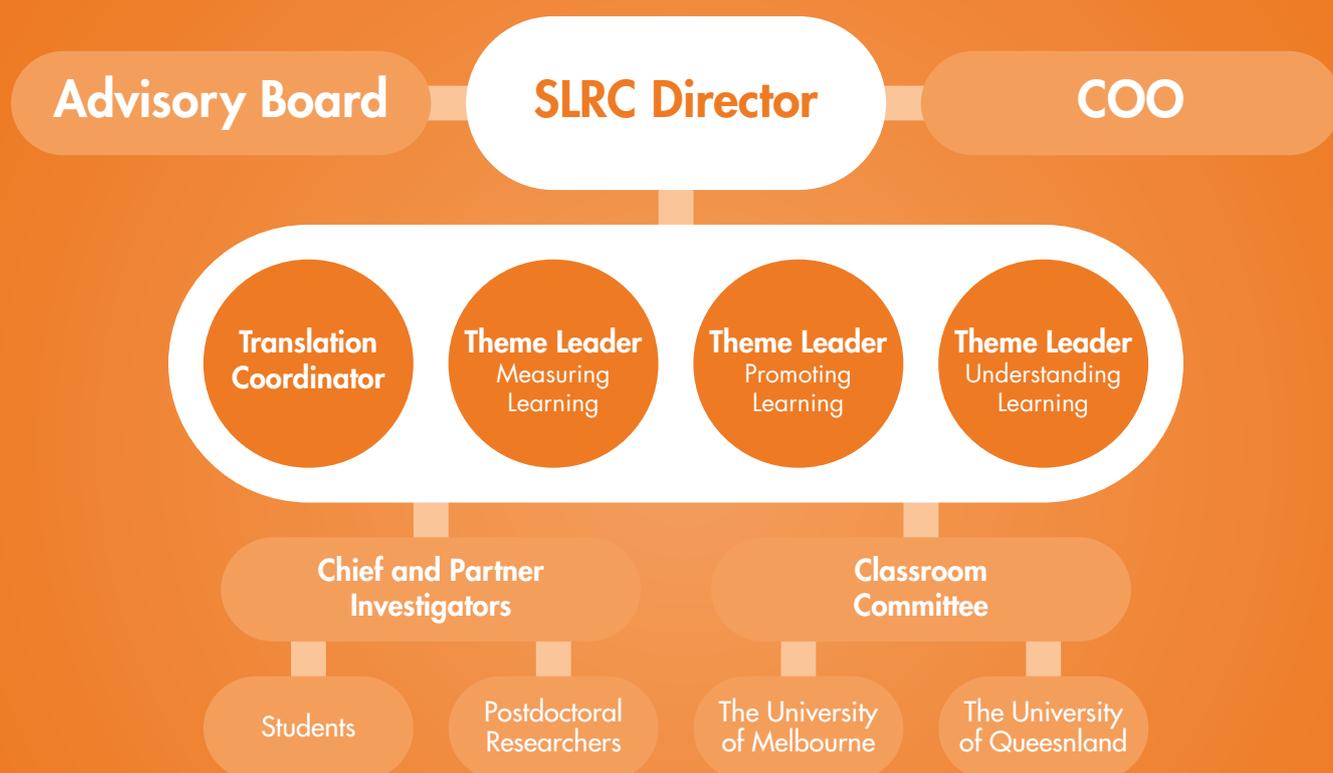
In addition to the Brisbane and Melbourne seminar series the Centre will run four special seminars on the Queensland Department of Education e-learning platform. This will allow for teachers in rural areas to engage with the Centre. Each seminar will be based on a project and presenters will include teachers engaged in the project at a classroom level as well as researchers.

Indigenous Research Fellow Mr Tony Dreise will work in the Centre, dividing his time between the Australian Council for Educational Research and the Queensland Brain Institute at The University of Queensland. An Indigenous research higher degree student will be recruited to the program. Members have been invited to join the Science of Learning Indigenous Reference Group, which will meet quarterly.

Professor Griffin will host the General Assembly of the International Academy of Education in 2015 and a special panel session will be devoted to the work of the SLRC, to be presented by Professor John Hattie.

GOVERNANCE AND PLANNING

The Executive Committee and the Advisory Board oversee Centre governance.



There were several major changes to the governance structure of the SLRC in 2014. Most significantly, Professor Pankaj Sah replaced Professor Ottmar Lipp as Centre Director. Now located at Curtin University, Professor Lipp still retains a position on the Executive Committee as Theme Leader, Understanding Learning. The Centre also welcomed Curtin University as a Collaborating Organisation.

Associate Professor Annemaree Carroll has joined the Executive Committee in the role of Coordinator, Research Translation. In this role Associate Professor Carroll will oversee the production of translational material across the nodes.

Recognising the importance of having Indigenous representation, Professor Cindy Shannon, Pro Vice-Chancellor (Indigenous Education) at The University of Queensland has joined the Advisory Board. Already Professor Shannon has contributed significantly to the SLRC. Professor Shannon was instrumental in the organisation of a think-tank on Indigenous Learning and she is now a member of the newly formed Consultation group on Indigenous Learning, which stemmed from the think-tank.

Executive Committee

The Executive Committee comprises the Centre Director, each of the three theme leaders, the Coordinator, Research Translation and the Chief Operating Officer. The Executive Committee members are:

- Professor Pankaj Sah – Chair and Centre Director (The University of Queensland)
- Professor Ottmar Lipp – Theme Leader – Understanding Learning (Curtin University)
- Dr Mike Timms – Theme Leader – Measuring Learning (Australian Council for Educational Research)
- Professor John Hattie – Theme Leader – Promoting Learning (The University of Melbourne)
- Associate Professor Annemaree Carroll – Coordinator, Research Translation (The University of Queensland)
- Ms Annita Nugent – Secretary and Centre Chief Operating Officer (COO) (The University of Queensland)

The Executive Committee meets monthly and is responsible for facilitating the running of cross-nodal, multi-disciplinary projects and ensuring the Centre reaches its overall objectives.



From left to right: Dr Mike Timms, Ms Annita Nugent, Professor John Hattie, Associate Professor Annemaree Carroll, Professor Ottmar Lipp, and Professor Pankaj Sah.

Advisory Board

The Advisory Board consists of representatives from key education stakeholders as well as world leaders in the fields of education and neuroscience research. In 2014 Professor Cindy Shannon joined the Advisory Board and Professor Pankaj Sah replaced Professor Ottmar Lipp with the change of Director.

