



SCIENCE OF LEARNING
RESEARCH CENTRE

ARC SPECIAL RESEARCH INITIATIVE FOR SCIENCE OF LEARNING
ANNUAL REPORT 2013



IMPROVING LEARNING OUTCOMES



**8 NODES
1 GOAL
IMPROVE
LEARNING
OUTCOMES
FOR
AUSTRALIANS**

VISION, GOALS & KEY ACTION PLANS

TRAINING
EVIDENCE BASED
STRATEGIES
COLLABORATION
TRANSLATION



COLLABORATING ORGANISATIONS



PARTNER ORGANISATIONS



Carnegie Mellon University



NC STATE UNIVERSITY



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APPLYING NEUROSCIENCE, COGNITIVE PSYCHOLOGY AND EDUCATION TO **DEVELOP** EVIDENCE BASED STRATEGIES FOR LEARNING, **EVALUATE** EXISTING STRATEGIES, AND **DISPEL** LEARNING MYTHS.

IMPROVING LEARNING OUTCOMES FOR AUSTRALIANS

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

Established in 2013, the SLRC brings together 25 of Australia's leading researchers in Cognitive Psychology, Education and Neuroscience with a shared goal, **To Improve Learning Outcomes for Australians.**

Applying neuroscience, cognitive psychology and education, the Centre is developing evidence based strategies for learning, evaluating existing strategies, and creating a powerful narrative about the role of aspects of the brain in learning.

The Centre's research is broadly organised into three themes, Understanding Learning, Promoting Learning and Measuring Learning. In order to achieve the Centre's goal, three themes feed into, and off, each other, and many of the Centre's research projects straddle multiple themes.

Although coming from distinct fields, this group of researchers is collaborating on projects which address some of the big questions in learning.

Researchers are combining information gathered from educators working within schools, in a classroom specially designed to study learning interactions, the **Learning Interaction Classroom**, and a classroom equipped to monitor neurological and physiological activity during learning events, the **Educational Neuroscience Classroom.**

This report summarises the performance of the SLRC between 1 September 2013 and 31 December 2013, and outlines the Centre's plans for meeting its strategic objectives in 2014.



BENCH-TOP TO BLACKBOARD

OTTMAR LIPP DIRECTOR'S REPORT



It has been a privilege and honour to serve as the inaugural Director of the ARC-SRI Science of Learning Research Centre (SLRC), and I am very sorry to say that my first annual Director's report will also be my last as I am stepping down from the position to take up a position at Curtin University. However, what a year it has been for the SLRC. Within a very short period of time we have laid a very strong platform from which the Science of Learning can be launched in Australia.

This platform reflects the combination of the new research infrastructure that was enabled by the SLRC, in particular the two simulated classrooms - the Educational Neuroscience Classroom at The University of Queensland and the Learning Interaction Classroom at The University of Melbourne - and the core research programs that were developed by the Chief Investigators (CIs) and Partner Investigators (PIs) under the three research themes of the Centre. These research programs (and I would encourage you to learn more about them by reading this report and visiting the SLRC website - www.slrc.org.au) form the backbone of the Centre's research. They reflect the core tenet of the Centre, trans-disciplinarity, by requiring that CIs and PIs from different home disciplines (Neuroscience, Education, and Psychology), who represent different Research Themes ('Understanding Learning', 'Measuring Learning', and 'Promoting Learning'), work across these disciplines and themes. This requirement will ensure that the projects do not just deliver more of the same, but a make a genuine, novel contribution.

The rapid development of the Centre reflects, of course, that it was not born from a vacuum, but is set on the very firm foundations of the CIs' and PIs' past research efforts. Furthermore, it appears that the ARC Special Research Initiative was timed perfectly, as it was taken up by a group of researchers who, when given the right opportunity, seem poised to deliver a new Science of Learning. Having witnessed this rapid development and knowing the robust structure of the SLRC, I am assured that it will be the success that we were hoping for when we first got together a little more than a year ago. I am looking forward to contribute to this success further in the role of Theme Leader and by supporting my successor in the role of Director, Professor Pankaj Sah.

