

ARC Special Research Initiative for Science of Learning



IMPROVING LEARNING OUTCOMES



TO IMPROVE LEARNING OUTCOMES

VISION

through the

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

MEASURE outcomes in order to identify and develop evidence.

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 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

NC STATE UNIVERSITY





Carnegie Mellon University











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APPLYING

NEUROSCIENCE, COGNITIVE PSYCHOLOGY AND EDUCATION

DEVELOP EVALUATE DISPEL

EVIDENCE-BASED STRATEGIES FOR LEARNING

STRATEGIES
LEADNING

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.

At the heart of the Centre is a drive to improve learning outcomes at pre-school, primary, secondary, tertiary and vocational levels.

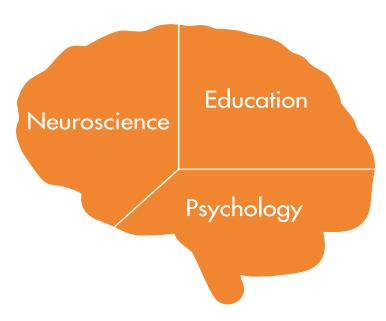
Education and health are two of the biggest influences on a person's life; and, just like for healthcare, the Centre believes in evidence of safety and efficacy for education.

The SLRC brings together 25 of Australia's leading researchers in Neuroscience, Education and Cognitive Psychology from across the country, collaborating on programs to better understand learning, using innovative experimental techniques.

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, these will be shared with educators and policy makers to enhance teaching and learning outcomes.

Research is being conducted in the molecular research laboratory; in two specially constructed classrooms (1) the Learning Interaction Classroom at The University of Melbourne, designed to study learning interactions at a granular level; and (2) the Educational Neuroscience Classroom at The University of Queensland, equipped to monitor neurological and physiological activity during learning events; using human brain imaging facilities, and in real world classrooms.

This report summarises the performance of the SLRC for 2015 and outlines the Centre's plans for meeting its strategic objectives in 2016.



BRINGING TOGETHER THE FINDINGS OF

NEUROSCIENTISTS, PSYCHOLOGISTS AND EDUCATIONAL RESEARCHERS

TO BETTER UNDERSTAND HOW THE BRAIN LEARNS

DIRECTOR'S REPORT

It is with great pleasure that I report on the activities of 2015, the year the SLRC transitioned beyond the establishment phase. The Centre has now grown to over 100 members across six states and territories; great minds from the disciplines of education, neuroscience and cognitive psychology, working together with educators to improve learning outcomes. With the Educational Neuroscience Classroom at The University of Queensland and the Learning Interaction Classroom at The University of Melbourne fully operational, the Centre's focus turned to engaging with educators, policy makers and the broader community.

In 2015 we were extremely fortunate to have Ms Tennille Seary join the Centre on secondment from the Queensland Department of Education and Training. Tennille's passion for teaching was inspirational to all of us who met her. Tennille engaged in several research programs, participated in many of the Centre's research meetings and made a huge contribution to the Centre's outreach program. We are very grateful to Brisbane State High School and the Department for agreeing to extend the secondment in to a second year.

A highlight of the year was the Nature – Science of Learning Symposium at Customs House, Brisbane in April. Marking the launch of the *Nature Partner Journal – Science of Learning*, the Symposium was attended by over 100 educators, researchers and policy makers from across the country and included several international speakers. As editor-in-chief of the journal I am extremely excited by the opportunity it presents to provide researchers and educators alike with open access to the latest research in learning. Fellow editors include SLRC researchers Professor John Hattie, Professor Jason Mattingley, Dr Mike Timms, Professor Diana Laurillard and Professor Brian Butterworth.

In June the Centre ran its first professional development workshops for teachers, in Brisbane and Melbourne. By all reports these were extremely well received, with demand by attendees for a follow up workshop, which took place in the September school holidays. Preparation is well underway for workshops in 2016 in Brisbane and Melbourne, and other states. I would like to extend a special thanks to Professors Annemaree Carroll and John Hattie and the Translation Team for their dedication to ensuring the success of these events.

The Australian Research Council's mid-term review of the SLRC provided the opportunity to reflect on what the Centre had achieved in a relatively short period and also consider opportunities for improvement. Several recommendations from the review have already been adopted including the establishment of a Student and Early Career Research Committee, chaired by Amanda Bourgeois and overseen by Professor Ross Cunnington. Following input from Centre members at its December meeting, the Executive Committee reviewed the research program of the Centre, prioritizing research outcomes.

This has been a year of highlights for many of our researchers and I would like to take this opportunity to congratulate Annemaree Carroll and Ross Cunnnington on their promotion to full professor, Professor John Hattie on his award for Contribution to Psychological Education from the Australian Psychological Society, Professor Jason Mattingley on his appointment to the Australian Research Council College of Experts (Social, Behavioural and Economic Sciences), Professor Ottmar Lipp on being elected President of the Society for Psychophysiological Research and Chair of the Psychology, Education and Social Medicine Panel of the Academy of Social Sciences in Australia, and Professor John Pegg on being awarded a Doctor of Education from the Phillipine Normal University.

On a personal note, in July I was honoured to be appointed Director of the Queensland Brain Institute at The University of Queensland. I accepted this position on the proviso that I could continue as Director of the SLRC, a role that I am extremely passionate about. Making it possible for me to continue in both roles, Professor Ross Cunnington agreed to take on the role of Deputy Director, taking on responsibility for the student and early career researcher portfolio and international collaborations. These activities are reported on later in this report.

None of the Centre's achievements would be possible without the support of the Australian Research Council, the Centre's Partner and Collaborating organisations, its dynamic Advisory Board chaired by Professor Barry McGaw, researchers, students and the education community, for which we are extremely grateful. We look forward to working closely with you in 2016, as we translate the outcomes from the Centre's research to the classroom.

Most importantly, I would like to thank the 1,000 plus educators who gave up their time to attend Centre workshops and seminars, and participate in research projects. You make, without doubt, the most important contribution to this Centre and we look forward to your involvement, and that of your colleagues, into the future.

As the SLRC enters its final year of funding from the Australian Research Council Special Research Initiative, our focus will turn to securing further funding to take the Centre into 2017 and beyond. It would be a travesty for the Centre's research and translation activities to end, just as it approaches its pinnacle, without achieving its full potential to enhance learning outcomes.

With best wishes,

Pany Sol



RESEARCH PERSONNEL, TRAINING AND DEVELOPMENT

25 CHIEF
INVESTIGATORS
2 PARTNER
INVESTIGATORS
35 RESEARCH HIGHER
DEGREE STUDENTS
33 POSTDOCTORAL
RESEARCHERS

CHIEF INVESTIGATORS



DR TIMOTHY BREDYThe University
of Queensland



PROFESSOR ANNEMAREE CARROLL The University of Queensland



PROFESSOR DAVID CLARKE The University of Melbourne



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 KHOOAustralian 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 THOMSONAustralian 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

The SLRC offers a unique opportunity to work with leading researchers, nationally and internationally, and cutting-edge infrastructure, making it a very attractive destination for both students and postdoctoral researchers.

Graduate students and postdoctoral researchers are at the heart of the SLRC, contributing to research programs across the Centre and bridging the gaps across disciplines and locations. Recognising the value of this group, a new portfolio was created within the Centre, Training, Development and Mentorship in June, with Professor Ross Cunnington taking responsibility. Under Professor Cunnington's guidance, in the second half of 2015 the Student and Early Career Researcher Committee was formed. Chaired by Amanda Bourgeois (PhD candidate at UQ), with representation from across the country, the Committee is identifying ways to increase networking and collaboration among Postdoctoral Researchers and Students; assisting to develop training programs for Centre members; and contributing to the organisation of Centre Big Days Out.

This year members of this group contributed to 28 peer reviewed publications, including 20 first or sole author papers; contributed to 5 book chapters; and 17 conference publications.

Many of the Centre's students received awards and prizes during the year including

- Natalie Rens Graduate School International Travel Award to undertake a placement at UCLA and an Australasian Cognitive Neuroscience Society Travel Award to present at the 5th Australasian Cognitive Neuroscience Society Conference in Auckland – the title of the presentation was *Decoding free decisions* in a virtual environment
- Dr Claire Scoular was promoted from Level A to Level B research fellow
- Luke Hearne Best PhD oral for his presentation *Functional brain networks underlying high-level cognitive* reasoning and fluid intelligence at the 5th Australasian Cognitive Neuroscience Conference in Auckland

A further 7 postdoctoral researchers were recruited to the SLRC in 2015, taking the total number to 33. Of these, 20 are within 5 years of completing their PhD.

In 2015 the Centre had a total of 35 students enrolled in PhD programs across the nine nodes, one of whom graduated and is now working as a Postdoctoral Researcher in the Centre. Of the 8 new students to enrol in 2015, three are formerly jointly supervised by CIs from different nodes and/or disciplines, with all benefiting from mentorship of senior researchers across nodes and disciplines within the Centre.

SLRC researchers supervised a total of 12 Honours students in 2015, all of whom graduated. These students were predominantly from the disciplines of psychology and neuroscience. This distribution across disciplines reflects the structure of training in education, where a Masters of Educational Studies coursework program or a PhD are more commonly undertaken than an Honours course.

Twelve SLRC researchers teach in to 7 Masters by coursework courses, incorporating the research of the Centre, including Masters of Neuroscience (Queensland Brain Institute, The University of Queensland - Sah, Mattingley, Cunnington), Master of Education, ICT in Education specialisation (Macquarie University - Lockyer), Master of Educational Studies (School of Education, The University of Queensland - Brooks, Carroll, Goos, MacMahon), Master of Instructional Leadership (The University of Melbourne - Scoular), Masters of Educational Psychology (The University of Melbourne - Scoular), Masters of Psychology (The University of Melbourne - Hester) and Master of Child Public Health (The University of Melbourne - Tayler). SLRC research is also being drawn in to curriculum design courses in the Graduate Certificate in University Teaching at The University of Melbourne (Lodge).

Postdoctoral Researchers

Dr George Aranda	.Deakin University
Dr Amael Arguel	
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 Cohrssen [†]	.The University of Melbourne
Dr Belinda Craig [†]	.Curtin University
Dr Anita D'Aprano†	.The University of Melbourne
Dr Sacha DeVelle	.Australian Council for Educational Research
Dr Hannah Filmer [†]	.The University of Queensland
Dr Florence Gabriel [†]	.Flinders University
Dr Kelly Garner [†]	.The University of Queensland
Dr Felicia Goh [†]	.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 Sasha Lynn	.The University of Queensland
Dr Lars Marstaller [†]	.The University of Queensland
Dr Natasha Matthews	.The University of Queensland
Dr Greg McPhan	.University of New England
Dr John Morris [†]	.The University of Queensland
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
_	.Australian Council for Educational Research
Dr Angelo Tedoldi [†]	.The University of Queensland
Dr Kelly Trezise [†]	.The University of Melbourne

Started in 2015

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

Dr Lars Marstaller

The University of Queensland

Lars is a cognitive neuroscientist working with Professor David Reutens at the Centre for Advanced Imaging at The University of Queensland. His research focuses on large-scale neural plasticity and how the brain networks underlying higher cognitive functions such as language and memory change as a result of learning, ageing, or injury. In his current project, Lars is investigating structural and functional connectivity changes associated with emotional learning in patients with temporal lobe epilepsy and healthy controls. In collaboration with Professor Annemaree Carroll, Lars is further investigating the effects of mindfulness training on the neural networks sup-



porting emotion regulation in school-teachers. "I believe that one of the core ideas of the SLRC-to use cognitive neuroscience to better understand learning-is very exciting and has the potential to make a real difference to students, teachers, and parents."

Dr Sacha DeVelle Australian Council for Educational Research, Perth Office

Sacha is Principal Research Fellow and Head of ACER Perth. She has worked as a researcher and educator in Latin America,



the United Kingdom, East Africa and Australia.

Her PhD in Linguistics (Language Processing) is what primarily drives her research interests. She managed the Psycholinguistics Laboratory at The University of Queensland for three years across the Linguistics Program, School of Psychology and Department of Speech Pathology.

Sacha is currently working with Dr Mike Timms (ACER) and Professor Ottmar Lipp (Curtin) to further investigate, at the behavioural and neural level, how adolescents benefit from feedback when engaged in creative problem solving tasks. 'The SLRC is at the cutting edge of neuroscience, education and psychology. Bringing together experts from diverse fields is allowing me to address the difficult questions, collaborate on research and educate the wider public on what learning and the brain really means. Most importantly, the SLRC is an Australian initiative led by Australian researchers: that is inspirational' she said.

Dr George Aranda Deakin University

George is a science education research fellow with a PhD in cognitive neuroscience. He is primarily interested in the construction of representations in the classroom and how neuroscience can inform this work to assist teachers.



Working with Professors Russell Tytler (Deakin University) and David Clarke (The University of Melbourne), his work focuses on examining how the 'social' is involved with the construction of knowledge in the classroom. This is done by working in the state-of-the-art Learning Interaction Classroom at The University of Melbourne; constructed to video-capture in detail the interactions of a classroom of students at a time. This project forms part of the 'sociocultural group' within the SLRC, including Professors Ross Cunnington (The University of Queensland) and Robyn Gillies (The University of Queensland). George commented "I feel very lucky to be part of the SLRC, actively working at the crossovers of neuroscience and education. The concepts, ideas and language that different researchers bring allows new questions to be asked and for new directions in research to be attempted."

Dr Mariya Pachman *Macquarie University*

Mariya is an educational researcher specialising in cognitive and metacognitive aspects of learning. She completed her PhD in 2013 at the University of New South



Wales. There she investigated the development of expertise in well-structured domains on examples of secondary mathematics classroom using randomised controlled trials. Mariya's research interests include design of multimedia learning environments aligned with the human cognitive architecture, expertise development and problem solving. She has worked with various population groups in secondary and higher education settings throughout Australia and the USA.

As a part of the 'confusion group', Mariya is collaborating with Professor Gregor Kennedy (UM), Associate Professor Rob Hester (UM) and Drs Rachel Buckley (UM) and Jason Lodge (UM). Together with the 'MQ project group', Professor Lory Lockyer (MQ) and Dr Amael Arguel (MQ), she focuses on the role of confusion, feedback and self-regulation in virtual learning environments. Mariya considers the best part of working in the SLRC is the unique combination of available expertise and resources to offer exceptional opportunities for early career researchers at the Centre.