The Advisory Board comprises:

- Professor Barry McGaw - Chair (Vice Chancellor's Fellow, The University of Melbourne)
- Professor Perry Bartlett (Director, Queensland Brain Institute, The University of Queensland)
- Professor Rita Colwell (Distinguished University Professor, University of Maryland, USA)
- Mr Simon Kent (Deputy Secretary, Strategy and Review Group, Victorian Department of Education and Early Childhood Development)
- Dr Hideaki Koizumi (Research Fellow, Hitachi Ltd, Japan)
- Professor Geoff Masters (Chief Executive Officer, Australian Council for Educational Research)
- Mr Joe McLean (Director, International Development, The University of Queensland)
- Professor Richard Noss (Institute of Education, University of London)
- Professor Field Rickards (Director, Melbourne Graduate School of Education, The University of Melbourne)
- Professor Pankaj Sah (Director, SLRC, The University of Queensland)
- Professor Cindy Shannon (Pro Vice-Chancellor (Indigenous Education), The University of Queensland)
- Dr Jim Watterston (Director-General, Queensland Department of Education, Training and Employment)
- Secretary - Ms Annita Nugent (COO, SLRC, The University of Queensland)

The Advisory Board met in July and December of 2014.

Research Classroom Committee

The operations of the Learning Interaction Classroom and the Educational Neuroscience Classroom are overseen by Professor David Clarke and Professor Jason Mattingley respectively. Together with the Centre Director and Chief Operating Officer, Professors Clarke and Mattingley constitute the Research Classroom Committee. This committee meets on an *ad hoc* basis. The Research Classroom Committee reports quarterly to the Executive Committee.

Indigenous Learning Consultation Group

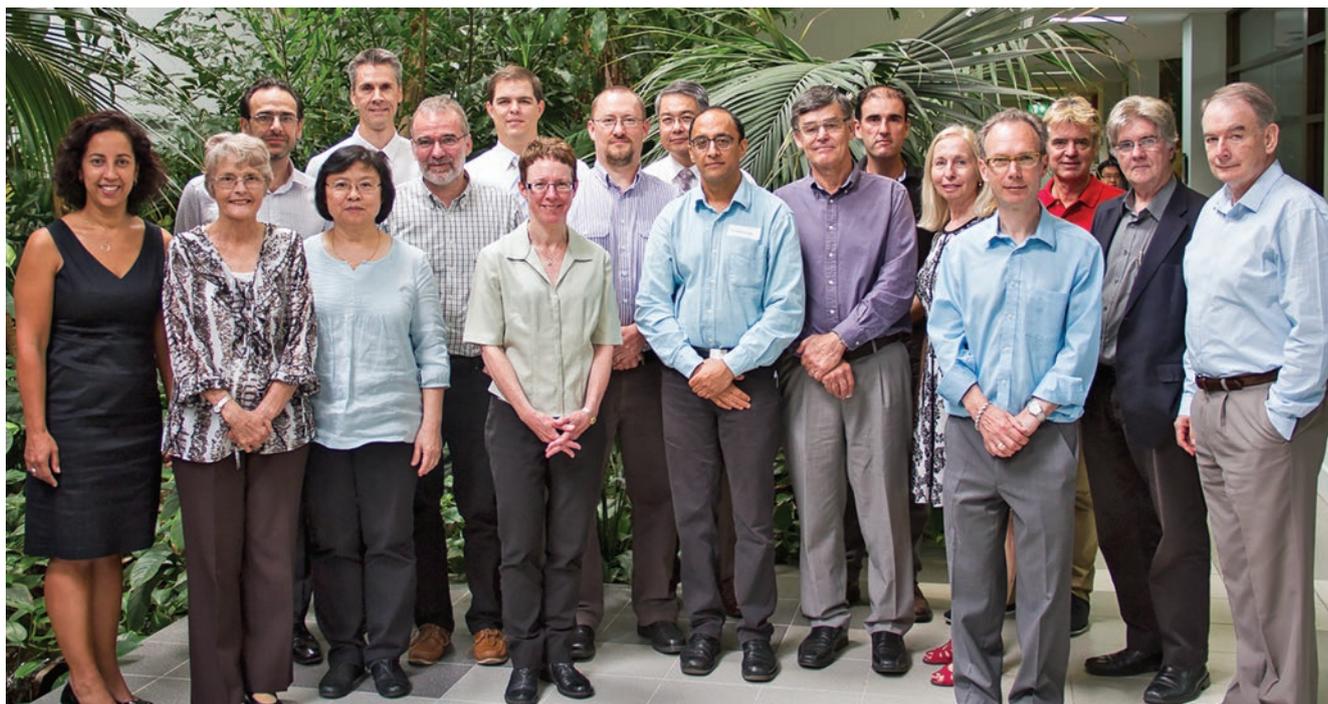
An Indigenous Learning Consultation Group was formed in November, as a result of the recommendations of the Indigenous Learning think-tank that was held in October at The University of Queensland. The group will meet twice a year to review the SLRC Indigenous Learning research program and ensure its continued relevance.

The Indigenous Learning Consultation Group comprises

- Professor Cindy Shannon (Pro Vice-Chancellor (Indigenous Education), The University of Queensland)
- Professor Collette Tayler (SLRC CI, the University of Melbourne)
- Tony Dreise (Principal Research Fellow, Indigenous Education ACER)
- Gina Milgate (Research Fellow, Indigenous Education ACER)
- Associate Professor Jon Willis (Aboriginal and Torres Strait Islander Studies Unit, The University of Queensland)
- Cameron Brooks (SLRC PhD candidate, The University of Queensland)
- Professor Pankaj Sah (Director, SLRC)
- Ms Annita Nugent – Secretary (COO, SLRC, The University of Queensland)

Chief Investigator meetings

This year the Centre held two chief investigator meetings, fondly referred to as the Big Day Out. The first meeting for Chief Investigators was held in March at the Australian Council for Educational Research in Melbourne and was predominantly dedicated to program workshops. In August more than 70 Centre members gathered at Flinders University for a one and a half day meeting, commencing with a poster session. For part of the program the students and early career researchers participated in a workshop on research communication while Chief Investigators discussed translation activities of the Centre. The Centre was extremely fortunate to have two outside presenters, Dr Fiona Cameron from the Australian Research Council who gave a presentation on research impact, and Professor Phil Long from The University of Queensland who spoke on the virtues of MOOCs. The afternoon allowed time for the students and early career researchers to practise what they had learnt in the morning session, each giving a 3-minute elevator pitch on their research.