I would like to take the opportunity to thank all those who made this role such a positive experience for me, foremost the COO, Annita Nugent, and my colleagues on the Executive Team, Pankaj Sah, John Hattie, and Mike Timms.

**WITH THE BEST WISHES FOR YEAR TWO,
OTTMAR LIPP**

RESEARCH PERSONNEL, TRAINING AND DEVELOPMENT

The Centre brings together 25 of Australia's leading researchers in their respective fields of Cognitive Psychology, Education and Neuroscience – each sharing the same goal, To Improve Learning Outcomes for Australians.

CHIEF INVESTIGATORS



DR TIMOTHY BREDY
The University of Queensland



ASSOCIATE PROFESSOR ANNEMAREE CARROLL
The University of Queensland



PROFESSOR DAVID CLARKE
The University of Melbourne



ASSOCIATE PROFESSOR ROSS CUNNINGTON
The University of Queensland



ASSOCIATE PROFESSOR PAUL DUX
The University of Queensland



PROFESSOR ROBYN GILLIES
The University of Queensland



PROFESSOR MERRILYN GOOS
The University of Queensland



PROFESSOR PATRICK GRIFFIN
The University of Melbourne



PROFESSOR JOHN HATTIE
The University of Melbourne



ASSOCIATE PROFESSOR ROB HESTER
The University of Melbourne



PROFESSOR TIANZI JIANG
The University of Queensland



PROFESSOR GREGOR KENNEDY
The University of Melbourne



DR SIEK-TOON KHOO
Australian Council for Educational Research



PROFESSOR OTTMAR LIPP
The University of Queensland



PROFESSOR LORI LOCKYER
Macquarie University



PROFESSOR JASON MATTINGLEY
The University of Queensland



PROFESSOR JOHN PEGG
University of New England



PROFESSOR DAVID REUTENS
The University of Queensland



PROFESSOR PANKAJ SAH
The University of Queensland



PROFESSOR SVEN SILBURN
Charles Darwin University



PROFESSOR COLLETTE TAYLER
The University of Melbourne



DR SUE THOMSON
Australian Council for Educational Research



DR MICHAEL TIMMS
Australian Council for Educational Research



PROFESSOR RUSSELL TYTLER
Deakin University



PROFESSOR MARTIN WESTWELL
Flinders University

PARTNER INVESTIGATORS

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

POSTDOCTORAL RESEARCHERS

Jeff Bednark.....The University of Queensland
 Sarah Buckley.....Australian Council for Educational Research
 Carol Cohrssen.....The University of Melbourne
 Sacha DeVelle.....Australian Council for Educational Research
 Susan Maree Harding.....The University of Melbourne
 Helen Harper.....Charles Darwin University
 Frank Niklas.....The University of Melbourne
 Kate Reid.....Australian Council for Educational Research
 Ling Tan.....Australian Council for Educational Research
 Xiaoxun Sun.....Australian Council for Educational Research