Dr Florence Gabriel Flinders University

Florence is a postdoctoral researcher working with Professor Martin Westwell at Science21, Flinders University. Her background is in cognitive psychology



and her main research interest is understanding and developing 21st century skills. She is currently investigating problem solving skills and creativity in the classroom. Florence completed her PhD at the Université Libre de Bruxelles in 2011. Before joining Science 21, she worked as a research associate at the Centre for Neuroscience in Education at the University of Cambridge. Her PhD and post-doctoral work have focused mainly on numerical cognition with a particular interest in fractions and developmental dyscalculia. Florence says the best thing about the SLRC is the opportunity to meet experts from different fields who share a common interest in learning. She finds the SLRC a great source of inspiration and a great platform to talk about ideas from different perspectives on the common goal of improving learning.

Student and Early Career Researcher Committee

The inaugural meeting of the Student and Early Career Researcher Committee was in Melbourne on Friday 13th November. As part of the meeting the Committee visited the Learning Interaction Classroom.

Discussion focussed on the future of the Centre and what it meant for the students and early career researchers, and also the potential for further training and development opportunities.

Topics included:

- Maintaining the brand of the SLRC
- Continuing connectivity and collaborations
- Ideas for using the Big Days Out to facilitate mentoring
- Science of Learning the challenges of being in a new field, careers, publishing, grants
- Summer/winter retreat to complement theme workshops.

The main focus of the Committee is to establish a vibrant and diverse network of researchers that is sustainable beyond the current funding cycle of the SLRC; an invaluable and lasting legacy of the Centre.

Student and Early Career Researcher Committee:

- Amanda Bourgeois chair (The University of Queensland)
- Amael Arguel (Macquarie University)
- Megan Campbell (The University of Queensland)
- Michelle Hall (The University of Queensland)
- Florence Gabriel (Flinders University)
- · Dan Jazby (The University of Melbourne)
- Natalie Rens (The University of Queensland)
- Thomas Stephen (Australian Council for Educational Research)
- Paul Wiseman (The University of Melbourne)



Student and Early Career Researcher Committee (left to right): Paul Wiseman, Florence Gabriel, Amael Arguel, Michelle Hall, Amanda Bourgeois, Natalie Rens, Megan Campbell

Research Higher Degree Students

Angela Bender	ne nd nd nd ne ne ne nd
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Sandra MilliganThe University of Melbourn	
John Morris*The University of Queensla	
Aisling MulvihillThe University of Queensla	
Sadia NawazThe University of Melbourn	
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Adrian Norman	
Kellie Picker	
Natalie Rens	
Luke Rowe	ıe
Greg Scott	
Clare Scoular The University of Melbourn	
Chase Sherwell	
Tim Smith	
Samantha Simpson The University of Melbourn	
Lauren Sperotto	
Christina Van HeerThe University of Melbourn	
Paul Wiseman The University of Melbourn	ıe

* Graduated in 2015

Commenced in 2015

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 Scott *University of New England*

Greg is interested in the concept of 'understanding' and how students can improve their learning of algebra. One aim of his PhD, due for completion in 2016, is to develop and integrate the findings of past researchers, leading to a methodology, applicable to all ability levels, that enables students to grow their understanding to the point of being able to able to attempt previously non-attempted problems. Greg has taught for



over 35years in Australia, New Zealand and the UK where he has interacted with a wide variety of student learning approaches and educational systems. He says that the best thing about being part of the SLRC is the opportunity to share ideas and network with researchers investigating how students learn and understand from a variety of perspectives especially neuroscience.

Paul Wiseman The University of Melbourne



Paul is interested in task-level psychological engagement (flow) in higher education. Paul's research will be investigating this aspect of engagement within digital learning environments as well as exploring differences between individual and group experiences of engagement.

With a background in business schools and employee motivation, Paul is undertaking his PhD with the Melbourne Centre for the Study of Higher Education with Professor Gregor Kennedy and Dr Jason Lodge, and is excited about the exposure to different disciplines and approaches to learning within the SLRC. "I have enjoyed opportunities to hear ideas from each of the disciplines within the SLRC about their understanding of learning. It forces me to continually stretch the boundaries of my own views and understanding of the learning process."

Stephanie MacMahonThe University of Queensland

Stephanie is investigating the important role played by social synchrony in the learn-ing context and its impact upon teacher and student engagement. Stephanie's study hopes to identify what social synchrony looks and



feels like in the classroom, how it is developed and sustained, and whether this can be explicitly taught to other teachers, enhancing school connectedness in the adolescent years. Before commencing her PhD in 2014, Stephanie worked as a Head of Arts and Music teacher for over 20 years at schools in Sydney, Perth and Queensland.

Stephanie says being a part of the diverse academic community of the SLRC has provided her with the opportunity to develop a far more comprehensive understanding of the processes involved in effective teaching and learning. Stephanie is also a member of the SLRC Translation Team, working under the leader-ship of Professors Annemaree Carroll and John Hattie.

Natalie Rens The University of Queensland



Natalie is studying free decisions and how they are represented in brain activity. Natalie uses virtual environments in conjunction with neuroimaging in her studies.

Natalie's research has shown that free choices engage brain networks underlying attention

to a greater degree than instructed actions and result in greater activity in reward centres of the brain.

Natalie has a background in Biomedical Sciences and commenced a PhD with Professor Ross Cunnington in 2014. The most rewarding aspect of being part of the SLRC is pursuing a vision that aims to bring practical benefit to learners. She believes that we are in need of an education reform and looks forward to seeing how the science of learning can help bring about this change.

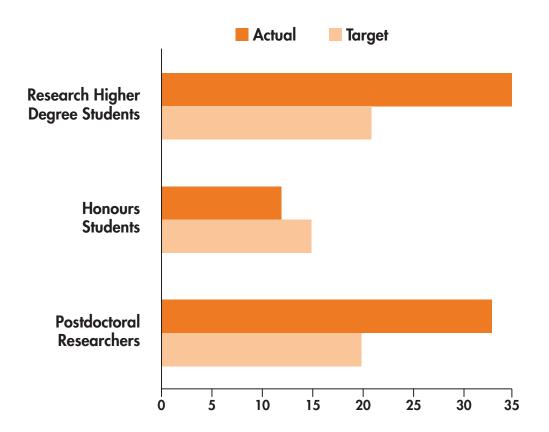
Dan Jazby *The University of Melbourne*

Dan is researching the in-the-moment cognition of teachers as they teach maths lessons. He adapts research methods which have been used to investigate the in-the-moment cognition of pilots and firefighters to be used with primary school teachers. Part

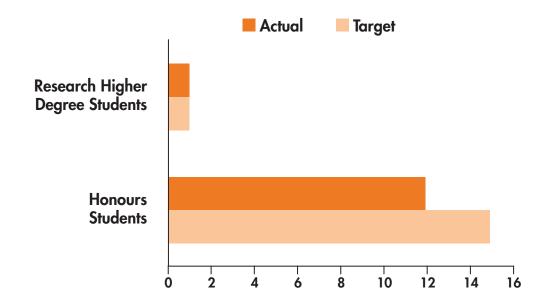


of these studies, supervised by Professor David Clarke, explore what teachers learn from the act of teaching in response to environmental feedback. Before starting his PhD in 2013, Dan was a primary school teacher with a background in philosophy. Becoming part of the SLRC has provided Dan with opportunities to present his research internationally and meet with researchers from outside of education. He is interested in the differences in timescale evident when the different disciplines of the SLRC research similar phenomena and hopes that, by combining data collection techniques from across the disciplines, the SLRC will be able to corroborate research findings across the disciplines.

Personnel working on core program research



Graduating Students in 2015



TRAINING AND DEVELOPMENT

The SLRC's most valuable asset is its research personnel, and it is a priority of the Centre to ensure each individual reaches their full potential. In order to achieve this goal, the Centre provides both formal and informal training and mentoring opportunities at a number of levels. In addition to training for research staff the Centre provides training and development opportunities to educators. The Centre's engagement with end-user stakeholders provides an opportunity for invaluable bi-directional knowledge transfer.

Professional development and training

The SLRC ran a total of 16 training sessions in 2015, including 3 professional development workshops specifically tailored for educators. 84 students, researchers and Chief Investigators attended 21 training and professional development courses. The Translation Team also delivered four training sessions on the Queensland Department of Education and Training eLearning platform.

Each of the theme workshops – Understanding Learning, Measuring Learning and Promoting Learning - as well as the two Big Days Out provided a unique opportunity for researchers to develop a better understanding of the different research methodologies employed by other disciplines to address the same question, as well as an insight in to ways to address some of the more challenging questions. In keeping with the spirit of encouraging the development of students and early career researchers, this group actively participates in these events through poster displays, oral presentations and moderation of sessions.

SLRC Training Sessions

anuary

Contemporary Classroom Research

Professor David Clarke
The University of Melbourne

January

EEG Workshop

Dr Natasha Matthews *The University of Queensland*

January

BIOPAC Physiological Monitoring workshop

Dr Natasha Matthews The University of Queensland

ebruary

Measuring Learning Workshop

Dr Mike Timms

Australian Council for Educational Research, Melbourne April

Understanding Learning Workshop

Professor Ottmar Lipp
The University of Queensland

Мау

Procam Training

Cameron Mitchell and Reggie Bowman (UM)

The University of Queensland

June

Bringing the Science of Learning to the Classroom

Translation Team

The University of Queensland

June

Promoting Learning Workshop

Professor John Hattie

The University of Melbourne

July

Bringing the Science of Learning to the Classroom

Translation Team

The University of Melbourne

July

EEG workshop

Dr Natasha Matthews

The University of Queensland

July

BIOPAC Physiological Monitoring workshop

Dr Natasha Matthews

The University of Queensland

eptember

More on Bringing the Science of Learning to the Classroom

Translation Team

The University of Queensland

Bringing the Science of Learning to the Classroom

The two-day professional development workshops, hosted in Brisbane and Melbourne, saw over 120 eager participants gain insight into current research across the fields of neuroscience, cognitive psychology and education; translating it into relevant, future-focused, practical information for educators. Feedback from participants was exceptionally positive with many participants returning for a follow-up day in September.

"I am hugely appreciative of everything I have been able to experience with SLRC so far. Both workshops I attended were excellent."

"It was so exciting to hear more of their knowledge and passion, as well as the extremely valuable work from Stephanie MacMahon on the role of teachers' emotions in teaching and all through the lens of the science of learning."

"My mind is always reeling when I leave and I need plenty of time for my neurons and synapses to assimilate the knowledge! It's always a fun day and our knowledge is appreciated as well. I love the two-way dynamics of discussion. Thanks to all the team and I can't wait until the next time." "These 2 days have helped me reaffirm that teaching is BOTH an ART and a SCIENCE: Complex and Beautiful."

"Thank you for re-humanising teaching: I feel valued again."

"It's refreshing to come away from a PD feeling empowered by knowledge rather than overwhelmed by it."









Mentoring

All students and early career researchers benefit from mentoring within the Centre. In addition to the mentorship young researchers receive from their primary supervisors, the SLRC has four formal mentoring programs:

• Educator mentorship

The SLRC is fortunate to have 10 teachers, including 3 school leaders, studying within the Centre, in addition to a teacher intern. On completion of their studies many of these teachers will return to leadership roles within schools. Professors Annemaree Carroll and John Hattie provide mentoring to this group.

Program mentorship

All students and early career researchers are paired with Chief Investigators from another node and/or discipline in their program.

• 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.

Mentorship in leadership

The student/early career research committee is overseen by Professor Ross Cunnington who mentors the chair and the group in leadership. Under Professor Cunnington's guidance, the group is planning its own two-day retreat in 2016 as well as contributing to the planning of the Big Days Out.

SLRC Chief Investigators mentor in excess of 120 students and early career researchers, including summers and winter research placements and professional training placements.

The year ahead

With the establishment of the Training, Development and Mentorship portfolio and the coming on line of the Student and Early Career Research Committee, there will be greater focus on the development of the Centre's up and coming researchers. In addition to providing formal and informal training and mentoring, the Centre will look to increase opportunities and experiences for young researchers, such as chairing sessions at research meetings, liaising with government and industry bodies, and participating in operational and planning meetings.

A winter retreat is being planned for the 2nd half of 2016, tailored for the student and early career researcher cohort.

There are 12 PhD students on track to graduate during 2016. Several of these students will stay on with the Centre as Postdoctoral Researchers.

The Queensland Department of Education and Training teacher internship program will continue to run in 2016, and an intern from the Victorian Department of Education and Training will also be appointed at The University of Melbourne.

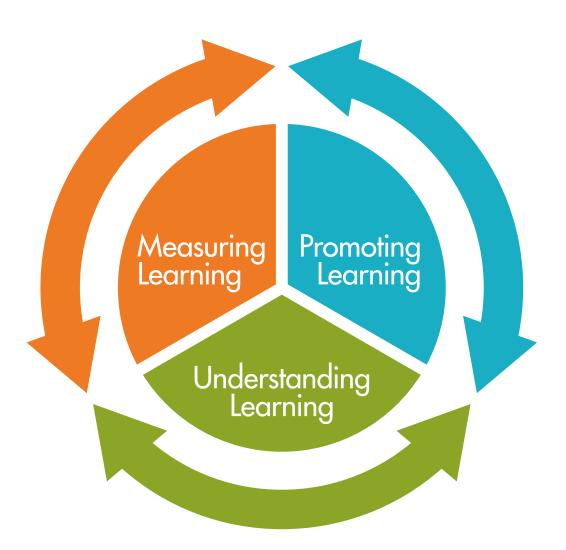
RESEARCH 3 THEMES 1 GOAL

TO IMPROVE LEARNING OUTCOMES

With new collaborations well and truly cemented, research in the Centre revealed several key findings in 2015, which have application in both formal and informal learning settings. These breakthroughs are a result of the converging of bright minds from various backgrounds and disciplines pooling ideas, challenging ideologies and learning from each other.