SLRC Chief Investigators at the Big Day Out in Melbourne – March 2014.

Day-to-day management

The Chief Operating Officer (COO), Ms Annita Nugent manages the operations of the Centre, including finance, engagement and reporting, and supports the Director in ensuring the Centre reaches its overall objectives. Ms Nugent partakes in strategic planning for the Centre and engages in the implementation of new initiatives. Ms Nugent is secretary to the Advisory Board and the Executive Committee and directly liaises with all Chief and Partner Investigators as well as Partner and Collaborating Organisations. Ms Nugent is supported by classroom managers at The University of Queensland and The University of Melbourne, and the Engagement Officer at The University of Melbourne.

SLRC Strategic Plan

To understand the neural mechanisms that underpin learning and develop robust methods to measure outcomes in order to identify and develop evidence based learning strategies that promote learning

Strategies (What)	Actions (How)	Who	Delivery date
Provide funding for research	SLRC	CIs	Ongoing delivery through publications in journals, books, etc and presentations at conferences (Publications: 51 in 2015, 75 in 2016)
Provide cutting edge research infrastructure	SLRC, Infrastructure managers at the Learning Interaction Classroom and the Educational Neuroscience Classroom	UM and UQ nodes	Ongoing delivery through publications in journals, books, etc and presentations at conferences (Publications: 51 in 2015, 75 in 2016)
Provide strategic funding to expedite research programs	SLRC Executive	SLRC Executives, CIs	Ongoing delivery through publications in journals, books, etc and presentations at conferences (Publications: 51 in 2015, 75 in 2016)

To use cross-disciplinary collaborations between neuroscience, education and cognitive psychology, and practicing teachers to understand and accelerate research outcomes in learning

Strategies (What)	Actions (How)	Who	Delivery date
Promote cross-disciplinary collaboration	Provide strategic funding to support cross-disciplinary collaborations	SLRC Executive Postdocs strategically appointed	Ongoing – many initiatives receive ongoing funding. As the Centre is fully established, it is unlikely many more new initiatives will be funded.
Provide opportunity for collaboration between disciplines	2 Big Days Out 3 theme workshops	SLRC Executive to organise All Centre members attend	December 2015 (to be repeated in 2016)

To develop (i) tools and strategies that promote learning in formal and informal settings and (ii) resources for educating students and teachers about how the brain learns

Strategies (What)	Actions (How)	Who	Delivery date
Produce 3 books describing the science of learning and strategies and tools for learning based on this knowledge	Translation team to develop research volume. Teacher feedback from the research volume will then feed in to the production of the teacher practitioner volume and the student volume	Translation team All CIs	Q4 2015 Book 1 – research volume Q3 2016 Book 2 teacher - practitioner volume Q4 2016 - Book 3 student volume
Develop teacher and student resources	Develop worksheets and corresponding podcasts, marketed through the SLRC website	Translation team All CIs	2015 – first 6 2016 – second 6

To translate research outcomes into the classroom by incorporating new knowledge into pre-service teacher training and professional development programs

Strategies (What)	Actions (How)	Who	Delivery date
Develop Masters program	Translation team will develop framework and curriculum for 10 units – distributed between the 2 UQ and UM. Students will have the opportunity to do units from both nodes.	Translation group All CIs	UM – S2 2016 UQ – S1 2017 2018 – expand to other nodes??
Professional development	A 2 day professional development course will be developed and coordinated by the translation team	Translation team All CIs	Qld and Vic – 2015 (repeat and develop in 2016 with delivery to Qld, Vic, SA, NSW, NT and WA, through nodes)
Develop course for pre-service teachers	Translation team will develop framework and curriculum for a course to go in a pre-service teaching course. This will be trialled at UM and UQ in the first instance and then distributed to other nodes.	Translation team All CIs	UQ – S12016 UM – S1 2016 Other nodes - 2017

To train future researchers and teachers with an understanding of neuroscience, psychology and education who will continue to scrutinise and develop new learning strategies in a constantly evolving environment

Strategies (What)	Actions (How)	Who	Delivery date
Provide mentoring for students and early career researchers	Mentoring programs Strategic funds to support travel of students and early career researchers to theme workshops and Big Days Out Strategic funds to support travel between nodes in specific areas and equipment/facilities	Exec, CIs	Ongoing
Seminars on science of learning with opportunity for critical analysis of research with national and international researchers	Hold regular seminars at each node	Exec, CIs	18 seminars in 2015 (to be repeated in 2016 with target of 20)

The year ahead

Following the many significant changes in 2014, the Centre organisation will continue in its current form in 2015.

The Executive Committee will continue to meet on a monthly basis, with more regular face-to-face meetings, meeting in person in alternate months. There are two Big Days Out planned for the year, in Sydney and Melbourne.

The Advisory Board and the Indigenous Learning Consultation Group will meet twice a year.