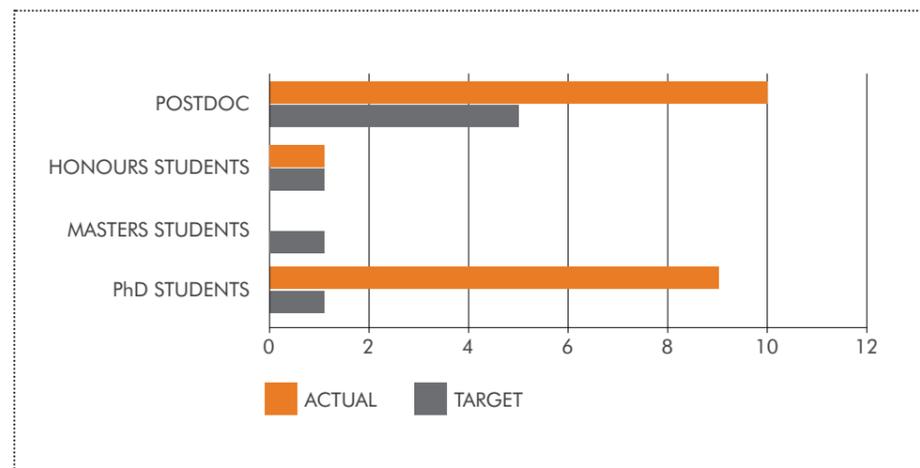
STUDENTS

GRADUATE INTAKE

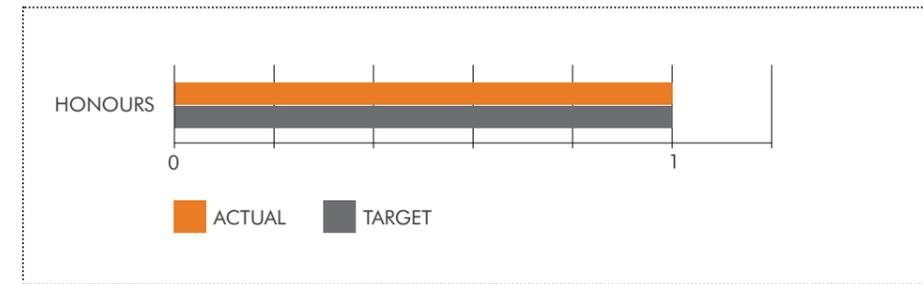
NAME	NODE	SUPERVISOR	COURSE
Angela Bender	UQ	Dux	PhD
Cameron Brooks	UQ	Carroll/Gillies	PhD
Greg Donoghue	UM	Hattie	PhD
Kelly Garner	UQ	Dux	PhD
Michelle Hall	UQ	Dux/Mattingley	PhD
Stephanie McMahon	UQ	Carroll/Gillies	PhD
John Morris	UQ	Sah	PhD
Camilla Luck	UQ	Lipp	PhD
Adrian Norman	Macquarie	Lockyer	PhD
Hannah Jensen -Fielding	UQ	Lipp	Honours

Due to the late commencement of the Centre, no formal mentoring programs were offered in 2013.

PERSONNEL WORKING ON CORE PROGRAM RESEARCH



STUDENT COMPLETIONS

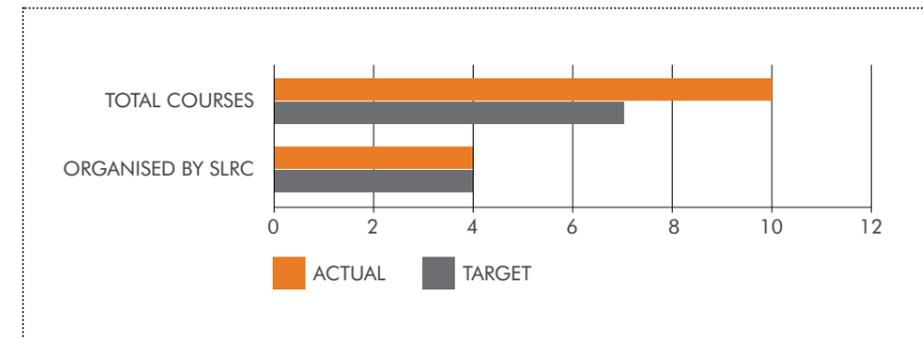


TRAINING AND DEVELOPMENT

During 2013 SLRC arranged a number of Professional Development workshops. In addition to this SLRC members attended numerous training programs, workshops and seminars.

EVENT	DATE	VENUE	AUDIENCE
CI meeting	13 June 2013	QBI and virtual	Investigators
MERI seminar	16 July 2013	MERI	Investigators, postdocs and students
SLRC symposium	27 November 2013	QBI and virtual	Investigators
Learning Analytics workshop	22 August 2013	ACER	Investigators and postdocs

NUMBER OF PROFESSIONAL TRAINING COURSES ATTENDED BY SLRC MEMBERS



THE YEAR AHEAD

In 2014 the SLRC expects to recruit a further five PhD students, 10 Masters students and 10 Honours students into the program. It is anticipated that many students will be jointly supervised and/or mentored by one or more SLRC CIs and PIs. Already nine PhD students have been recruited. The Centre is on track to graduate two PhD students in 2014.