The SLRC operates under three broad themes: Understanding Learning, Measuring Learning and Promoting Learning, which feed into and off each other. The three themes run across all seven Centre programs. The Research Theme workshops conducted throughout the year were one of the many opportunities for the sharing of knowledge and expertise. In the second half of 2016, the Centre reviewed the research program, identifying the most significant discoveries thus far, many of which are featured in the following pages. These include:

- the ability to detect confusion in digital learning tasks
- the identification of two different types of attention during learning
- a neural mechanism by which training improves the ability to multitask-and why some individuals respond better to executive training than others
- how endogenous brain states predict performance.



RESEARCH THEMES

Measuring Learning

Theme Leader: Dr Mike Timms

Australian Council for Educational Research



Having robust tools to measure learning, both qualitatively and quantitatively is integral to the Centre's success. Reliable measuring tools are critical for research into understanding learning and also in the validation of new and existing learning strategies to promote learning.

Measuring Learning Theme Workshop

The Australian Council for Educational Research hosted the Measuring Learning Theme Workshop at Melbourne in February. It was attended by 17 researchers, including 4 students. The one-day workshop began with an introduction and overview of the day by Dr Mike Timms. The morning session included brief project presentations of five ongoing projects; 1. Learner processing of feedback in Intelligent Learning Environments, 2. Problem solving in cooperative learning in science, 3. Measuring learning in Massive Open Online Courses (MOOCs), 4. Measuring learner engagement and 5. Predicting learner confusion. To facilitate discussion, each project was asked to focus on one aspect of measuring learning that was essential to the project and explain what measurement methods had been used and any challenges that were faced. After each presentation there was a short question and answer exchange so that participants could learn from each other.

In the afternoon, the focus turned to measurement methodology, which was started by Dr Siek Toon Khoo who presented an overview on the importance of measurement. This was followed by three instructional presentations that included 1. Data mining, 2. Data mining in digital learning and 3. EEG methods. To wrap up the workshop, there was a final session in which all participants discussed the challenges that we still face in the SLRC, particularly in light of our desire to conduct trans-disciplinary research and also how we can prepare to meet those challenges.

Understanding Learning Theme Leader: Professor Ottmar Lipp

Curtin University

Understanding the learning process is essential for developing new learning strategies in a targeted fashion. For example, knowledge of how students process feedback in interactive digital leaning environments will allow for the development of more effective digital learning software. Researchers in the Centre are using a vast range of approaches to better understand the learning process, ranging from investigating cellular mechanisms and cell circuits that mediate learning in rodents to Magnetic Resonance Imaging and the in situ monitoring of physiological changes in students and teachers during a lesson.



Understanding Learning Theme Workshop

The Understanding Learning Workshop, held in April at The University of Queensland's School of Psychology was attended by 34 researchers, including 11 PhD students representing all nine nodes. A highlight of the workshop was the presence of Dr Hideaki Koisumi from Hitachi, Japan, a member of the SLRC Advisory Board. As part of the workshop, attendees had the opportunity to experience first hand the Educational Neuroscience Classroom and tour the 3T whole body Magnetic Resonance Imaging facility which is located within The University of Queensland's Centre of Advanced Imaging. The two sessions provided ample opportunity for discussion of the projects conducted under the Understanding Learning Theme.

To facilitate discussion, participants had been asked to provide information about their projects under investigation. This information was circulated to all in advance and attendees were asked to speak briefly to their project, highlighting the big question(s) pursued within it and the methods used to do so. They were encouraged to point to advantages and disadvantages of using the methods, settings etc. chosen (in a manner understandable for non-experts) and to explain how the project relates to the theme 'Understanding Learning'. This approach was chosen over the usual sequence of presentations on the projects and their findings to date in order to encourage discussion and to highlight the communalities in topics and methodological approaches. Although it took the attendees out of their comfort zone of powerpoint supported presentations, the approach was very successful in stimulating discussion and allowing a focus on key concepts like feedback, error and error correction, and emotion regulation, and how these are understood in different disciplines and conceptualised within different research settings.

Promoting Learning

Theme Leader: Professor John Hattie

The University of Melbourne



The ultimate goal of the SLRC is to improve learning outcomes by developing tools and strategies that promote learning in formal and informal settings. Through a better understanding of the learning process, it is possible to direct the development of more effective approaches to learning. Improved and novel measurement tools will ensure the robustness of these new strategies.

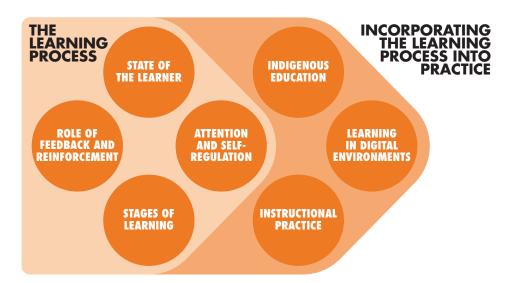
Promoting Learning Theme Workshop

The Melbourne Graduate School of Education at The University of Melbourne was the venue for the Promoting Learning Theme Workshop in June which was attended by 23 researchers including 7 students. The purpose of the workshop was for researchers to come together, share information about the kinds of questions their projects are addressing and define the particular aspect of promoting learning.

During the day, through a series of presentations and group activities, there was ample opportunity to: 1. outline the attendees' research and success so far; 2. seek support to solve current challenges; 3. brainstorm how SLRC can provide a systematic overview about the Promotion of Learning research; and 4. help in the translation of research into classroom practice.



RESEARCH PROGRAMS



Understanding the learning process is at the heart of the SLRC. The development of new techniques to accurately measure learning, both qualitatively and quantitatively, is essential for studying the learning process and the development and validation of practices that promote learning. The Centre's research is based on seven programs spanning the three themes of Understanding Learning, Measuring Learning and Promoting Learning. These seven research programs comprise:

State of the learner

The emotional 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.

Mathematics anxiety

Dr Sue Thomson (ACER), Dr Sarah Buckley (ACER), Dr Kate Reid (ACER), Professor Merrilyn Goos (UQ), Professor Ottmar Lipp (Curtin)



Mathematics anxiety, those feelings of tension, nervousness and worry associated with carrying out mathematical tasks, can impact on an individual's ability to demonstrate their mathematical capabilities and is also thought to be prevalent among primary school teachers. This project is designed to address this phenomenon with two research aims. The first is to investigate relationships between trait mathematics anxiety and attitudes towards maths (collected via an online survey), state mathematics anxiety (collected in the Experimental Neuroscience Classroom) and mathematics performance (collected in the Experimental Neuroscience Classroom),

amongst pre-service primary school teachers. The second aim is to describe the experience of mathematics anxiety among pre-service teachers to determine efficacy through a brief workshop in increasing participants' understanding of mathematics anxiety and of approaches to regulate its effects. The workshop draws on data collected in the Experimental Neuroscience Classroom to demonstrate the physiological and psychological impact of anxiety. This project has widespread significance for primary teacher training, given the influence of primary teachers on their students' attitudes towards and competence in mathematics. Better understanding of the experience of mathematics anxiety and of strategies to reduce its impact among pre-service teachers is likely to have implications for initial teacher training.

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 on learning outcomes. Knowledge gained in this program is being used to develop guidelines and paradigms for the delivery of feedback in various scenarios, including in classroom and digital environments.

Feedback for Learning: A mixed methods study in the upper primary classroom Cameron Brooks (UQ), Professor Annemaree Carroll (UQ), Professor Robyn Gillies (UQ), Professor John Hattie (UM)

Since 2013, we have been investigating how students use feedback in the classroom. Analysis of classroom dialogue revealed that over 75% of feedback within English lessons was directed at the task level which can be equated to promoting surface thinking whilst correspondingly less than 25% of feedback could be attributed to engendering deeper thinking and learning processes. When students were questioned on their perceptions of feedback, they rated feed forward (feedback that is improvement focused) as the most helpful feedback

type. Frequency data however shows this is the least used feedback type in the classroom. In response to these findings, we developed and implemented (through teacher coaching) a feedback for learning in the classroom matrix. Results showed significant improvements in academic achievement in writing between control and intervention groups. Students perceived the feedback intervention to offer more improvement focused feedback and teachers observed greater self-regulation amongst their students.



Attention and self-regulation

Attention and self-regulation have been hypothesisied to play key roles in learning and class-room 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.

Investigating "attention" during cooperative inquiry problem-solving activities in science Professor Robyn Gillies (UQ); Professor Annemaree Carroll (UQ); Professor Ross Cunnington (UQ); Professor Russell Tytler (Deakin)

Attentional focus and effortful control are required for children and young people to be active participants in classroom settings and to regulate academic performance. Our study is being conducted in over 15 authentic classrooms with years 6 and 7 students (aged 11-13 years) and their teachers to understand the effects of different representational tools on students' conceptual understandings, dialogic processes, attentional states, motivation, and learning. Unique to the study is the inclusion of methodologies from neuroscience, psychology and education. Using a combination of these techniques at pre- and post-intervention, including (a)



wireless wristbands to measures autonomic arousal, attentional states, and levels of synchrony between children; (b) videos to capture teacher and student interactions, and sustained and selective attention; and (c) a series of measures to assess actual and self-perceived ability in science, we are investigating how students solve problems through coordinating multimodal representations during cooperative inquiry problem-solving activities in science.

The results of our study so far demonstrate that two types of attention in students are emerging. 'Direct attention' is prominent when students listen and/or respond to very effective teachers who demonstrate capacities to elicit reciprocally high levels of attention and engagement from their students. However, there is also a form of attention that could be labelled 'vicarious attention' which is evident when students work in small groups. This latter type of attention appears to be needed to enable the students to have time to process information being discussed with fellow students. While 'direct attention' is more effective, the latter is still required as both are important. This thesis, if demonstrated to have support with further in-depth analysis across the range of methodological techniques employed, will potentially influence teachers' understanding of the different types of attention students demonstrate when they employ different types of pedagogical practices.

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 practice within the brain.

Reflex versus reflection: Model based and model free learning

Dr Marcus Gray (UQ), Professor David Reutens (UQ), Professor John Pegg (UNE), Dr Greg McPhan (UNE)

In this study we are focusing on two fundamental features of learning; the acquisition of automaticity during stable probabilistic learning, and on the transfer between explicit (model-based) and implicit (model-free) learning systems to examine how poor autonomic regulation impacts on the key neural structures underlying learning and automaticity (hippocampus and striatum). This will inform pedagogical practice by improving understanding of (i) how basic knowledge use is transformed from a slow and effortful process to a rapid, habitual and automatic process within the brain, and (ii) how this depends importantly on autonomic (bodily) state. These findings may allow for future optimisation of successful remedial programs such as QuickSmart, by identifying which features of learning and automation are most susceptible to over and under arousal.



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 effect of adult prompts and feedback on Australian aboriginal children's language development

Isabel Brookes (UM), Professor Collette Tayler (UM)

Using teaching practices that involve sustained back and forth interaction between educator and child is an effective approach that is found to promote children's learning. In 2015, we conducted a study of children aged between two and three years at a long day care centre in central Australia. Over a period of nine months we investigated changes in children's language development and joint attention initiations and responses alongside participation in an intensive intervention conducted on-site at the centre by two local educators and an occupational therapist. The pre and post intervention comparative analyses of the children's language



and joint attention behaviour revealed significant change in both the children's receptive and expressive language performance and their initiation of joint attention episodes. Children's age equivalence language scores increased an average of seven months over a three and a half month period, and the frequency of their initiation of joint attention increased by 71 per cent. These changes were supported by live observation within the regular program which showed an increase in children's observed verbal utterances and active engagement, over the course of the intervention. Following these findings, the study site has embarked on a 'whole of early learning centre' improvement strategy focussed on integrating the active ingredients of the intervention into the educational program.

Learning in digital environments

The last 20 years has seen an exponential increase in the use of digital technology for learning. Digital learning environments are software in which a learner is able to build knowledge and skills through activities that are designed to teach a topic or provide guided practice in using newly learned concepts or knowledge. 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. A significant breakthrough has been the ability to detect confusion in digital learning tasks – making it possible to identify and address confusion in a digital environment.

Examining how confusion can assist learning in digital environments

Professor Gregor Kennedy (UM), Associate Professor Rob Hester (UM), Dr Rachel Buckley (UM), Dr Jason Lodge (UM), Professor Lori Lockyer (Macquarie), Dr Amael Aguel (Macquarie), Dr Mariya Pachman (Macquarie), Professor Ottmar Lipp (Curtin), Dr Mike Timms (ACER)



Confusion can be beneficial as part of the learning process. For example, being confused cues students to change their learning strategies to overcome impasses as they learn about new concepts or correct misconceptions. Using a combination of techniques including eye tracking, video and EEG we are examining the role of confusion in learning in digital environments. It is important that we understand subjective states such as confusion in order to design more effective learning tasks in digital environments and provide feedback and help for students when they need it.

We are attempting to better understand what causes confusion in learning and how we can design learning environments to support students to achieve productive outcomes from episodes of confusion. Our research spans neuroscience, psychological science and education, with studies being conducted in research laboratories and in real life digital learning environments.

The results of our studies so far suggest a complex relationship between confidence, understanding and prior knowledge that influences confusion and the strategies students use in simulations and other digital learning environments. As the capacity for automatic detection of student learning processes becomes more sophisticated, we will be better able to predict in advance when students become confused and reach an impasse. This will allow for personalised scaffolding and feedback to be delivered within the environment in real time to help students overcome impasses and achieve productive learning outcomes.

Instructional practice

Researchers in the Centre are working closely with teachers and their classes to better understand how our new knowledge of 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.

Social interaction in the learning of mathematics and science *Professor David Clarke (UM), Professor Russell Tytler (Deakin)*

The Learning Interaction Classroom at The University of Melbourne is being used to reveal how student social

interactions with each other and with the teacher mediate their engagement in problem solving tasks in mathematics and science, and shape the consequent learning. As part of the project a junior secondary class, complete with their regular class teacher, comes into the classroom for a 50 to 60 minute session. Students undertake carefully structured mathematics and science tasks individually, in pairs and in groups of four.

The lessons, designed by the research team, involve problem solving activities in mathematics and science. They are delivered by the students' actual mathematics/science teacher from the partner school, recreating existing social relationships central to our understanding of the social nature of learning. The lessons are video and audio recorded in the Science of Learning Research Classroom, with multiple cameras and microphones, allowing researchers to conduct very detailed analyses of the social interactions through which classroom learning is facilitated and effected. Of particular interest in this project is the meaning and significance accorded by the students to explanations provided by their peers and the learning entailments of this attribution.