APPENDICES



Appendix 1: Publications

Journal Publications

- Aizikovitsh-Udi, E., **Clarke, D.J.** & Kuntze, S. (2014). Hybrid Tasks: Promoting Statistical Thinking and Critical Thinking through the Same Mathematical Activities. *PNA*, 8(3), 115-126.
- Arnold, J. & **Clarke, D. J.** (2014). What is 'Agency'? Perspectives in Science Education Research. *International Journal of Science Education*, 36(5), 735-754 [DOI: 10.1080/09500693.2013.825066].
- Beckman, K., Bennett, S., & **Lockyer, L.** (2014). Understanding students' use and value of technology for learning. *Learning, Media and Technology*, 39(3), 346-367.
- Benjamin, C. F., Saling, M. M., Wood, A.G. & **Reutens, D. C.** (2014). Elemental spatial and temporal association formation in left temporal lobe epilepsy. *PLoS One*, 30;9(6):e100891. doi: 10.1371/journal.pone.0100891. eCollection 2014.
- Bourgeois, A., Bower, J., & Carroll, A.** (2014). Impacts of the use of social networking on social and emotional well-being of adolescents in Australia. *Australian Journal of Guidance and Counselling, special edition*, 24(2), 167-182.
- Bower, J., Carroll, A., & Ashman, A.** (2014). The development and validation of the Contextualised Assessment Tool for Risk and Protection Management (CAT-RPM). *Journal of Psychoeducational Assessment*, 32(2), 107-122. DOI 10.1177/0734282913497782.
- Bower, M., Kenney, J., Dalgarno, B., Lee, M. J., & **Kennedy, G. E.** (2014). Patterns and principles for blended synchronous learning: Engaging remote and face-to-face learners in rich-media real-time collaborative activities. *Australasian Journal of Educational Technology*, 30(3), 261-272.
- Bramwell, S., Mallan, K.M., & **Lipp, O.V.** (2014). Are two threats worse than one? The effects of face race and emotion on fear conditioning. *Psychophysiology*, 51, 152-158.
- Carroll, A., Houghton, S., & Bourgeois, A.** (2014). Self-reported substance use among high school students with and without learning difficulties. *Australian Journal of Learning Difficulties*, 19 (1), 47-59. doi.org/10.1080/19404158.2014.909861.
- DeBoer, G.E., Quellmalz, E.S., Davenport, J.L., **Timms, M.J.**, Herrmann-Abell, C.F., Buckley, B.C., Jordan, K.A., Huang, C-W, Flanagan, J.C. (2014). Comparing three online testing modalities: Using static, active, and interactive online testing modalities to assess middle school students' understanding of fundamental ideas and use of inquiry skills related to ecosystems. *Journal of Research in Science Teaching*. 51(4), 523-554.
- Fang, S. C, Hart, C., & **Clarke, D. J.** (2014). Unpacking the meaning of the mole concept for secondary teachers and students. *Journal of Chemical Education* 91(3), 351-356.
- Fenton G.E., Pollard A.K., Halliday D.M., Mason R., **Bredy T.W.** and Stevenson C.W. (2014). Persistent prelimbic cortex activity contributes to enhanced learned fear expression in females. *Learning and Memory*, 21(2), 55-60.
- Filmer, H. L., **Dux, P. E., & Mattingley, J. B.** (2014). Application of transcranial direct current stimulation for understanding brain function. *Trends in Neurosciences*, 37 (12), 742-753.
- Flavell C.R., Lambert E.A., Winters B.D. and **Bredy T.W.** (2014). Mechanisms governing the reactivation-dependent destabilization of memories and their role in extinction. *Frontiers in Behavioural Neuroscience*, 7:214. doi: 10.3389/fnbeh.2013.00214.
- Gan, M.J.S., & **Hattie, J.A.C.** (2014). Prompting secondary students' Use of Criteria, Feedback Specificity and Feedback Levels during an Investigative task. *Instructional Science*, 42, 861-878.
- Garner, K. G., Tombu, M. N., & **Dux, P. E.** (2014). The influence of training on the attentional blink and psychological refractory period. *Attention, Perception, & Psychophysics*, 76, 979-999.
- Geiger, V., **Goos, M., & Dole, S.** (2014). The role of digital technologies in numeracy teaching and learning. *International Journal of Science and Mathematics Education* DOI 10.1007/s10763-014-9530-4.
- Gillies, R.** (2014). Cooperative Learning: Developments in Research. *International Journal of Educational Psychology*, 3 (2), 125-140. doi.104471/ijep.2014.08.
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- Gillies, R.** (2014). Developments in Cooperative learning: Review of Research. *Anales De Psicologia*, 30 (3), 792-801. <http://dx.doi.org/10.6018/analesps.30.3.201191>.
- Glikmann-Johnston, Y., Saling, M. M., Chen, J., O'Keefe, G., Gong, S., Tochon-Danguy, H., Mulligan, R. & **Reutens, D.C.** (2014). Hippocampal 5-HT1A receptor binding is related to object-location memory in humans. *Brain Structure and Function*. 2014 May 8. [Epub ahead of print]
- Goos, M.** (2014). Creating opportunities to learn in mathematics education: A sociocultural perspective. *Mathematics Education Research Journal*, 26(3), 439-457.
- Harks, B., Rakoczy, K., **Hattie, J.**, Besser, M., & Klieme, E. (2014). The effects of feedback on achievement, interest, and self-evaluation: The role of feedback's perceived usefulness. *Educational Psychology*, 34(3), 269-290.
- Ho, Y., & **Lipp, O.V.** (2014). Faster acquisition of conditioned fear to fear-relevant than to non fear-relevant conditional stimuli. *Psychophysiology*, 51, 810-813.
- Houghton, S., **Hattie, J.A.**, Wood, L., **Carroll, A.**, Martin, K., & Tan, C. (2014). Conceptualizing loneliness in adolescents: Development and validation of a self-report instrument. *Child Psychiatry and Human Development*, 45, 604-616.
- Houghton, S., Hunter, S., Trewin, T., Glasgow, K., & **Carroll, A.** (2014). The multidimensional anxiety scale for children (MASC): A further validation with Australian adolescents with and without Attention-Deficit/Hyperactivity Disorder. *Journal of Attention Disorders*, 18 (5), 402-411. doi:10.1177/1087054712439100.
- Houghton, S., Roost, E., Brandtman, M., & **Carroll, A.** (2014). Loneliness in children and adolescents with and without Attention-Deficit/Hyperactivity Disorder. *Journal of Psychopathology and Behavioral Assessment*. 10.1007/s10862-014-9434-1.
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Appendix 2: Financial Statements

Income

Source	Amount
ARC	\$ 4,279,428
Administering Organisation	\$ 220,000
Collaborating Organisations	\$ 1,120,000
Partner Organisations	\$ 210,000
Total	\$5,829,428

Expenditure

	Purchased equipment	Travel	Salaries	Scholarships*	Other expenditure	Total
UQ	128,522	103,548	890,695	42,380	510,525	1,675,670
UM	198,541	46,150	663,150	38,951	266,430	1,213,222
ACER	7,913	36,019	307,777	-	-	351,709
CDU	-	830	172,184	-	76	173,090
MQ	-	619	59,096	-	-	59,715
UNE	-	3,861	84,567	-	-	88,428
Deakin	-	2,030	63,555	-	-	65,585
Flinders	-	607	59,423	-	7,345	67,375
Curtin	-	-	-	-	-	-
Total	334,976	193,664	2,300,447	81,331	784,376	3,694,794

*Scholarships include top-ups, Summer Scholars, and living expenses.