As funding is now available, by the end of the first half of 2014 it is expected the Centre will have a near to complete cohort of Postdoctoral Researchers. An induction for all students and Postdoctoral Researchers will be held in quarter 3 of 2014 in Brisbane.

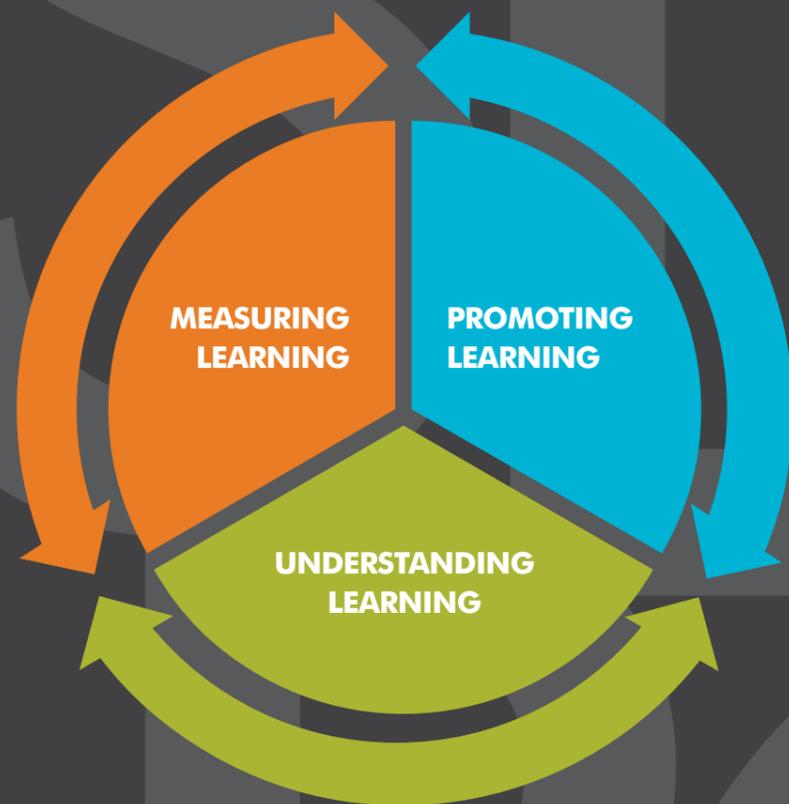
The experimental classrooms in Brisbane and Melbourne are expected to be fully operational by June 2014. The classrooms form the centrepiece of many projects in the SLRC and we expect to have data from both by the end of 2014.

Each theme will have a full day workshop that will provide opportunity for networking among postdocs and students from various nodes, and will also provide structured education sessions. Vacation programs will be offered for students and teachers over the summer break.

A series of seminars is being planned for students and early career researchers including topics such as career development, science writing, media training and leadership.

RESEARCH— THREE THEMES, ONE GOAL

The Centre's research is categorised under three themes: *Understanding Learning*, *Promoting Learning* and *Measuring Learning*, which feed into and off each other.



RESEARCH PROGRAM THEME LEADERS



UNDERSTANDING LEARNING

Professor Pankaj Sah
The University of Queensland

Professor Sah holds an MBBS from the University of New South Wales (1983) and was awarded a PhD in neuroscience from the Australian National University in 1988. His main research interest is in understanding the neural mechanisms that underpin learning and memory formation. He is known for his work in understanding the neural circuits and synaptic plasticity in the amygdala, an area of the brain involved in emotional processing and learning. He is currently Deputy Director (Research) at the Queensland Brain Institute. Previously he was group leader at the John Curtin School of Medical Research at the Australian National University, and moved as a founding member of the Queensland Brain Institute in 2003. His laboratory continues to study the amygdala using a combination of behavioural studies, electrophysiology, and molecular tools.