The research is giving insights into the role that social interactions play in amplifying the learning capabilities



Photo by Marcel Aucar Photography

of individuals. This is one of the most fundamental questions in contemporary education. In addition, particular investigations are addressing questions such as the optimal use of representations in the teaching and learning of mathematics and science, the effectiveness of instructional prototypes such as the 'worked example' or the 'experimental demonstration' and the relative effectiveness of different social arrangements in facilitating student learning in classrooms.

Many of the processes by which educational phenomena are experienced and by which the products of the learning process are enacted are essentially social. Our analysis has documented the parallel and entangled social negotiations related to: mathematical facts and procedures; socio-mathematical norms and expectations; and considerations of social obligation and interaction. An adequate understanding of these interconnecting modes of interaction requires parallel analyses from related but distinct theoretical perspectives. International collaborators have been recruited to assist in current analyses of the sophistication of student mathematical performance and product, forms of dialogic interaction and argumentation, and the emotive entailments of specific transient micro-cultures created by group participants. The results of these analyses promise insights into the social nature of learning and the identification of potential points of instructional intervention, whereby teachers might act strategically to promote particular forms of interaction with respect to each of the three negotiative modes and guide student interactions into optimally productive forms. The research design makes visible the social aspects of the learning process and, particularly, those for which "the social" represents the most fundamental and useful level of explanation and modelling.

RESEARCH INFRASTRUCTURE



A unique feature of the SLRC is the extensive research infrastructure that researchers have access to, allowing for the study of learning at multiple levels of granularity ranging from *in situ* in the school classroom to the cellular level within the laboratory.

In situ

Research in school classroom settings is a key component of the SLRC's research program and essential for ensuring the validity and relevance of the program. The SLRC is observing, trialing and validating strategies for learning in the classroom in early childhood, primary, secondary and tertiary settings across Australia, including rural Indigenous communities. In 2015 the Centre worked with teachers and students from more than 40 schools across 4 states and territories including the Northern Territory, Queensland, South Australia and Victoria. In addition to standard research protocols such as questionnaires and video, Centre researchers have access to physiological monitoring devices and sociometric badges which are being used, for example, to measure the correlation between student stress and learning.

iMotions Facial Expression Analysis Module Dr Felicia Goh, The University of Queensland

The iMotions tool is a platform for integrative analysis of eye tracking, biometric (such as electroencephalography, galvanic skin response and heart rate) and facial expression data of a person in response to a stimulus. The facial expression analysis (FACET) module in particular uses video footage of a single person's face to measure their emotional reactions to stimuli in real time. FACET (pictured right) has the capacity to recognise 9 key emotions using a 19 point Facial Action Coding System: joy, sadness, anger, frustration, surprise, fear, contempt, disgust and confusion. It also distinguishes between 3 emotional valences to capture nuances within those 9 emotions: positive, negative and neutral; as emotions such as fear may have elements of joy (positive; such

Emotient FACET

Anger

Surprise

Fear

Contempt

Confusion (all the contempt)

Frustration

as when experiencing a roller coaster) or anger (negative; such as when worried or stressed).

Traditionally, this technology has been used to monitor effectiveness in advertising or commercial interest, such as whether are spondent's gaze is drawn towards a particular product or whether visual or audio stimuli have successfully prompted the desired emotional reaction from a respondent. Our aim in using the iMotions FACET tool is to observe areas of teaching that encourage positive responses (ie. emotions appropriate for the stimuli) by students, as well as identifying events prompting negative reactions (eg. confusion, frustration or neutral/disinterest), to investigate which teaching strategies and stimuli may be the most effective in driving student engagement.

Sociometric Badges

Dr Felicia Goh, The University of Queensland

Sociometric badges are an observational tool used to detect various metrics relating to social interactions between people wearing these devices. The basic metrics measured include proximity to other users (via Bluetooth and infrared sensors), body movement and activity (via an accelerometer) and speech characteristics such as volume, speaking time and tone (via microphones). More advanced features of the associated software allow measurement of shared activity (mirroring) and conversational characteristics such as turn-taking, participation in conversation and frequency of interruptions. As an example, for a discussion between members of a small group, one can determine which person speaks the most, when the times of increased excitement were and which person is adept at interrupting the flow of conversation. In this way, information can be gathered about how key participants (such as group leaders or those with disruptive influences) affect the interest of the group as a whole.

Whilst these badges were designed to be used for groups of 10 or fewer people and have until now mainly been used in sports teams or corporate business groups, we are currently testing their capability to examine the activity of student-student and student-teacher interactions in classrooms. Ultimately, our aim is to determine the most effective strategies for student engagement and promotion of cooperative learning.



Learning Interaction Classroom

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

The Learning Interaction Classroom, located in the Melbourne Graduate School of Education at The University of Melbourne, is physically structured like a conventional classroom. The classroom, capable of accommodating a class of 30 students, is equipped with 16 channels for high definition video-capture, 32 channels of audio and space for post-lesson interviews with teachers and students. This complex facility offers researchers the opportunity to engage in fine-grained analyses of classroom interactions at an unprecedented level of detail.

Seventeen complete classes, including teachers, participated in studies at the Learning Interaction Classroom in 2015. In total over 500 mathematics, science, English, Chinese language and drama students contributed to projects, including the social unit of learning project led by Professor David Clarke and Professor Russell Tytler and the collaborative group work pilot study lead by Professor Patrick Griffin. Other studies involving children in their early years and university students included the expressive language study led by Professor Collette Tayler and the confusion study led by Professor Gregor Kennedy, respectively.

Social unit of learning project

In the Social Unit of Learning project, students engage in carefully crafted mathematical tasks individually, in pairs, as members of a small group and as an entire class. Conditions (task and social unit) are strategically varied to support the simultaneous recording of the social interactions of the teacher and every student as the class undertakes a series of mathematical tasks in situations of carefully varied social complexity.





This level of detailed and simultaneous documentation of student and teacher activity is only possible because of the facilities available in the Learning Interaction Classroom. The research design facilitates the identification of those aspects of learning for which "the social" represents the most fundamental and useful level of explanation, mod-elling and instructional intervention.

Photo by Marcel Aucar Photography

Educational Neuroscience Classroom

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

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

In 2015 over 440 people participated in studies in the Educational Neuroscience Classroom across 12 projects. Projects were led by researchers from the Australian Council for Educational Research, Deakin University and The University of Melbourne, as well as The University of Queensland.

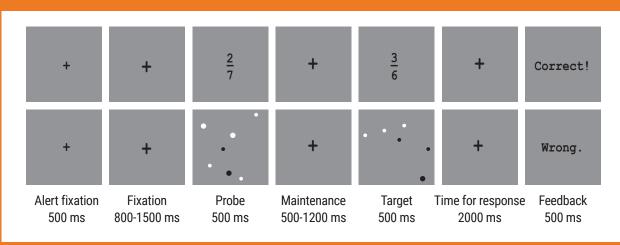
Influence of pre-trial alpha oscillations on mathematical reasoning

While we often think of our brain as simply reacting to information around us, recent evidence suggests that even before we start a task, our brains can be in a state that makes us more or less able to take in information. In this project we were interested in determining if these changes in brain state can influence our ability to complete a mathematics task. Specifically, we measured alpha oscillations using electroencephalography (EEG). These alpha oscillations are a measure of the state that the brain is in. We also had participants perform a fraction comparison task.



In this task participants were shown two fractions that were sometimes presented as numbers, and

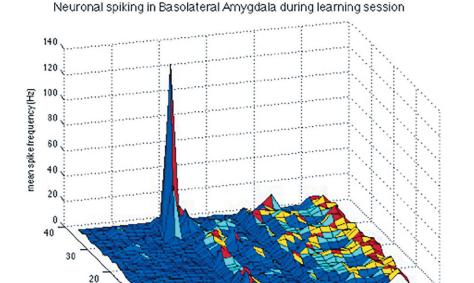
sometimes as pictures/dots. We asked the participants to decide which of the two fractions represented the greatest proportion. We recorded instances in which participants answered questions correctly, as well as those in which they did not. We found that alpha oscillations were higher before the fractions questions which participants answer incorrectly compared to questions that were answered correctly.



These results show for the first time, that our ability to engage in a complex reasoning problem, like solving the fractions comparison used in our experiment, is dependent upon the state that our brain is in prior to even seeing the two fractions. In future work we hope to explore ways in which we can change the baseline brain state to make people better prepared for learning.

Molecular laboratory

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



Microelectrodes were chronically implanted in rats and electrophysiological recordings made over several days as the animals were exposed to fear conditioning and extinction learning protocols. The figure shows the neuronal spiking frequency of a single unit in basolateral amygdala during an extinction learning session.

trials

Image - Dr John Morris

time (seconds)

Imaging

Functional magnetic resonance imaging (fMRI) is being used to monitor changes in brain activity and structure at an anatomical level by researchers at The University of Queensland's Centre for Advanced Imaging and The University of Melbourne.



The left hemisphere inferior frontal junction is a key brain region involved in coordinating multiple tasks concurrently – multitasking. Researchers are employing fMRI to investigate how training enhances multitasking performance and executive function, and why some individuals respond better to executive training than others.

Image - Associate Professor Paul Dux

The year ahead

As we enter 2016 the Centre will focus on its most significant discoveries to date. Further funding has already been allocated to support additional personnel to work on these discoveries in an effort to ensure that the promise of these breakthroughs is fully realised in the classroom.

RESEARCH OUTPUT

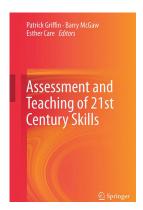


PUBLICATIONS

The SLRC produced 119 publications in total in 2015. Centre researchers authored 55 peer reviewed publications and 37 conference publications. Researchers contributed to 20 book chapters and 2 books.

Highlights of the year include

- Cao, Y., Contreras-Huerta, L. S., McFadyen, J. & **Cunnington, R.** (2015) Racial bias in neural response to others' pain is reduced with other-race contact. *Cortex*, 70, 68-78.
 - This was the top research highlight and most downloaded article in the journal Cortex for 3 months. On social media, it made the front page of Reddit with over 2000 comments and more than 4600 "up" votes. This was also the news story with the most website "hits" for The University of Queensland in 2015.
- **Garner, K. G.,** & **Dux, P. E.** (2015). Training conquers multitasking costs by dividing task representations in the frontopariental-subcortical system. *Proceedings of the National Academy of Sciences*, 112 (46), 14372-14377.
 - This paper represents the largest fMRI multitasking training study to date. Specifically, this large scale (n=100), individual differences, fMRI study employed advanced analysis techniques (multi-voxel pattern classification) to show, in human adults, how neural coding in prefrontal and parietal cortical areas and subcortical regions of the brain change with training to enhance multitasking performance and executive function. Importantly, it showed a mechanism for why some individuals respond better to executive training than others.
- **Gillies, R.** (2015). Teacher Dialogue that supports Collaborative Learning in the Classroom. In Lauren B. Resnick, Christa S. C. Asterhan and Sherice N. Clarke (Eds.) Socializing Intelligence through Academic Talk and Dialogue (pp.335-346). AERA: Washington, DC. This chapter is the outcome of a special invitation to join a collaborative research initiative on socialising intelligence through academic talk and dialogue with colleagues from the Science of Learning Research Center at the University of Pittsburgh, USA.



- **Griffin, P.** & Care, E. (Eds.) Assessment and Teaching of 21st Century Skills: Methods and Approach. Dordrecht: Springer Science and Business Media.
 - Many SLRC researchers contributed to this text, which was coauthored by SLRC Chief Investigator Professor Patrick Griffin.
- Hattie, J., Visible Learning in to Action.

 This is a book of case studies of visible learning from around the world.
- **Hearne, L.**, Cocchi, L., Zalesky, A., & **Mattingley, J.B.** (2015). Interactions between default mode and control networks as a function of increasing cognitive reasoning complexity. *Human Brain Mapping*, 36, 2719-2731.

Higher cognitive reasoning capacity—also known as "fluid intelligence"—is crucial for organising behaviour and optimising learning outcomes. Researchers in the Centre have undertaken a series of investigations to better understand how large-scale brain networks organise themselves dynamically from moment to moment when confronted with mental reasoning problems of various levels of complexity. Using functional magnetic resonance imaging (fMRI) acquired on both the 3T and 7T scanners at The University of Queensland's Centre for Advanced Imaging several key aspects of neural activity patterns associated with higher cognitive reasoning have been characterised. Luke Hearn was awarded best student oral for his presentation of this work at the 5th Australasian Cognitive Neuroscience Conference in Auckland, New Zealand in November.

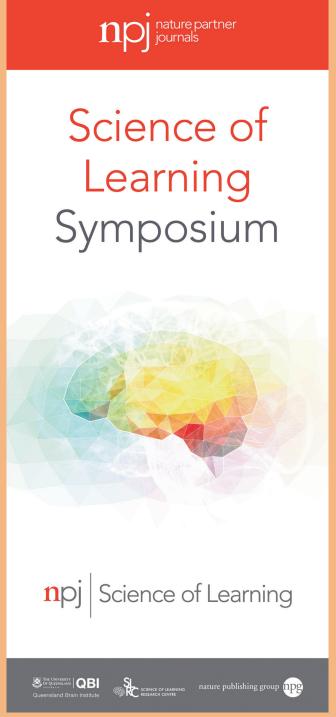
• Tayler, C., (2015). Learning in Early Childhood: experiences, relationships and "Learning to Be", European Journal of Education. 50(20), doi: 10.1111/ejed.12117

Professor Collette Tayler was invited by the European Journal of Education, through the OECD Education Directorate, to provide an article for the Special Edition on "Learning to Be".

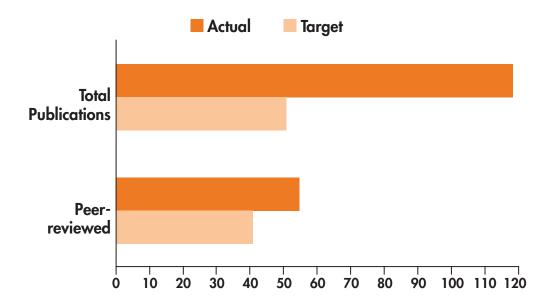
npj Science of Learning

The *Nature Partner Journal – Science of Learning* was officially launched in April at Customs House in Brisbane. npj Science of Learning is a new open access, online-only journal that brings together the findings of neuroscientists, psychologists, and education researchers to understand how the brain learns. Professor Pankaj Sah is Editor-in-Chief of the new journal, the editorial board including a number of SLRC reseachers.