Appendix 3: Key Performance Indicators

	2014 Target	2014 Achieved
Research Findings		
Number of research outputs (research outputs may include journal articles, books, book chapters, conference publications and patents)	38	84
Quality of research outputs: At least 80% of papers will be:	31	42
<ul style="list-style-type: none"> • peer reviewed • in top 20% of journals per discipline (ISI impact factor) 		
Number of invited talks/papers/keynote lectures given at major international meetings (include international conferences held in Australia)	25-35	32
Number of nature of commentaries about the Program's achievements (list media releases and articles separately)	20-30	30
Research training and professional development		
Number of professional training courses for staff and postgraduate students attend	22-30	26
<ul style="list-style-type: none"> • professional development is standard requirement for all researchers 		
Number of Program participants who have attended professional training/development courses offered by the Program (include courses offered for external stakeholders and clients)	6-10	10
Number of new PhD students working on core Program research and supervised by Program staff	10-15	19
Number of PhD student completions and completion times, by students working on core program research and supervised by program staff	0	1
Number of new Masters by research and Masters by coursework students working on core Program research and supervised by Program staff	10-15	1
Number of Masters by research and Masters by coursework student completions and completion times, by students working on core Program research and supervised by Program staff	1-5	0
Number of new Honours students working on core Program research and supervised by Program staff	10-15	13
Number of Honours student completions and completion times, by students working on core Program research and supervised by Program staff	10-15	13
Number of new postdoctoral researchers recruited to the Program working on core Program research	15	16
Number of Early Career Researchers (within five years of completing PhD) working on core program research	25	19
Number of students mentored: Summer and winter research placements; International exchange programs; Honours and PhD students	55-70	105
Number of mentoring programs offered by the program (include programs for students, new staff, external stakeholders and clients)	3-6	3

Appendix 3: Key Performance Indicators continued

	2014 Target	2014 Achieved
International, national and regional links and collaboration		
Number of international visitors and visiting fellows	5-12	17
Number of national and international workshops held/organised by the program	2	3
Number of visits to overseas laboratories and facilities	20-30	23
Examples of relevant interdisciplinary research supported by the Program:		
<ul style="list-style-type: none"> Aligning teaching to attention Classroom instruction to maximize memory consolidation Benchmarking the learning state and process Measuring learning with digital tools Learning from example The role of feedback in learning 	2-3	Multiple examples throughout report
Participation on national and international bodies, including Government and community groups	10-15	56
Community engagement, translation and outreach		
Number of strategic partnerships with community, national and international organisations with a view to providing access to the Program's research	6-12	10
Number of government, industry, business and community briefings to inform policy	5-8	29*
Number and nature of industry awareness/outreach programs	Lectures: 5-10	24
	Visits: 5-9	24
	Events: 1-4	2
Number and nature of public awareness/outreach programs	Lectures: 3-9	3
	Visits: 3-12	3
	Events: 1-3	5
Currency of information on the program's website	Weekly updates	Weekly review with update of events, news items, publications and personnel
Number of website hits	800	2742 hits for January
Number of talks given by program staff open to the public	15-25	15
Number of Indigenous stakeholders consulted	2-5	6
Number of Indigenous stakeholders on boards and committees	2-3	3
Governance		
Frequency of meetings on the Program's Advisory Board	Annually	Twice in 2014
Attendance rate of members at the Program's Advisory Board	75%	24/07/14 85% 1/12/14 61%

*SLRC Chief Investigators are involved in 26 committees and advisory boards that directly influence education policy. SLRC representatives meet with the three partner State Departments of Education regularly to provide briefings and updates.

	2014 Target	2014 Achieved
Organisational support		
Annual cash contributions from Administering and Collaborating Organisations (\$)	UQ: 440,000	220,000 ¹
	UM: 240,000	480,000
	ACER: 120,000	240,000
	Curtin: 40,000	0 ²
	CDU: 40,000	80,000
	Deakin: 40,000	80,000
	Flinders: 40,000	80,000
	Macquarie: 40,000	80,000
	UNE: 40,000	80,000
	Annual in-kind contributions from Administering and Collaborating Organisations (\$)	UQ: 548,400
UM: 372,754		372,754
ACER: 301,884		321,112
Curtin: 45,964		45,964
CDU: 35,000		35,000
Deakin: 40,000		40,000
Flinders: 20,098		20,098
Macquarie: 20,000		20,000
UNE: 42,300		42,300
Annual cash contributions from Partner Organisations (\$)		DEECD Vic: 100,000
	Questacon: 5,000	10,000
Annual in-kind contributions from Partner Organisations (\$)	DEECD Vic: 170,000	170,000
	QLD DETE: 50,000	50,350
	SADECD: 25,600	25,600
	Benevolent Soc: 10,007	10,007
	CMU: 10,000	10,000
	NCSU: 20,000	20,000
	IOE: 11,000	11,000
	UCL: 11,000	11,000

¹ Due to a misalignment in funding periods, there was a shortfall in the UQ contribution. The full financial contribution has now been received.

² Curtin University formally joined the SLRC at the end of 2014. The financial contribution for 2014 has now been received.

Appendix 4: Chief Investigators

Dr Tim Bredy

Queensland Brain Institute, The University of Queensland

The main aim of my research is to understand how epigenetic mechanisms contribute to the formation and maintenance of long-term memories. As part of the feedback and reinforcement program, our SLRC project, in collaboration with Professor Pankaj Sah, deals with the molecular mechanisms of long-term memory stability and how abnormally strong memories are established. We focus on a paradigm known as partial reinforcement, which creates memories that are resistant to decline over time. A deeper understanding of this learning process will aid in our understanding of the optimal parameters required for persistence of memory, which will have implications for the transfer of information in the classroom, and the SLRC provides an ideal conduit for that transfer.



Associate Professor Annemaree Carroll

School of Education, The University of Queensland

The SLRC has provided two major transformations to my program of research pertaining to attention and emotion regulation: interdisciplinary research partnerships and the implementation of new technologies to understand research problems. During the past 18 months, I have partnered with neuroscientists and cognitive neuroscientists to understand attentional preparedness and the impact of emotional states on learning outcomes in the classroom from a neuro-scientific perspective. My data collection methods have begun to incorporate EEG, fMRI, wireless recording devices that measure autonomic arousal levels including measurement of heart rate and skin conductance, and sociometric badges that are small electronic devices worn on a lanyard around the neck that gather multiple data about the tone of social interactions, closeness, and proximity. I have also begun to examine emotional states in the classroom through the development of web-based applications that tap into students' real-time emotions and through the use of emotion recognition video recording software that identifies basic and more complex emotions of the learner during individual activities and group work. Much of this work would have been difficult to establish without the SLRC.