More recently, his group has begun to investigate the role of reinforcement in learning in rodent models as well as human subjects. This research suggests that partial reinforcement, as opposed to full reinforcement, engages larger numbers of neurons in the brain and also improves long-term behavioural outcomes. The Centre offers a forum for these basic neuroscience findings to be translated into improved learning outcomes in humans.



MEASURING LEARNING

Dr Mike Timms
Australian Council for Educational Research

Dr Michael Timms is an education researcher specialising in the measurement of learning in interactive learning environments. He has a background in the development of high quality assessments and educational measurement in a range of settings. In 2005 he was awarded a PhD in Quantitative Methods in Education from the University of California, Berkeley. He joined ACER in 2011 as Director of Assessment and Psychometric Research. He has twice received the Paul D. Hood Distinguished Contribution to the Field Award for his involvement in the development of assessment frameworks for the US National Assessment of Educational Progress, in 2006 and 2009. In 2013 he received the Journal of Research in Science Teaching Award from the National Association for Research in Science Teaching (NARST), a worldwide organisation for improving science teaching and learning through research.

Dr Timms is interested in how to track and support learning in intelligent learning environments (ILEs) and, in particular, how students receive and process feedback. Dr Timms' research in the SLRC will build a body of knowledge that will inform the design of feedback systems for future ILEs to optimise student learning.



PROMOTING LEARNING

Professor John Hattie
The University of Melbourne

John Hattie is Director of the Melbourne Educational Research Institute at the University of Melbourne. His areas of interest are measurement models and their applications to educational problems, and models of teaching and learning. Previous appointments were in Auckland, North Carolina, Western Australia, and New England. He was chief moderator of the NZ Performance Based Research Fund, is Past-President of the International Test Commission, associate editor of British Journal of Educational Psychology and of American Educational Research Journal, serves on many editorial boards and is part-time cricket coach and umpire. He has published and presented over 550 papers, and supervised 180 theses students.

His research has led to the development of a model of teaching and learning called "Visible Learning". There are now four books in this series, and many schools and systems throughout the world are implementing the ideas. He works with a group of implementers, and this has led to a healthy research base of the effects of these methods on learning. His current research focusses on learning strategies, models of teaching and learning and feedback.



UNDERSTANDING LEARNING

Learning is the process by which we acquire new knowledge, skills or behaviours and underpin all aspects of education. Experimental neuroscientists, cognitive psychologists and educationalists are investigating the learning process in both animals and humans. The understanding gleaned from this initial work will form the basis for the validation of existing learning strategies, the development of novel strategies and assist in the development of tools to measure learning.

Two of the main topics of research under this theme are to understand the role of feedback and attention in learning. The study of these topics will provide a detailed understanding of the neural mechanisms that are engaged during acquisition, memory consolidation, and retrieval, key stages in the learning process. Two of the most relevant aspects to emerge from these studies are: (1) The key role of attention in learning and (2) The finding that both the pattern of feedback, as well as the external environment, can have a major impact on memory consolidation.

Traditionally, interest in the role of feedback and attention in learning has been confined to silos in which experimental neuroscientists, cognitive psychologists and educationalists work independently, investigating distinct issues in learning and reach conclusions that address questions in their relevant areas. The Centre, with its complementary classrooms that bring together experimental neuroscientists, cognitive psychologists and educationalists working in the field, will make it possible to jointly study the neural processes that underpin learning in animal models, and in students in the classroom.

Animal models are used as a tool to understand the neural mechanisms that are engaged during learning and to define the changes that occur during successful learning. These studies provide the opportunity of controlled manipulation of both the learning environment and the neural activity that is engaged to arrive at quantitative, testable hypotheses to assess learning, memory formation and memory consolidation. Knowledge gained from these studies can be transferred to human learning. The SLRC harnesses the expertise of educationalists, cognitive psychologists and neuroscientists; animal experiments are being designed in collaboration with these experts, making use of lessons learned from the classroom when designing stimulus presentation. The results from animal models can also be used to guide the development of physiological measurements in humans aimed at evaluating learning and memory formation. The studies in this theme will provide insight into the conditions under which effective and robust learning takes place.