Research Output



COMMUNICATING SCIENCE

Invited talks, papers and keynote lectures

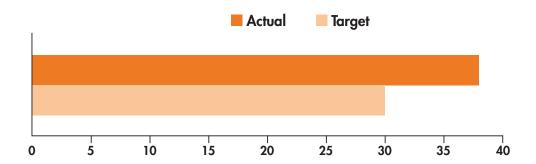
Centre researchers delivered over 80 presentations at national and international conferences, 38 were at major international conferences.

Conference highlights include:

- 5th Australasian Cognitive Neuroscience Conference, Auckland, New Zealand. Six members of the Centre presented their research at this conference in November which attracted over 250 delegates. Luke Hearne received the award for best PhD oral for his presentation "Functional brain networks underlying high-level cognitive reasoning and fluid intelligence" and Natalie Rens was awarded a travel prize.
- Professor Merrilyn Goos gave a keynote presentation on her work "Linking communities
 of research and practice in mathematics education" at the 25th biennial conference of the
 Australian Association of Mathematics Teachers, Adelaide, in July.

 This keynote invitation for a national teacher conference acknowledged her ability to com-
 - This keynote invitation for a national teacher conference acknowledged her ability to communicate research ideas effectively to practitioners. The invitation and the keynote topic exemplify the SLRC's commitment to researching with (not just for) teachers. It was attended by approximately 300 people; mainly teachers but also included university academics in education and mathematics, curriculum writers and education department officers.
- Professor Ross Cunnington's presentation, "The SMA and cingulate cortex sustain premovement activity in readiness for action: An EEG-fMRI study" was a Top 5 Conference Highlight at the 21st Organisation for Human Brain Mapping. The conference, held in Hawaii, is one of the most important annual brain imaging conferences, attracting over 3,000 delegates.

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 800 recipients.

March

Professor David Clarke - Herald Sun SLRC Quarterly Newsletter Professor David Clarke - Herald Sun Online

April

Professor David Clarke - University of Melbourne Campus Review Professor David Clarke - MGSE Magazine ACER Teacher Magazine - Spotlight on Practitioners https://www.teachermagazine.com.au/article/spotlight-on-practitioners

May

Professor John Hattie - ACER Teacher Magazine https://www.teachermagazine.com.au/article research-files-episode-10-professor-john-hattie

Professor John Hattie – ACEL Perspectives – How can university and school's partnerships be strengthened to ensure classroom readiness of teaching graduates.

June

Mr Jared Horvath and Dr Jason Lodge – The Conversation - It's not PowerPoint's fault, you're just using it wrong.

 ${\it https://the conversation.com} its-not-power points-fault-your e-just-using-it-wrong-43783$

Professor David Clarke - MGSE Broadcast SLRC Quarterley Newsletter Professor David Clarke - Education HQ Professor David Clarke - ARC Online Newsletter

July

Dr Jason Lodge – Lifehacker website – How to use powerpoint without sucking. http://www.lifehacker.com.au/2015/07/ its-not-powerpoints-fault-youre-just-using-it-wrong/

Dr Jason Lodge *et al* – The Conversation – Should MOOCs be used as credit for high school? *https://theconversation.com/should-moocs-be-used-as-credit-for-high-school-45226*

August

Dr Jason Lodge – Australian Financial Review – Education of the digital natives. http://www.afr.com/news/special-reports/teaching-the-digital-natives-20150814-giz77q

Dr Jason Lodge – Australian Financial Review – Debating the new modes of instruction. http://www.afr.com/news/special-reports/debating-the-new-modes-of-instruction-20150813-giyhly

Dr Jason Lodge – The Guardian – As laptop scheme ends what next for families and learning?

Professor John Hattie – ACEL Perspectives – How can university and school's partnerships be strengthened to ensure classroom readiness of teaching graduates.

September

Professor Ross Cunnington – Australian Geographic - Taking science into the classroom and beyond.

Dr Hilary Hollingsworth - Saturday Extra, radio interview - Science of Learning classroom.

https://soundcloud.com/educationmelbourne/science-of-learning-classroom-on-saturday-extra)

Jared Horbath and Gregory Donohue - The Conversation, - So much talk about "the brain" in education is meaningless. http://theconversation.com/so-much-talk-about-the-brain-in-education-is-meaningless-47102

October

Professor Jason Mattingley - SBS "Insight" program – How much more can we use our senses? http://www.sbs.com.au/news/insight/tvepisode/sensational

Dr Jason Lodge – Panorama SYN90.7FM – Test test testing: A true measure of intelligence? https://soundcloud. com/tillygraovac-test-testing-a-true-measure-of-intelligence

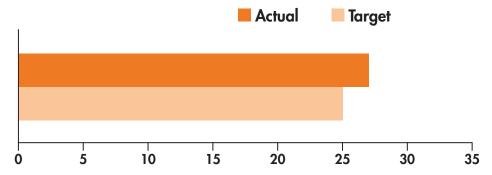
Dr Jason Lodge et al – The Conversation – The campus experience is changing all over the world. https://theconversation.com/the-campus-experience-is-changing-all-over-the-world-46866

SLRC Quarterley Newsletter

December

Professor Pankaj Sah - Forge magazine

Commentaries about the program's achievements



The year ahead

In 2016 the SLRC will continue to communicate its findings to the research community, the education community and the general public.

The first edition of the Nature Partner Journal - Science of Learning will be available on line in April 2016.

The Australian Journal of Education is running a special edition in June with guest editors Associate Professor Rob Hester and Dr Mike Timms. The journal will showcase SLRC findings.

A special issue of *Australasian Journal of Educational Technology* is being compiled by Professors Gregor Kennedy and Lori Lockyer and Dr Jason Lodge. Entitled *Brain, mind and education: Understanding learning in digital environments,* the journal will feature SLRC research.

The translation team is producing a portfolio of commentaries on topical issues in education based on SLRC research which will form the basis of media statements in a more coordinated fashion in 2016.

INTERNATIONAL, NATIONAL AND REGIONAL

LINKS AND COLLABORATIONS

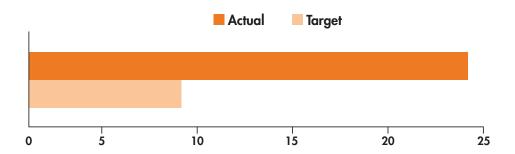
INTERNATIONAL VISITORS

The SLRC had an influx of international visitors in Q1 of 2015. The Nature Science of Learning Symposium in March attracted six international speakers and guests, several of whom also visited the Centre. Advisory Board member Dr Hideaki Koizumi from Hitachi in Japan was an inspirational participant at the Understanding Learning Theme Workshop. Keynote speaker Professor Jonathon Sharples from University of York and the Education Endowment Foundation visited the Centre's Adelaide and Brisbane nodes. Dr James Leicester from the SLRC Partner Organisation North Carolina State University spent time at the Australian Council for Educational Research in Melbourne. He also gave a seminar Narrative-centred learning environments at The University of Melbourne prior to participating in the panel discussion - Intelligent Learning Environments - at the symposium. Discussions between the Unites States National Science Foundation Program Director and Chair of Coordinating committee, Science of Learning Centers Program, Dr Soo Siang Lim and Professor Pankaj Sah, during her visit for the symposium, resulted in an invitation to the Science for Education Symposium, a Satellite event of the International Brain Research Organization Congress in Rio de Janeiro. Professor Ross Cunnington, who represented the SLRC at the meeting was appointed to the Steering Committee for establishment of an International Consortium for Science of Learning.

The SLRC was privileged to have Dr David Osher from the American Institutes for Research (AIR) visit in August. Dr Osher's research delves into the importance of and relationship between conditions for academic learning and Social and Emotional Learning (SEL). With an increasing body of evidence highlighting the effects of SEL on learning, social development and school quality it is vital that stakeholders in the education industry understand how these effects can be measured and improved. During his visit Dr Osher presented to over 55 teachers at the The University of Queensland. His topic Social and emotional learning and the conditions for learning generated a lively discussion.

As part of the "Science Without Borders" program PhD student Nathalia Souza from the Federal University of Bahia, Brazil spent the winter months working with Professor Ross Cunnington and his group at The University of Queensland.

Number of international visitors and visiting fellows



OVERSEAS VISITS

SLRC researchers visited developing and established science of learning centres around the world, including Chile, United Kingdom, Brazil, United States, Argentina, Phillipines and Saudi Arabia.

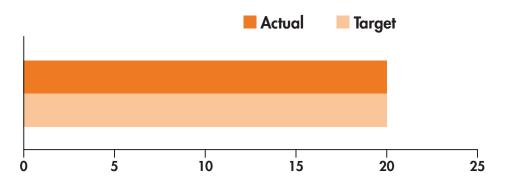
Professor Ross Cunnington spent the last months of 2015 working with Professor Jorge Moll at the D'Or Institute for Research and Education (http://idor.org) and Professor Roberto Lent who is head of the Brazilian Network for Science in Education (http://cienciaparaeducacao.org/eng/). Professor Lent is creating a Science of Learning Research Centre at the main Federal University of Rio de Janeiro campus, as part of the Institute of Biomedical Sciences.

A delegation, lead by Professor Annemaree Carroll visited two United States National Science Foundation Science of Learning Centers in July. At the Visual Language Visual Learning Center at Gallaudet University they spent time gaining a greater understanding of the biological, cognitive, linguistic, sociocultural and pedagogical conditions that influence the acquisition of language and knowledge through the visual modality. This was followed with a visit to the Centre of Excellence for Learning in Education (CELEST) at Boston University. There they met with Centre Director Professor Barbara Shinn-Cunningham, focusing on selective attention and the networks involved in auditory versus visual attention.



Image (left to right): Dr Julie Bower (UQ), Professor Barbara Shinn-Cunningham (CELEST), Professor Annemaree Carroll (UQ), Amanda Bourgeois (UQ) and Associate Professor Heather Ames ICELESTI

Number of visits to overseas laboratories and facilities



CENTRE WORKSHOPS

In addition to the three theme workshops and three teacher professional development workshops held throughout the course of the year the Centre hosted several events featuring national and international participants.

The Australian Council for Educational Research continues to provide a platform for SLRC activities at two of its national conferences: the ACER Research Conference and the Excellence in Professional Practice Conference. Learning more about feedback from education and



neuroscience was the theme for the discussion between Centre Director Professor Pankaj Sah and Theme Leader Professor John Hattie at the ACER *Excellence in Professional Practice Conference*, facilitated by Dr Elizabeth Hartnell-Young. The conference ran over two days in Sydney, which attracted over 300 participants from around the country was run in parallel with the SLRC Big Day Out.



In conjunction with the Melbourne Graduate School of Education and the International Centre for Classroom Research the SLRC hosted the *The world of mathematics education: a panel presentation that brings the World to you.* The event, hosted by Professor David Clarke and attended by 150 people, provided a forum for lively discussion of current issues in mathematics education and how these are being addressed around the world. Panel members included:

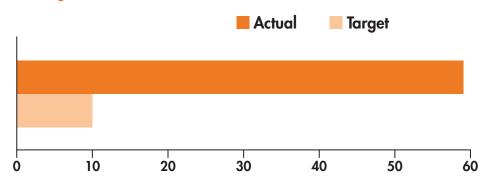
- Professor Michele Artigue, Universite Paris Diderot, Felix Klein Medal Recipient
- Professor Cao Yiming, Beijing Normal University, China, president of the Chinese Association of Mathematics Education
- Professor Jarmila Novotna, Charles University, Prague, Czech Republic, founding member
 of the European Society for Research in Mathematics Education (ERME) and founder of
 Symposium on Elementary Maths Teaching (SEMT)
- Professor Markku Hannula, University of Helsinki, Finland, influential contributor to research on teachers' beliefs and the role of affect in mathematics learning and Nordic mathematics
- Professor Yoshinori Shimizu, Tsukuba University, Japan, member of Mathematics Expert Group for OECD/PISA and consulant for the TIMMS Videotape Classroom Study.

ORGANISATION PARTICIPATION

SLRC researchers participated in over 59 committees, working groups and panels, both nationally and internationally in 2015. These include:

- Professor Merrilyn Goos member, Australian Academy of Science's National Committee for Mathematical Sciences.
- Professor John Hattie Chair, Board of Directors, Australian Institute for Teaching and School Leadership Limited (AITSL)
- Professor Jason Mattingley member, Australian Academy of Science's National Committee for Brain and Mind
- Professor John Pegg member, New South Wales Board of Studies, Teaching and Educational Standards. Professor Pegg was reappointed as the NSW Education Minister's nominee for a further three years during 2015.
- Professor Collette Tayler member, Victorian Curriculum and Assessment Authority
- Professor Martin Westwell member, UNESCO (Bangkok) Education Beyond 2015 group
- Professor Martin Westwell member, South Australian Certificate of Education Board
- Professor Sven Silburn commissioned by Prime Minister and Cabinet to lead a proofof-concept study to improve educational outcomes for Indigenous Australians through better targeting of early childhood interventions

Organisation participation



The year ahead

The Centre will play a key role in the establishment of the International Consortium for Science of Learning with representation on the Steering Committee by Professor Ross Cunnington. Professor Cunningon will spend the first two months of the year in South America, building networks with researchers at D'Or Institute for Research and Education and Federal University of Rio de Janeiro. The Centre will continue to strengthen its ties with Hitachi, with Professor Pankaj Sah visiting Japan in the first half of 2016.

Partner Investigators Professors Diana Laurillard and Brian Butterworth will spend several weeks visiting the Centre in the Autumn months, spending time in Melbourne and Brisbane. As part of their visit the Centre will run workshops on learning mathematics in digital environments at both locations for teachers and researchers.

The Centre will continue to have a presence on many organisation boards and committees - scientific, educational and policy; both national and international.

COMMUNITY ENGAGEMENT, TRANSLATION AND OUTREACH



The effort that went in to planning and preparation in 2014 came to fruition this year, commencing with the official opening of the Learning Interaction Classroom at The University of Melbourne in March by Senator the Hon Scott Ryan. The opening was live streamed, for those who could not attend in person. This was followed by the Science of Learning Symposium held in Brisbane in April which launched the *Nature Partner Journal – Science of Learning*. The symposium was attended by over 100 delegates, including researchers, teachers, education leaders and policy makers. The Centre ran the first of its professional development workshops for teachers in 2015, which will be repeated and expanded in 2016.