Professor David Clarke

Melbourne Graduate School of Education, The University of Melbourne

The SLRC Classroom at the University of Melbourne offers the possibility of more detailed documentation of the learning process in social settings than has been possible previously. In addition, the SLRC Classroom provides a level of control over the learning environment and the instructional stimulus that has not been possible before. In combination, these two capabilities: more control and greater detail, offer the possibility of much greater insight into learning as a socially mediated process. Three projects of mine exploit these new capabilities. Each project examines the social mediation of learning through a series of experiments organised around a distinct focus: first, the teacher; second, the units of pedagogical organisation; third, the social unit of instruction/learning. The combination of control and detailed documentation offered by the SLRC classroom provides the possibility of fine-grained analysis of individual, pair or small group responses to the same instructional stimuli. The level of detail available for comparative analysis will provide insights into the social processes of learning not otherwise possible and generate a database amenable to multiple analyses, including analyses by Russell Tytler and his co-workers into the role of representations and other analyses related to the investigations by Collette Tayler and her colleagues into student metalinguistic knowledge. It is the combination of control and detail that will generate hypotheses regarding the nature of learning with a specificity and a precision that should prove open to investigation by researchers such as Ross Cunningham with the tools of neuroscience.





Associate Professor Ross Cunnington

Queensland Brain Institute and School of Psychology, The University of Queensland

Research in my laboratory has been examining synchrony in brain states between children in primary schools during class activities, really taking neuroscience into the classrooms. My research typically examines “mirroring” processes in the brain, whereby brain activity normally associated with first-hand experience of actions, sensations, and emotions appears to be “mirrored” in our brain when we observe the same activities or states in others. This mirroring activity is thought to be important for our ability to perceive and understand others’ actions, intentions, and emotional states. Through the SLRC and collaboration with education researchers, we have been examining synchrony or mirroring of biological states between children during classroom activities. We are examining shared states or experiences between children, down to the level of their mirrored neurologic or biological responses, during whole-class lessons and small-group co-operative learning. This will allow us to understand the importance of common engagement or shared states between children for learning outcomes in classrooms.



Associate Professor Paul E. Dux

School of Psychology, The University of Queensland

Despite the immense processing power of the human brain, severe ‘bottlenecks’ of information processing are revealed when individuals attempt to perform two tasks – even simple ones – at once. Under such multitasking conditions, performance of one or both tasks is impaired relative to when the tasks are performed in isolation and performance on the second task improves as the time between the tasks increases. Importantly, multitasking limitations are not only relevant for psychological theory, but these difficulties are exacerbated as humans age and in many developmental conditions (e.g., ADHD). In addition, they are believed to reflect key executive function processes which have been strongly linked to learning and educational outcomes. Thus, it is vital to understand the antecedents of multitasking costs and ways in which they can be alleviated. My research focuses on understanding the cognitive and systems level neural mechanisms underlying enhanced multitasking, executive function and attention following cognitive training. The SLRC allows large-scale training studies to be conducted so that both group and individual difference measures can be taken. In addition, and crucially, linking this research program with those in Education allows me to examine how training translates into real-world education settings. The goal is to develop cognitive training protocols that can be introduced in schools, leading to the generalised facilitation of learning.



Professor Robyn Gillies

School of Education, The University of Queensland

Involvement in the SLRC has challenged me to consider a wider range of variables in conceptualising my research and the potential effect these variables may have on teachers’ teaching and students’ learning. For example, I have just completed a project, An investigation into how students solve problems through coordinating multimodal representations during cooperative inquiry problem-solving activities in science, where I have worked collaboratively with a neuroscientist, an educational psychologist and a science educator to bring this project to fruition. Working with colleagues from other disciplines has compelled me to read more broadly in order to understand the rationale behind the need to collect specific types of data and the contributions these data have to better inform the teaching and learning process in school science. As part of the process of investigating how teachers use different multimodal representations in teaching science, the project has collected physiological data on the students’ attending behaviours. By correlating these data with other behavioural data, the project has the potential to better inform the teaching and learning process in schools and the development of engaging activities in science education.



Professor Merrilyn Goos

School of Education, The University of Queensland

Being part of the SLRC has made it possible for me to conduct research on interdisciplinary collaboration between education researchers, cognitive psychologists and neuroscientists. These collaborations did not really exist before the SLRC. Indeed, the purpose of the Centre is to promote such interactions in order to create new knowledge that will help us to understand learning in a more theoretically integrated way. So rather than only “doing” interdisciplinary research on learning (which is the main aim of the SLRC), we are also able to “look inside” the process of interdisciplinarity to find out what forms of collaboration work, why, and under what circumstances. This is important if we are to understand and communicate to other people the transformation of research practice that the SLRC promises to achieve.



Professor Patrick Griffin

Assessment Research Centre, Melbourne Graduate School of Education.

The SLRC and the resources that it provides have enabled continuation of research into collaborative problem solving (CPS), a concept combining the notions of critical thinking, problem solving and collaboration. At the University of Melbourne we quickly established the world benchmark in this research, and CPS has become an important concept for education worldwide. In 2010, the OECD agreed with the corporations Intel, Cisco and Microsoft that the 2015 PISA study would measure collaborative problem solving in up to 65 countries, and in November 2014 the United States government agreed to include collaborative problem solving assessment as part of their national monitoring program in American schools. Without help from the SLRC, the University of Melbourne would have been buried in the avalanche of studies of this area. Instead, the SLRC has made it possible for myself and the Assessment Research Centre to continue this important work in the interpretation of data analytics, allowing the University of Melbourne to remain widely recognised as the world’s leading institution in this new and important area of educational measurement. On a national level, the SLRC has clearly enabled Australia to retain its world leadership status and has earned the respect of the psychometric research worldwide. We continue to break new ground, new ideas and new approaches in pioneering research in this area. The OECD recently funded the University of Melbourne in collaboration with the University of Luxembourg to examine the equivalence of two common forms of assessment of collaborative problem-solving – human to human interaction and human to computer agent interaction. The collaborations emerging with Asia and North America will also help make the work of the SLRC establish a high profile in those areas with research focusing on psychometric studies.



Professor John Hattie

Melbourne Graduate School of Education, The University of Melbourne

A new team has been created consisting of postdoctoral researchers and PhD and Masters students relating to major themes on the strategies of learning, how they can be measured, and the relations between strategies and brain science. In the first year we completed a major meta-synthesis of learning strategies based on about 15 million students with the aim of identifying a model for strategies (particularly given the major moderators for when various strategies should be used), and the most successful strategies at each point of the model. In the coming year we intend to look at measurement of the major strategies, particularly using simulations, brain science methods, and classroom observation. The team also has been part of a pioneering method of using professional captioning to better understand classroom practice, reviewed the major observational schemes, and refined the measurement of in-class teaching and learning. Other projects relate to teacher subject knowledge, growth vs. fixed mind frames, developing working memory and other attributes of learning strategies. In this respect, the main advantage of the SLRC is not just the development of a team devoted to the Science of Learning, but working with others to learn to apply different methodologies, different perceptions of how the brain works, and work translating these rich ideas into the classroom. The team has developed a major program of translation for implementation in 2015 across the SLRC.



Associate Professor Rob Hester

School of Psychological Sciences, The University of Melbourne

The SLRC has provided the opportunity to examine the effects of confusion on learning from mistakes. Experimentally, we find the influence of confusion to be an unhelpful confound to deal with during training, however, educators have known for some time that confusion can be productive. Our new experiments deliberately manipulate levels of confusion in an attempt to elucidate the conditions under which it positively influences adaptive behavior in the brain. Fortunately, the SLRC has provided funding to employ a talented post-doc, Dr Rachel Buckley, who is spearheading this work along with colleagues from the Universities of Melbourne, Macquarie and Queensland. Finally, the SLRC has provided me with the opportunity to converse with educators at primary and secondary level about the evidence base for maximising the conditions for learning. I've enjoyed the opportunity to engage with principals and teachers about the evidence from psychology and cognitive neuroscience that identifies strategies for improving learning of new information.



Professor Tianzi Jiang

Centre for Advanced Imaging and Queensland Brain Institute, The University of Queensland

I am particularly interested in the role of brain networks and connectivity in learning and memory formation, having researched this in human and animal models. Collaborating with Professor Reutens and his team we are able to investigate brain activity during learning using novel fMRI paradigms. This research is key to understanding learning, which, thanks to the SLRC, we are now able to relate to what is happening in the real world classroom.



Professor Gregor Kennedy

Centre for the Study of Higher Education, The University of Melbourne

The SLRC has allowed me to embark on a new area of research, founded on my previous research in the educational psychology of learning in digital environments. The team has embarked on an ambitious interdisciplinary program of research looking at confusion in digital learning environments, which ultimately has an applied focus of both improving feedback to students and supporting their self-direction. The SLRC has allowed me to collaborate with a set of researchers that I would otherwise not have an opportunity to work with: cognitive scientists and cognitive neuroscientists. The project also joins institutions together, fostering research collaborations and visits between laboratories in Melbourne, Macquarie and Curtin Universities. The SLRC has also allowed us to explore and develop new data collection protocols and methods in digital learning environments. The combination of these various techniques allows us to be at the methodological forefront of research and development in digital learning environments.



Dr Siek-Toon Khoo

Australian Council for Educational Research

Many institutions are making use of digital learning environments for the delivery of course material with built-in tutorials, hints and feedback to assist student learning, as a supplement to classroom learning. As part of the SLRC's digital learning program my group is modelling learning, measuring of student engagement and the use of hints and their effectiveness in digital learning environments. This research also complements the research being conducted in the Educational Neuroscience Classroom and the Learning Interaction Classroom as well as cellular level work into feedback.



Professor Ottmar Lipp

School of Psychology and Speech Pathology, Curtin University

One of the courses that I have taught when working as a teaching and research academic in the School of Psychology at The University of Queensland was a second year 'Learning Course'. It always irked me that in the opening lecture, I had to inform the students that in this course, they would learn a great deal about emotional learning, as addressed in Pavlovian fear learning, and about human behaviour (why we do what we do and not what we would like to do), but precious little about the learning that is necessary to be successful in the course and the rest of their university studies. Working with colleagues from education and neuroscience on the development of an evidence-based approach to human learning has enabled me to address this. This collaboration has highlighted to me the importance of an interdisciplinary approach to big issues like the Science of Learning. Combining the approaches that neuroscience, psychology and education have taken to address the issue (or not as it may be) makes it more likely that we will succeed in our endeavour.



Professor Lori Lockyer

School of Education, Macquarie University

As a member of the SLRC I am now contributing to the leadership of a multi-institution, multi-disciplinary research team conducting both real world and laboratory-based experiments to answer fundamental research questions about online and computer-based learning. Within this team I am now incorporating a broader range of research techniques and measures to answer these questions. In addition to my other research activities, funding from the ARC and Macquarie has helped to establish a 'mini-hub' of SLRC activity at Macquarie University with myself as CI, two full-time research fellows, two SLRC-supported PhD students, and the development of links to other researchers from relevant disciplines across Macquarie University. Most recently, we have successfully applied for a Macquarie University infrastructure support to establish a Learning Sciences Laboratory space with equipment.



Professor Jason Mattingley

Queensland Brain Institute and School of Psychology, The University of Queensland

As a cognitive neuroscientist, a typical experiment for me involves bringing a volunteer into a small, dark laboratory, having her sit alone in front of a computer display and asking her to perform a seemingly arbitrary task to measure some aspect of perception or cognition. Likewise, if I want to learn what is happening in a person's brain while they learn, I have them lie inside the narrow tube of an MRI scanner. With their head locked into position, they lie alone for an hour at a stretch while I record their brain activity. Using these well controlled but rather austere approaches, psychologists and cognitive neuroscientists have come to understand a great deal about human learning. But to what extent might data from these approaches reflect learning in "real world" environments, such as a classroom or a lecture theatre? For me the SLRC has provided a unique opportunity to address this question. I am Director of the Educational Neuroscience Classroom at The University of Queensland. Here we can measure behaviour, eye movements, autonomic responses and brain activity simultaneously, while research volunteers learn alone or in small groups. We can see what happens when people learn alone, co-operatively or competitively, and we can objectively test new strategies for enhancing learning outcomes.



Professor John Pegg

School of Education, University of New England

Currently, on international tests Australian students are falling behind (marginally) compared to similar countries, especially for those in the high-achievement bands. One possible reason could be that students are responding to discrete ideas, and limited work is offered where connections and relationships with known ideas are formed. Because of the SLRC, my team is now collaborating with neuroscientists and educators in Queensland, Victoria and South Australia to research the transition from surface learning (involving separate ideas) to deep learning (relating or extending ideas) using the SOLO model. Key questions include: What is the brain activity when the questions are directed at higher levels or are needing higher-level responses? What similar patterns are there in terms of brain function when students respond within similar levels of response? Are there neural correlates associated with working at certain levels? What is the neuroscience evidence to describe conceptual development or the development of higher-order processing skills, knowledge and understandings?