TRANSLATION

Under the leadership of Professors Annemaree Carroll (UQ) and John Hattie (UM) the SLRC Research Translation Team is working to translate the research findings of the Centre to the classroom. The team is taking a multi-pronged approach to ensure that research findings from the Centre reach the classroom, improving learning outcome for students. This is being achieved through the delivery of professional development workshops, development of post graduate courses for practicing educators, the implementation of courses for pre-services teachers and the development of resources for educators, as well as informal avenues.

Professional development

The Centre is working closely with the Education Departments of Queensland, South Australia and Victoria to deliver professional development in the Science of Learning that marries with the strategic objectives of the respective Departments. In 2015 the Centre delivered professional development to over 1,000 teachers in Queensland, South Austral and Victoria, with 120 educators attending a 2-day professional development workshop *Bringing the science of learning to the classroom* during their own time in Brisbane and Melbourne. Working with the Queensland Department of Education and Training, the Centre delivered four e-seminars to educators across the state.

By providing educators with an understanding of the cognitive, social, emotional and physical factors that impact learning at all stages of development, the Research Translation Team is empowering educators to understand the 'why' behind effective teaching and learning. The team is supporting educators to engage in critical reflection of their everyday decision-making and choices for practice through the use of evidence based research.

New curriculum for pre-service teachers and graduate programs

Schools of Education from eight leading Australian universities are represented in the SLRC. The Research Translation Team is developing course material to be incorporated in a Masters program and pre-service teacher training, which will be rolled out in semester 2 of 2016 at The University of Melbourne and The University of Queensland, and shared with other nodes in following years.

Resources for educators

The PEN Principles are a resource being developed by the Research Translation Team. The principles, based on evidence from Psychology, Education and Neuroscience have so far been developed in the form of podcasts and one page artefacts which are available on the SLRC website.

Teacher intern program

In 2015 the Queensland Department of Education and Training supported a teacher intern program which attracted over 90 applicants. The successful applicant, Ms Tennille Seary, was provided with the opportunity to learn from and collaborate with leading researchers in the Centre. The SLRC benefitted from the first-hand knowledge of Ms Seary.

Seminar series

The Centre conducted 13 seminars in Victoria and Queensland featuring national and international speakers, attracting up to 200 educators. The seminars are held outside school hours making it possible for educators to attend. Many of the presentations are also available on the SLRC website.

Ms Tennille SearyQueensland Department of Education and Training

The Centre was extremely fortunate to benefit from the knowledge and experience of Ms Tennille Seary, on secondment from Brisbane State High School. Tennille played a key role in the Research Translation Team, as well as contributing to several research projects in the Centre including the Teacher-Student Synchronicity project, which is investigating the ship in a classroom, led by Professor Ross Cunnington (QBI) and Professor Robyn Gillies (UQ School of Education). We thank the Queensland Department of Education and Training and Brisbane State High School for supporting this initiative.



STRATEGIC PARTNERSHIPS

The Americas was the focal point for new collaborations in 2015. The Centre is working towards building closer ties with the United States National Science Foundation Science of Learning Centers, with the support of the Program Director of the US Science of Learning Centers Program, Dr Soo-Siang Lim. Professor Annemaree Carroll led a delegation which visited two of the Centres; the Visual Language Visual Learning Centre at Gallaudet University and the Centre of Excellence for Learning in Education at Boston University. Professor Ross Cunnington's role in the Steering Committee for the establishment of an International Science of Learning Cosortium will be instrumental in building this relationship. In South America new partnerships have emerged with the Centre for Advanced Research in Education at the University of Chile and D'Or Institute for Research and Education in Brazil.

Locally, the Centre has been working with Euclideon, a software and digital technology development company and EnVizion, a not-for-profit training provider based in far north Queensland whose mission is to enhance the employability of disadvantaged Australians, with the aim of delivering digital education technologies to remote communities.

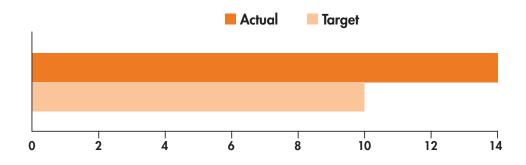
In addition to seeking new partnerships, the Centre continues to grow its existing relationships;

- 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, respectively)
- Australian College of Educators (Nugent)
- · Nature Publishing Group (Sah)

During the course of 2015 a new partnership emerged with the University of Chile's Centre for Advanced Research in Education (CIAE). Founded in 2008, the Centre is a joint initiative with 3 major universities in Chile: Universidad de Chile, Universidad de Concepción, and Pontificia Universidad Católica de Valparaíso. In March Dr Sacha DeVelle participated in a workshop with members of the Neuroscience and Cognition stream, exploring potential for collaboration between CIAE and SLRC. The workshop included several presentations with Dr DeVelle giving a presentation entitled *Towards a Science of Learning*. Subsequently, in June of 2015, Dr David Gomez from the CIAE spent several weeks visiting the SLRC. *Photo: Dr Sacha DeVelle and Professor Pablo Dartnell, Director of the Laboratory for Neuroscience and Cognition (centre) with researchers Mauricio Toro (left) and Rodrigo Avaria (right).*



Strategic partnerships



BRIEFINGS TO INFORM POLICY

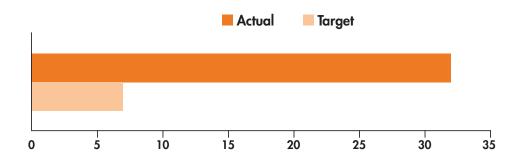
The SLRC influences education policy on many levels. The *Science of Learning* Symposium, held in April in Brisbane was attended by representatives of Education Departments, school leaders, and learning organisations from across the country. The launch of the Learning Interaction Classroom in Melbourne attracted a similar spectrum of attendees.

Representatives from the SLRC meet regularly with Department of Education Partner Organisations, providing briefings on latest research findings and collaborating to implement these findings to the classroom. In August, Professor Pankaj Sah and Dr Mike Timms presented to the Research in Education Network in Melbourne. Professor Annemaree Carroll joined with members of the Queensland and Victorian Departments of Education to present *When is a partnership truly a partnership* at the Australian Association for Research in Education, national conference in Perth.

SLRC researchers participate in a number of committees that influence education policy including:

- Australian Academy of Science's National Committee for Mathematical Sciences (Professor Merrilyn Goos)
- Australian Institute for Teaching and School Leadership (Professor John Hattie Chair)
- New South Wales Board of Studies, Teaching and Educational Standards (Professor John Pegg)
- South Australian Certificate of Education Board (Professor Martin Westwell)
- Victorian Curriculum and Assessment Authority (Professor Collette Tayler)

Briefings to inform policy



General Assembly of the International Academy of Education

Professor Patrick Griffin hosted the General Assembly of the International Academy of Education at the Melbourne Graduate School of Education. The Hon James Merlino MP, Victorian Deputy Premier and Minister for Education gave a keynote address to the assembly and later participated in a panel discussion along side Professor John Hattie.

Photo (left to right): The Hon James Merlino MP, Professor Lorin Anderston, (University of South Carolina), Professor John Hattie (UM), Kath-erine Henderson (UM)



Launch of the Learning Interaction Classroom

The Learning Interaction Classroom at The University of Melbourne was officially opened on March 10 by Senator the Hon Scott Ryan, Parliamentary Secretary to the Minister for Education and Training. The University of Melbourne Provost Professor Margaret Sheil, Dr Fiona Cameron, Australian Research Council Executive Director for Biological Sciences and Biotechnology, Professor Field Rickards, Dean of the Melbourne Graduate School of Education and Professor Pankaj Sah also addressed the audience at the launch which was hosted by Professor David Clarke. The opening was live streamed and is available to view at: http://www.ustream.tv/channel/SLRC-LAUNCH.









Bottom left photo (left to right): Dr Paul Dulhig, Mr Simon Kent, Professor Field Rickards, Professor Gregor Kennedy, Professor Margaret Shiel, Professor Pankaj Sah, Senator The Hon Scott Ryan, Dr Fiona Cameron, Professor David Clarke, Professor John Hattie, Dr Julie Wells.

Science of Learning Symposium

April saw the launch of the Nature Partner Journal – Science of Learning at the Science of Learning Symposium at Customs House. The event featured over twenty speakers and panel members from across Australia and internationally, including the Program Director of the US Science of Learning Centers Program Dr Soo-Siang Lim, Dr Philip Campbell, Editor-in-Chief of Nature, and Professor Marian Simms, Executive Director for Social,



Behavioural and Economic Sciences, Australian Research Council. The symposium was attended by in excess of 100 researchers, educators and policy makers. The new Journal will provide researchers and educators alike with open access to the latest research in learning. Photo (left to right): Dr Philip Campbell (Editor-in-Chief, Nature), Professor Perry Bartlett (Director, Queensland Brain Institute, The University of Queensland), Professor Marian Simms (Executive Director for Social, Behavioural and Economic Sciences, Australian Research Council), Professor Pankaj Sah (Director, SLRC), Professor Peter Høy (Vice Chancellor, The University of Queensland).

OUTREACH PROGRAMS

Industry Awareness

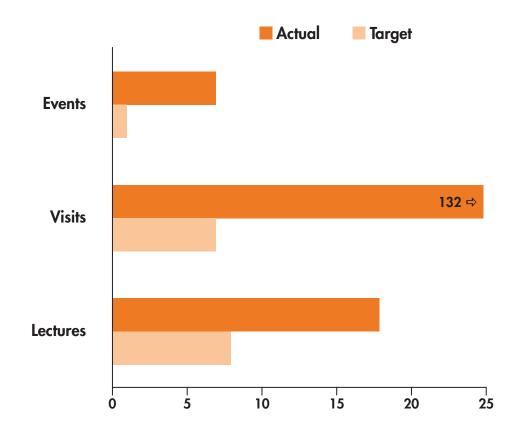
The SLRC ran 13 seminars throughout the year, attended by educators, school leaders, members of departments of education and other school bodies. In addition to the regular seminar series' held in both Brisbane and Melbourne, Professors John Hattie and Martin Westwell gave presentations to a full house of educators at The University of Queensland. International visitors Professor David Osher from American Institutes for Research and Dr James Lester from SLRC Partner Organisation, North Carolina State University, gave special seminars at several nodes during their stay in Australia.

As part of the Centre's research program, Centre researchers visited over 130 schools, raising awareness of the SLRC, delivering workshops and providing professional development.

Research from the Centre was showcased at two of Australia's premier conferences for educators; the ACER Research Conference in Melbourne and the Excellence in Professional Practice Conference in Sydney, each attended by over 600 delegates. In addition to having exhibits at these conferences, Centre members also presented latest research findings.

The Centre's industry outreach is not limited to Australia. In March Professor Robyn Gillies ran a webinar for the Smithsonian Science Education Center designed for teachers in low socio-economic schools. Entitled *Practices that Promote Student Questioning During Inquiry Science*, the webinar attracted over 1,000 registrants. http://www.laseri3.com/practices-that-promote-student-questioning-during-inquiry-science/

Outreach - Industry



Public Awareness

During the year, the SLRC participated in a range of public awareness activities including an exhibit at the Royal Queensland Show, an array of interactive displays at the Brain Bee Challenge in which over 200 children participated and the Solid Pathways Program.

The Educational Neuroscience Classroom and the Learning Interaction Classroom are the foundation of the Centre, and continue to attract much public interest and visits.

Centre members all gave presentations at a range of community events, including school community forums and to professional and business groups.

All seminars hosted by the SLRC are open to the public. These events are posted on the SLRC website, Facebook page, twitter and personal invites are sent to over 800 recipients on the SLRC mailing list.

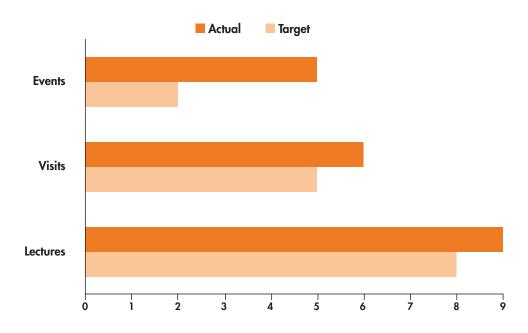
2015 Excellence in Professional Practice Conference: Improving assessment of student learning

Centre members Kristin Vonney and Deb Lasscock, working under the mentorship of Professor Martin Westwell were Outstanding Presentation Award Winners for their presentation Empowering local learners: A pre-school to secondary approach to improving executive functioning through a mathematics lens. The project was a collaboration with Mr Shane Loader, Port Augusta/Quorn Partnership and Ms Daniela Leone-Welfare and Mr Troy Welfare, Flinders View Primary School, Port Augusta, South Australia. Photo (left to right): Troy Welfare (DECD Pt Augusta-Quorn



Partnership), Deb Lasscock (Flinders/SLRC), Shane Loader (DECD Pt Augusta-Quorn Partnership, David Herring (Teachers Neutral Bank), Kristin Vonney (Flinders/SLRC), Danni Welfare (DECD Pt Augusta-Quorn Parnership.

Outreach - Public



INDIGENOUS ENGAGEMENT

The SLRC's Indigenous program continues to expand under the guidance of Professors Collette Tayler and Sven Silburn, and Indigenous Research Fellow Mr Tony Dreise. During the year Mr Troy Meston, a Research Fellow at the Australian Council for Educational Research, joined the Centre. In the second half of 2015 the Centre supported Troy's Advance Queensland Scholarship Application in partnership with the Australian Council for Educational Research. As part of his introduction to the Science of Learning, Troy participated in the teacher professional development workshops and attended the Big Day Out in Melbourne. Professor Sven Silburn was commissioned by Prime Minister and Cabinet to lead a proof-of-concept study to improve educational outcomes for Indigenous Australians through better targeting of early childhood interventions.

Professors Pankaj Sah and Annemaree Carroll have been scoping out a potential collaboration with Euclideon, a software and digital technology development company and EnVizion, a not-for-profit training provider based in far north Queensland whose mission is to enhance the employability of disadvantaged Australians. If this project comes to fruition, it has the potential to deliver 3D virtual learning experiences to students in remote communities across Australia.