Professor David Reutens

Centre for Advanced Imaging, The University of Queensland

My previous research in learning and memory has related to the neural substrates of memory as revealed using imaging and lesion models in patients. The SLRC has provided me with an opportunity to translate some of these research methodologies into an educational setting. By providing an environment that fosters collaboration with researchers in education, the SLRC has allowed me to develop research questions that are relevant to education and to understand some of the practical issues that SLRC research should aim to solve. My team is now collaborating with education researchers from the University of New England and Flinders University and The University of Queensland.



Professor Pankaj Sah

Queensland Brain Institute, The University of Queensland

For many years the role of feedback, particularly reinforcement in learning has been a focus of my research. My group uses animal models to study the brain circuits that underpin learning and memory formation and impact different forms of learning has on neural activity. In particular we are studying how different patterns of reinforcement, or reward, affect learning. This has initially been done in a rodent model using simple Pavlovian learning procedures. We have found that when learning is only partially reinforced, animals can learn just as well as when it is fully reinforced. That is, when learning is rewarded only intermittently for each successful trial, learning is as effective as when it is rewarded every time. Interestingly we find that partially reinforced memories are retained better than fully reinforced ones. The SLRC has allowed me to expand my networks, working with educational researchers such as Professor John Hattie and cognitive neuroscientists like Professor Jason Mattingley. As a result, we are now taking these findings to a classroom situation to see if similar results are possible in students. For this we will leave the laboratory and use the facilities of the Educational Neuroscience Classroom and the Centre for Advanced Imaging at The University of Queensland.



Professor Sven Silburn

Menzies Centre for Child Development and Education, Charles Darwin University

Over the years there have been a number of new learning initiatives 'rolled out' in remote and under-privileged communities, at huge cost and with no result. This is not surprising, as most of these new initiatives have not undergone any form of scientific rigour. SLRC funding has allowed us to build a strong school-based research agenda that examines what is actually happening in the classroom and how we can make it more effective. Under the ambit of the Measuring Learning theme, we are developing and implementing more robust tools to measure learning outcomes.



Professor Collette Tayler

Melbourne Graduate School of Education, The University of Melbourne

With a small team, including two post-doctoral fellows, Sven Silburn and I are examining the rudiments of very early learning, particularly investigating the learning and development of young Indigenous children. The base of this research draws from the original Abecedarian studies in the United States in 1960s and early 1970s. Being part of the SLRC allowed the design of a suite of connected laboratory and field experiments on very early learning that also link with implementation science studies. The focus includes joint-attention sequencing and the influence of contingent prompts and feedback behaviours on the rate of development of expressive English language in communities having different cultural and linguistic characteristics. To advance the usage of culturally appropriate research instruments we are also validating and standardising an early development screening tool for use with very young Aboriginal children. This work is being achieved through the mix of content expertise available through the SLRC, combined with the collaboration and experience of Indigenous communities in the Northern Territory and their local health and education practitioners. The conduct of research in remote locations requires established relationships, strong collaboration, longer-periods of time and greater resources. The SLRC, providing resources and a time period of four years, enables this suite of early learning projects to take place.



Dr Sue Thomson

Australian Council for Educational Research

Involvement in the SLRC has created opportunities to pursue research projects in the Science of Learning, which is an area of longstanding interest to me. Our SLRC research project has allowed me to collaborate with people from different research perspectives (education, neuroscience and psychology) on an important educational issue for pre-service teachers. Hearing how each of us interprets and would like to examine this issue is an experience that could only come from being part of the SLRC. Participating in our group CI meetings (or Big Days Out) has allowed me to discuss the Science of Learning and rapidly develop productive collaborations with researchers from diverse backgrounds. SLRC researchers use a range of research paradigms, often considered to conflict, however, my time in the SLRC has demonstrated the value of integrating diverse research approaches. Without the SLRC I would not have had the opportunity to work on projects that integrate these different paradigms in pursuit of answering questions about learning in the classroom.



Dr Mike Timms

Australian Council for Educational Research

The SLRC has given me the opportunity to learn about basic neuroscience and the research methodologies that are applied in that field, which has pushed me to become more interdisciplinary in my research. I have been able to forge new collegial relationships with neuroscience and cognitive psychology researchers and work collaboratively with them on projects. I am learning a lot! In addition, the SLRC has given me the opportunity to work with other research laboratories in the United States and the United Kingdom, which I was not doing before.



Professor Russell Tytler

School of Education, Deakin University

I'm planning to use the SLRC classroom at Melbourne to track the learning and reasoning of students undertaking representation construction activities in ways that are much more comprehensive than would have been possible before. Previously we have used video capture but it's been a matter of luck as to whether we capture decisive moments in thinking; the tracking and collating possibilities at the facility will now make it possible to yield high quality data across many groups. The data will also be useful for teacher education, again for the same reason of comprehensiveness. Having the classroom will also allow detailed monitoring within an experimental design so that investigating the affordances of inquiry and interaction can include detailed identification of student learning behaviours. Further, working with Professor David Clarke and our combined teams of associate researchers will enable collaboration in sharing and analysis of data across a number of interrelated constructs so that there are theoretical advances we would expect to come from this. Finally, working with a neuroscience-trained postdoc is opening up new perspectives and the discipline of moving towards neuroscience interpretations of our work is encouraging clarity of analysis and refinement of constructs for learning in classrooms.



Professor Martin Westwell

Faculty of Science and Engineering, Flinders University

The SLRC has allowed us to ramp up our basic research program to complement our translational activities to support educators to develop evidence-informed practices in their classrooms. The close relationship we have with educators has allowed us to make sure that the research was informed by teachers' needs and understandings (i.e., practice-informed research). We recruited an excellent early career researcher who was subsequently poached by Cambridge University but we returned the favour by replacing her with another excellent early career researcher from the Cambridge Centre for Neuroscience and Education. Given all of the work we, and others, have been doing in South Australia, it is fertile ground for research with an informed and willing education sector, but without the SLRC we would not have been able to build this capacity in practice-informed research.

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Front Cover: Early-career researchers from the SLRC shared knowledge of learning and the brain with school children as part of The University of Queensland's Solid Pathways Program.



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