The Centre continued its outreach with Indigenous students and their carers through the Solid Pathways program. The progam, run by The University of Queensland, attracts high achieving Indigenous students ranging in age from 9 to 15.

"The importance of the work that emerges from the SLRC is that it allows an additional frame of reference from which to view and engage the ongoing deficits still present in the Indigenous educational landscape. Considering the on going nature of the major deficits, refreshing perspectives carry weight and need-consideration." Troy Meston.



The year ahead

The research translation group will expand in 2016, with the inclusion of a teacher-in-residence based in Melbourne as well as a teacher-in-residence in Brisbane. This group will develop and deliver professional development workshops for teachers as well as produce material for teaching into undergraduate and post graduate courses.

Researchers in the Centre will collaborate with Hitachi on its cutting edge functional near-infrared spectroscopy technology – an emerging functional neuroimaging technology. Strategic funding will be provided to support the appointment of a researcher to run the technology which Hitachi is making available to the Centre.

With the assistance of the Advisory Board, the Centre will continue to assert its influence on policy through various avenues at all levels of government. Chief Investigators will continue to represent the Centre on a range of advisory boards and committees.

The seminar series will continue in Brisbane and Melbourne in 2016. Strategic funding has also been allocated to expand the seminar series into South Australia. The Centre will host a number of events throughout the year to engage with parents, in addition to its continued engagement activities with educators in schools.

The SLRC, in collaboration with Euclideon and EnVizion, has applied for further funding to support the development of transportable, flexible, interactive learning environments that can be taken into remote Indigenous communities.

GOVERNANCE AND PLANNING

The Executive Committee and the Advisory Board oversee Centre governance.



The SLRC continued under the leadership of Professor Pankaj Sah in 2015. During the year Professor Sah was also appointed Director of the Queensland Brain Institute at The University of Queensland. In order to support Professor Sah, in light of his new responsibilities, a Director Deputy was appointed to the Executive, Professor Ross Cunnington. Professor Cunnington is responsible for the student and early career researcher portfolio and international collaborations. In the second half of the year, under the guidance of Professor Ross Cunnington a Student and Early Career Researcher Committee was established.

Executive Committee

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

- Professor Pankaj Sah Chair and Centre Director (The University of Queensland)
- Professor Ross Cunnington Deputy Director (The University of Queensland)
- Professor Annemaree Carroll Coordinator, Research Translation (The University of Queensland)
- Professor John Hattie Theme Leader Promoting Learning (The University of Melbourne)
- Professor Ottmar Lipp Theme Leader Understanding Learning (Curtin University)
- Dr Mike Timms Theme Leader Measuring Learning (Australian Council for Educational Research)
- Ms Annita Nugent Secretary and 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. In 2015 the Executive Committee had meetings in Perth, Sydney, Melbourne, Brisbane and Adelaide.



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.

The Advisory Board comprises:

- Professor Barry McGaw Chair (Vice Chancellor's Fellow, The University of Melbourne)
- Professor Perry Bartlett (Foundation Professor, Molecular Neuroscience, 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 Training)
- Dr Hideaki Koizumi (Research Fellow, Hitachi Ltd, Japan)
- Professor Geoff Masters (Chief Executive Officer, Australian Council for Educational Research)
- Mr Joe McLean (Head of Strategy and Growth, Triple P International Pty Ltd)
- 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 and Training)
- Secretary Ms Annita Nugent (COO, SLRC, The University of Queensland)

The Chair of the Advisory Board provides mentorship and guidance to the Centre Director, meeting throughout the year and communicating on a regular basis.

The Advisory Board met formally in October 2015. There were a number of *ad hoc* meetings of advisory board members throughout the year.

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 *ad hoc*, as necessary. The Research Classroom Committee reports quarterly to the Executive Committee.

Student and Early Career Researcher Committee

The Student and Early Career Researcher Committee was established at the Big Day Out in August under the guidance of Professor Ross Cunnington. The committee is working toward improving collaboration between students and early career researchers, assisting in the development of training programs and contributing to the organisation of the Big Days Out among other activities. The committee meets quarterly, at various nodes. Networking and training sessions are arranged to coordinate with the meetings.

The Student and Early Career Researcher Committee comprises:

- Amanda Bourgeois chair (The University of Queensland)
- Amael Arguel (Macquarie University)
- Megan Campbell (The University of Queensland)
- Florence Gabriel (Flinders University)
- Michelle Hall (The University of Queensland)
- Dan Jazby (The University of Melbourne)
- Natalie Rens (The University of Queensland)
- Thomas Stephen (Australian Council for Educational Research)
- Paul Wiseman (The University of Melbourne)

Big Days Out

This year the SLRC had two whole of centre meetings, fondly referred to as the 'Big Day Out'. The first meeting was held in March in Sydney. This event was held in parallel with the Australian Council for Educational Research *Excellence in Professional Practice* Conference, sharing a discussion panel and poster session. In August more than 80 Centre members gathered at The University of Melbourne for a one-and-a-half-day meeting, commencing with a poster session. Associate Professor Rob Hester ran a workshop on career pathways for the students and early career researchers earlier in the day.

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 the 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 an administration officer, classroom managers at The University of Queensland and The University of Melbourne, and the Engagement Officer at The University of Melbourne.

Translation Team

The Translation Team is responsible for the development and delivery of training and outreach materials, including teacher professional development workshops, teacher resources and content for undergraduate and postgraduate courses. The Translation Team is lead by Professors Annemaree Carroll and John Hattie, with permanent members Gregory Donoghue, Jared Horvath and Stephanie MacMahon. Other members of the Centre contribute to the Translation Team on an *ad hoc* basis.

The year ahead

The Centre organisation will continue in its current form in 2016.

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 Melbourne and Brisbane.

The Advisory Board and the Indigenous Learning Consultation Group will meet in the first half of 2016.

APPENDICES



Appendix 1: Publications

Journal Publications

- Bennett, S., Agostinho, S., & Lockyer, L. (2015). Technology tools to support learning design: Implications derived from an investigation of university teachers' design practices. *Computers and Education*. 81, 211-220.
- Bower, J., & Carroll, A. (2015). Benefits of getting hooked on sports or the arts: Examining the connectedness of youth who participate in sport and creative arts activities. *International Journal of Child and Adolescent Health*, 8 (2), 169-178.
- Bower, J., Carroll, A., & Ashman, A. (2015). Development and application of the CAT-RPM report for strengths-based case management of vulnerable youth in schools. *International Journal of Inclusive Education*, 19(1), 36-52.
- Bower, J., van Kraayenoord, C., & Carroll, A. (2015). Building social connectedness in schools: Australian teachers' perspectives. *International Journal of Educational Research*, 70, 101-109.
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- **Garner, K. G., Matthews, N.**, Remington, R. W., & Dux, P. E. (2015). Transferability of training benefits differs across neural events: Evidence from event related potentials. *Journal of Cognitive Neuroscience*, 27(10), 2079-2094.
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Appendix 2: Financial Statements

Income

Source	Amount
ARC	\$ 4,356,074
Administering Organisation	\$ 550,000
Collaborating Organisations	\$ 670,000
Partner Organisations	\$ 103,750
Total	\$5,679,824

Expenditure

	Purchased equipment	Travel	Salaries	Scholarships*	Other expenditure	Total
UQ	113,368	200,598	2,383,276	96,169	695,621	3,489,032
UM	225,727	153,953	1,267,573	80,155	102,313	1,829,721
ACER	2,653	38,224	266,011	-	564	307,452
CDU	-	546	81,462	-	40,000	122,008
MQ	-	2,689	118,811	-	1,122	122,622
UNE	-	3,680	76,273	-	-	79,953
Deakin	-	7,822	58,225	-	966	67,013
Flinders	-	8,725	109,380	-	1,132	119,237
Curtin	-	-	50,933	11,211	3,663	65,807
Total	341,748	416,237	4,411,944	187,535	845,381	6,202,845

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

Appendix 3: Key Performance Indicators

	2015 Target	2015 Achieved
Research Findings		
Number of research outputs (research outputs may include journal articles, books, book chapters, conference publications and patents)	51	119
Quality of research outputs: At least 80% of papers will be: • peer reviewed	41	55
 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) 	30-40	38
Number and nature of commentaries about the Program's achievements (list media releases and articles separately)	25-35	27
Research training and professional development		
Number of professional training courses for staff and postgraduate students attend • professional development is standard requirement for all researchers	24-35	84
Number of Program participants who have attended professional training/ development courses offered by the Program (include courses offered for exter- nal stakeholders and clients)	6-10	16
Number of new PhD students working on core Program research and supervised by Program staff	10-15	8
Number of PhD student completions and completion times, by students working on core program research and supervised by program staff	1-5 (3 years)	1
Number of new Masters by research and Masters by coursework students working on core Program research and supervised by Program staff	10-20	12*
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	10-15 (2 years)	12*
Number of new Honours students working on core Program research and supervised by Program staff	15-20	12
Number of Honours student completions and completion times, by students working on core Program research and supervised by Program staff	15-20 (1 year)	12
Number of new postdoctoral researchers recruited to the Program working on core Program research	0	7
Number of Early Career Researchers (within five years of completing PhD) working on core program research	20	20
Number of students mentored: Summer and winter research placements; International exchange programs; Honours and PhD students	65-75	121
Number of mentoring programs offered by the program (include programs for students, new staff, external stakeholders and clients)	4-7	4

^{* 12} members of the SLRC teach into Masters by coursework programs incorporating SLRC findings.

Appendix 3: Key Performance Indicators continued

	2015 Target	2015 Achieved
International, national and regional links and collaboration	go.	
Number of international visitors and visiting fellows	8-12	23
Number of national and international workshops held/organised by the program	3	8
Number of visits to overseas laboratories and facilities	20-30	20
Examples of relevant interdisciplinary research supported by the Program: Aligning teaching to attention		Multiple
 Classroom instruction to maximize memory consolidation Benchmarking the learning state and process 	3-4	Multiple examples
Measuring learning with digital tools	3 1	throughout report
Learning from example		report
The role of feedback in learning		
Participation on national and international bodies, including Government and community groups	10-15	59
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	10-15	14
Number of government, industry, business and community briefings to inform policy	7-15	32
Number and nature of industry awareness/outreach programs	Lectures: 8-16 Visits: 10-15 Events: 1-4	18 132 7
Number and nature of public awareness/outreach programs	Lectures: 8-10 Visits: 5-10 Events: 2-4	9 6 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	1200	N/A
Number of talks given by program staff open to the public	25-40	20
Number of Indigenous stakeholders consulted	2-7	5
Number of Indigenous stakeholders on boards and committees	2-3	3
Governance		
Frequency of meetings on the Program's National Advisory Board	Annually	1
Attendance rate of members at the Program's Advisory Board	75%	78

	2015 Target	2015 Achieved
Organisational support		
Annual cash contributions from Administering	UQ: 440,000	550,000
and Collaborating Organisations (\$)	UM: 240,000	240,000
	ACER: 120,000	150,000
	Curtin: 40,000	80,000
	CDU: 40,000	40,000
	Deakin: 40,000	40,000
	Flinders: 40,000	40,000
	Macquarie: 40,000	40,000
	UNE: 40,000	40,000
Annual in-kind contributions from Administering	UQ: 548,400	548,400
and Collaborating Organisations (\$)	UM: 372,754	372,754
	ACER: 320,211	320,211
	Curtin: 45,964	45,964
	CDU: 35,000	35,000
	Deakin: 40,000	40,000
	Flinders: 24,117	24,117
	Macquarie: 20,000	20,000
	UNE: 44,200	44,200
Annual cash contributions from Partner Organisations (\$)	DET Vic: 100,000	100,000
	Questacon: 5,000	3,750

Appendix 4: Chief Investigators





Dr Tim BredyQueensland Brain Institute, The University of Queensland

With support from the SLRC, we have advanced understanding of the nature of epigenetic mechanisms in learning and memory. We have discovered that there are novel modifications to DNA that occur as a result of learning and that this process is critical for memory formation. We have also embarked on a new direction of research, demonstrating that the qualitative changes in RNA metabolism is essential for experience-dependent plasticity in the brain.

Professor Annemaree Carroll

School of Education, The University of Queensland

Two types of attention in students are emerging. 'Direct attention' is prominent when students listen and/or respond to very effective teachers who demonstrate capacities to elicit reciprocally high levels of attention and engagement from their students. However, there is also a form of attention that could be labelled 'vicarious attention' which is evident when students work in small groups. This latter type of attention appears to be needed to enable the students to have time to process information being discussed with fellow students. Both types of attention are important although 'Direct Attention' is more effective while the latter is still required. The snapshot of the data from one very effective teacher's classroom appears to support this thesis. This thesis, if demonstrated to have support, will potentially influence teachers' understanding of the different types of attention students demonstrate when they employ different types of pedagogical practices.



Professor David Clarke

Melbourne Graduate School of Education, The University of Melbourne

The Learning from Lessons project has confirmed the mediating role of teacher selective attention in shaping teachers' *in situ* learning in classrooms. A striking finding from our analyses is the distinctive and idiosyncratic way that teachers attend to similar social phenomena (such as student engagement or particular instructional features of a lesson), but interpret them in quite different ways, with significant differences in the consequences for their professional learning. Attempts to facilitate teacher learning must distinguish not only the objects of teacher attention, but the meaning and significance that might be accorded to each.



Professor Ross Cunnington

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

We have been using wristbands to measure biometric signals of alertness and arousal levels during normal science lessons, so far examining over 600 grade 6 and 7 children in 15 schools across Brisbane. We use computational models to examine the level of synchrony in physiological states between children that shows us who is more connected with whom. We find that students with low confidence, intrinsic motivation, and general self-esteem share connections with other similarly connected students. On the other hand, more confident students share fewer connections and are therefore less "synchronised" with the group. This is providing unique insights into group dynamics in the classroom.



Associate Professor Paul E. Dux

School of Psychology, The University of Queensland

I have recently conducted the largest fMRI multitasking training study to date with my PhD student Kelly Garner (now a postdoc at University of Birmingham). Specifically, this large scale (n=100), individual differences, fMRI study employed advanced analysis techniques (multi-voxel pattern classification, MVPA) to show, in human adults, how neural coding in prefrontal and parietal cortical areas and subcortical regions of the brain change with training, to enhance multitasking performance and executive function. Importantly, it showed a mechanism for why some individuals respond better to executive training than others.



Professor Robyn Gillies

School of Education, The University of Queensland

Preliminary analyses indicate that teacher-student synchronicity is not only apparent in the behavioural data that have been collected of the teachers as they introduced the different representational tools, including how they used the different literacy resources and social processes to facilitate student engagement, understanding, and learning, but how the students, in turn, demonstrated high levels of attention and engagement during the employment of these tools. Interestingly, all the students wore Empatica E3 wrist bands that measure physiological arousal and task engagement, and while these data have not yet been analysed, it is highly likely that there will be high correlations between the behavioural data collected from the teachers and students and the students' physiological data, confirming the key role teacher-student synchronicity plays in student engagement and learning.



Professor Merrilyn Goos

School of Education, The University of Queensland

My main breakthrough has involved discovering conditions that enable or hinder the kind of interdisciplinary collaboration that is vital to the existence of the SLRC. Factors enabling collaboration include personal qualities, the existence and structure of the Centre, and the participation of brokers or intermediaries. Factors that hinder collaboration and are best overcome include the need for participants to perceive a shared problem, as well as practical issues such as geography, institutional requirements, and time. Additional factors challenge interdisciplinary collaboration but have the potential to be productive if they are embraced: these include the inherent differences between disciplines, and participants' perceptions of the disciplines.



Professor Patrick Griffin

Assessment Research Centre, Melbourne Graduate School of Education.

The highlight of 2015 for my group was the release of the book Assessment and Teaching of 21st Century Skills: Methods and Approach, which I co-edited with Esther Care. This work describes how collaborative problem solving and learning in digital networks as 21st century skills are amenable to teaching and learning. With many of the SLRC researchers contributing to the text, it showcases some of the amazing research being undertaken in the Centre.



Professor John Hattie

Melbourne Graduate School of Education, The University of Melbourne

The major work has focused on a meta-synthesis of learning strategies. While we were able to identify the top ten most effective strategies there was a major moderator relating to when in the learning cycle the strategy was most effective. The model is based on conceiving learning as a process of moving from surface to deep to transfer, and there were two parts to each phase – enabling and embedding. Other findings relate to role of collective IQ, subject matter knowledge, mind frames about learning, and what teachers need to know about learning to be effective.



Associate Professor Rob Hester

School of Psychological Sciences, The University of Melbourne

Our findings suggest that a person's confidence in their answer appears to reflect the certainty they have for what success looks like. When they are wrong and make a high confidence error, they are more likely to subsequently correct their mistake. The correction of high confidence errors is associated with especially large prediction-error signals in cortical regions such as the dorsal anterior cingulate. These signals are thought to reflect the difference between our expectation and outcome, so the confidence effect we find suggests that learning benefits from a strong expectation of what success looks like, even if that expectation is wrong.



Professor Tianzi Jiang

Centre for Advanced Imaging and Queensland Brain Institute, The University of Queensland My laboratory has made significant progress in the study of adolescent socially isolated mice. By combining dMRI and behavioural examinations, we have revealed that the isolated mice displayed a disorganised brain connectome, which was most evident in the dorsolateral orbitofrontal cortex and was associated with fear memory deficits and hyper-locomotion activities induced by social isolation. Considering the key role of the orbitofrontal cortex in social behaviors, adolescent social isolation may primarily disrupt the orbitofrontal cortex and its neural pathways, thereby contributing to a disorganised structural connectome.



Professor Gregor Kennedy

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

In digital learning environments students are often asked to engage in tasks that require autonomy and self-direction. If students come to a conceptual impasse and experience persistent confusion in these environments, it is difficult for them to progress. Research we have conducted to date has explored the association between students' confidence, the challenge they experience, and their confusion while undertaking autonomous learning tasks in digital environments. Our findings suggest a complex relationship between the complexity of the task – and students' level of prior knowledge – and the confidence and challenge students report while completing it. We also have preliminary findings suggesting that students' self-reported confusion at the conclusion of a task is positively correlated with their on-task challenge, and negatively correlated with on-task confidence. These findings will drive the program of research towards applications to support students' educational autonomy in digital learning environments.



Dr Siek-Toon Khoo

Australian Council for Educational Research

We have been modelling the relationships between developmental trajectories of enabling skills such as phonemic awareness in the early years of schooling and the development of reading comprehension and find that not only does the proficiency in phonemic awareness helps in reading comprehension development, how fast the skills are mastered also influences the development in reading comprehension. On another front, we have been investigating student engagement in the digital learning environment and the use of hints provided. We work on the methodology of measuring behavioural engagement through the massive log data collected on the interactions between the students and the learning system and have linked the level of engagement measured to the subject proficiency acquired by the students.



Professor Ottmar Lipp

School of Psychology and Speech Pathology, Curtin University

Most learning scenarios involve cognitive as well as emotional components (learning what will happen and how we will feel about it). Research in our program has documented the similarities and differences between the two components in their response to direct and vicarious experiences. This research highlights when instruction may be sufficient to achieve emotional learning and when explicit practise is required.



Professor Lori Lockyer

School of Education, Macquarie University

The ability to identify and address learner confusion in digital environments has been a significant breakthrough for me. As part of the confusion project, which includes members from The University of Melbourne, Curtin University and the Australian Council for Educational Research, as well as my team at Macquarie, we have demonstrated that we can detect confusion in digital learning tasks. We are planning to build on our initial research findings to investigate more complex digital learning tasks. Findings related to these studies will support direct translation to practical teaching/learning environments.



Professor Jason Mattingley

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

In 2015, we made significant progress toward understanding how knowledge about fractional quantities is represented in the brain. In a collaboration led by Natasha Matthews, and involving Paul Dux and Annemaree Carroll, we had university students undertake a novel task requiring judgement of the relative sizes of pairs of fractional quantities, and recorded brain activity using EEG. The fraction stimuli were presented either as conventional alphanumeric values, or in pictorial form, so that we could determine whether fractional quantity is represented as an "abstract" (conceptual) code in the brain. We found that neural markers of readiness prior to the presentation of each problem reliably predicted whether a participant would get the fractional judgement correct or incorrect. Using neural decoding algorithms, we also showed that the brain contains an abstract representation of fractional quantity. The findings formed the basis for two honours students' research dissertations, adding an important training component to the study, and will soon be submitted for publication.



Professor John Pegg

School of Education, University of New England

The breakthrough was a brain-based explanation for the strong achievement gains by low-achieving students undertaking QuickSmart interventions. QuickSmart's primary focus is to develop automaticity with understanding in basic/fundamental skills over an extended time-period to establish enhanced neural networks and brain activity. Learners' ability to develop rich understandings and meanings relies on effectively transferring skills, such as word recognition and mental arithmetic, from effortful, conscious thought to an automatic response. Development of automatic processing on basic skills offers decreased demand in cognitive capacity (working memory) in the pre-frontal cortex, allowing conceptual development and higher-order thinking such as authentic problem solving.



Professor David Reutens

Centre for Advanced Imaging, The University of Queensland

Anxiety contributes to poor academic performance and poor engagement in the classroom and teachers aim to provide an environment which does not trigger fear or anxiety. Safety learning describes the ability to learn to predict the absence of danger. In our research to date, we have examined the human brain networks associated with fear and safety learning. We have found that several dedicated networks are engaged in these forms of learning and that they are comparable to those in experimental animals. The two main functional networks that underlie conditioning and extinction are anti-correlated. These findings are significant because they provide strong evidence for evolutionary continuity in neural network organization and provide a novel dynamic perspective, which suggests that the competition between networks differentiates fear conditioning from extinction learning. We also found that regions overlapping with the default mode network (DMN) are activated by safety signals, that this activation increases over time and in response to changes in stimulus contingencies. Our results suggest that the DMN does play a functional role in safety learning rather than simply reflecting sensory-decoupled, internally-driven cognitive processes.



Professor Pankaj Sah

Queensland Brain Institute, The University of Queensland

The Sah lab continues to conduct fundamental molecular, cellular and electrophysiological research into partial reinforcement extinction effect (PREE) and its general implications for learning. In the PREE, the unpredictable omission of reinforcement during the acquisition of conditioning produces a paradoxical enhancement of learned responses in the extinction phase, i.e. learning persists longer when reinforcement is omitted. We are attempting to understand this effect both in terms of changes in neuronal excitability of specific brain regions, such as amygdala, hippocampus and medial prefrontal cortex, and also in terms of the interactions between different cell populations. The goal is to characterise as fully as possible the neural circuitry involved in mediating the effect. It is intriguing that reconsolidation, which involves the unpredictable presentation of unreinforced conditioned stimuli following acquisition, and the testing effect, which involves the repeated, unpredictable and incomplete presentation of material to be learnt, both result in enhanced learning and memory. At the SLRC understanding learning workshop held at UQ in April 2015, there were also very productive discussions concerning how the PREE relates to the "learner confusion" project and the predictability of visual information processing project. The way the brain deals with uncertainty and unpredictability appears to be crucial in all these different learning phenomena. Exploring the possibility of common, overlapping mechanisms between these phenomena is likely to prove very fruitful in understanding how they all succeed in enhancing learning.



Professor Sven Silburn

Menzies Centre for Child Development and Education, Charles Darwin University

I have been commissioned by Prime Minister and Cabinet to lead a proof-of-concept study to improve educational outcomes for Indigenous Australians through better targeting of early childhood interventions. The project is one of seven 'high value' case studies recommended in the Public Sector Data Management report which was released in conjunction with the Prime Minister's Innovation Statement in December 2015. The study involves demonstrating the feasibility of de-identified linkage of Commonwealth and NT administrative data to develop a more comprehensive evidence base to inform policy and services for improving NT children's development and educational outcomes. Combining data from these, usually separate, datasets will enable policy relevant analyses, not previously done, as well as economic modelling of the costs and benefits of alternate policy scenarios and programs.



Professor Collette Tayler

Melbourne Graduate School of Education, The University of Melbourne

In the research context of Central Australia, in a budget-based Indigenous early childhood education and care service, we found significant positive outcomes for the very young children who took part in a case-control experiment to lift their joint-attention sequencing capacity, and their receptive and expressive language skills. In a 3.5 month period, we found a 71% increase in children's initiation of joint attention episodes, and an average language gain of 7 months for the children, the majority of whom were in living in out-of-home care contexts. Auditory comprehension was slightly stronger than expressive language at each of the time points (100 words to here). This work is part of a doctoral research study being undertaken within the SLRC (by Isabel Brookes). The relationship with the main agency in Central Australia was also formalised through a Memorandum of Understanding with the University of Melbourne, to continue studies and practice improvements related to the health, education and family support services that are available.



Dr Sue Thomson

Australian Council for Educational Research

Our work on the maths anxiety project with pre-service teachers has demonstrated that there is enormous scope to work with policy makers and educators from all sectors to help them better understand the intersection of education, psychology and neuroscience research. In particular, pre-service and experienced teachers have expressed interest and enjoyed learning about the physiological and cognitive underpinnings of emotion regulation and the learning process in general. These educators have emphasized that this knowledge is important when reflecting on teaching practices.



Dr Mike Timms

Australian Council for Educational Research

Our research of learner processing of feedback in intelligent learning environments has established a new model of how learners process feedback in interactive digital learning environments. It has revealed how individual differences among learners has a profound influence on whether feedback that is delivered by the learning system is actually processed fully by the learner. This lack of processing of feedback then impairs the learning. This is significant as more and more digital learning environments are being used in education. The project is in the process of validating the model through experimentation in the Learning Interactions and the Educational Neuroscience classrooms.



Professor Russell Tytler

School of Education, Deakin University

We have become much more aware through reviewing the neuroscience literature of the complexity of brain processes in reasoning and learning. We have been able to use this to make better sense of the inquiry approach to teaching and learning science we have been pursuing, that involves active representational work across a variety of perceptual modes. The filming we have undertaken in the Learning Interaction Classroom at The University of Melbourne has alerted us to the possibility of identifying not only the way in which different modes – talking, drawing, symbolic representation, kinesthetic – feed into collaborative reasoning, but also the conditions under which productive reasoning and learning best occur.



Professor Martin Westwell

Faculty of Science and Engineering, Flinders University

Teachers and early years educators in the Port Augusta-Quorn region of South Australia have been collaborating with SLRC staff to use principles and research evidence from the Science of Learning to innovate in their mathematics and numeracy teaching. By intentionally changing the way that students think in their maths activities, the teachers have improved student engagement and achievement. For example, the 2015 NAPLAN numeracy results shows improvement, particularly in the problem-solving questions at all year levels (i.e., years 3, 5, 7 and 9). When one teacher considered how her students' resilience and ability to deal with challenging problems had changed she said it was "One of the most proud, precious moment for a class teacher."

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Curtin University

 School of Psychology and Speech Pathology

Deakin University

School of Education

Flinders University

- Faculty of Science and Engineering
- Research Services Office

Macquarie University

 School of Education, Faculty of Human Sciences

University of New England

School of Education



Australian Research Council

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. - *Nick Valmas*

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Adelaide Secondary School of English, West Croydon, SA

All Hallows' School, Brisbane, QLD

Alginda Primary School

Ambrose Treacy College, Indooroopilly, QLD

Augusta Park Childhood Services Centre, SA

Augusta Park Primary School

Australian Science and Mathematics School, Bedford Park, SA

Brighton Primary School, SA

Carlton School, Port Augusta, SA

Cavendish Road State High School, Holland Park, SA

Eden Hills Kindergarten, SA

Edwardstown Primary School, Melrose Park, SA

Flinders Children's Centre / Tiji Wiltja Preschool, Port Augusta, SA

Flinders View Primary School, Port Augusta, SA

Glen Waverley Secondary College, VIC

Holy Spirit Catholic School, Cranbrook, QLD

Iona College, Lindum, QLD

Kormilda College, Darwin, NT

Milton State School, QLD

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Stirling North Childhood Services Centre, SA

Stirling North Primary School, SA

University High School, Parkville, VIC

Unley High School, Wetherby, SA

Wavell Heights State School, QLD

West End State School, QLD

Willsden Childhood Services Centre, Port Augusta, SA

Willsden Primary School, Bradford, SA