LEARNING FROM ANIMALS

The effect of feedback scheduling in learning has been known since the early 19th century, and these findings have stood the test of time. However, in the last few decades, modern neuroscience has been reinvestigating this phenomenon in both humans and animals. These studies have found that animals, in which expected behaviours are only partially rewarded, learn equally well as those that receive rewards 100 per cent of the time. More surprisingly, research has shown the number of active neurons in the brains of partially rewarded learners is more than two-fold greater than for full reward.

“These findings raise questions regarding the role of reinforcement and brain circuits engaged by reinforcement,”

– The University of Queensland researcher Professor Pankaj Sah.

In the first phase of this program Professor Sah, in collaboration with Dr Tim Bredy (UQ), plans to study the neural mechanisms engaged during partially reinforced learning paradigms, using rats as an animal model. They will then go on to investigate changes at a molecular level associated with such learning. In the third phase of the study SLRC researcher Professor Jason Mattingley (UQ) will use EEG and fMRI recordings to determine whether humans use the same brain regions as the animal model during similar learning paradigms. These studies address questions regarding how student performance should be reinforced with feedback and the impact and role of testing during teaching.



MEASURING LEARNING

Measuring learning is a key component in assessing the success of particular teaching methods and what is learnt. Importantly, measuring learning also underpins decisions about the type and content of feedback that is provided to students and how to adapt instruction to meet their needs. New techniques developed for measuring learning will assist in studies in the Understanding Learning theme and be used to validate strategies for Promoting Learning.

The main program of research in the Measuring Learning theme centres on feedback, particularly with respect to expanding electronic learning environments. The use of electronic learning environments is growing exponentially, both in formal school and training settings, as well as in informal educational settings such as for pre-school children in the home environment. The research cluster is looking at how different aspects of feedback can be utilised to assist learners in electronic learning environments.

This program of research is investigating ways of optimising feedback in intelligent learning environments and the impact of analytic systems to automatically analyse classroom dialogues and learning. It aims to provide immediate feedback about learning processes, predicting learner confusion for enhanced feedback and self-regulation, and will improve measurement methodology in digital learning environments, focussing on the monitoring of learning behaviours.

Working together, the cluster, comprising researchers from five organisations across three states and including overseas Partner Organisations, is exploring if there are opportunities to use the same digital learning environments across different research studies. This will allow for the same data to be analysed and used for multiple projects, enabling the examination of different aspects of the learners' behaviours. Data collected from the feedback and learner confusion studies will be used by collaborating researchers in the Centre to develop measurement methodologies for use in digital learning environments.



MEASUREMENT METHODOLOGY IN DIGITAL LEARNING ENVIRONMENT

The growth in the use of digital learning environments in education has created opportunities for tailoring instruction and learning to the needs of individual students. Due to the complexity of the data that can be gathered from these learning environments, it is a challenge for psychometricians to develop measurement methodologies. They must dynamically calibrate and then provide predictive estimates of each student's trajectory of learning, in order to monitor learning behaviour and learning gain, and to provide useful and timely feedback.

“The main aim of the research project is to investigate methodologies for monitoring learning behaviour to measure learning gains and to model factors influencing the trajectory of learning,”

– ACER's Dr Siek Toon Khoo.

Learning gain will be measured by tracking change over time using tasks that are designed to detect increase in knowledge, methods of learning, and change in performance and understanding. Longitudinal and repeated observations are necessary to observe and detect learning change. Longitudinal random coefficient models will provide the techniques and opportunities for modelling the repeated observations/measurements, allowing the investigation of time-specific factors that influence learning temporally at the observation points and individual-level factors that influence individual learning overall. This study will first make use of available data from the learning analytics community to formulate different statistical and measurement models to evaluate and demonstrate their usefulness. What is learnt from the digital learning context will hopefully be applicable to other longitudinal learning science research.

Similarly, given the ubiquity of students of all ages using technology, MOOCs, iPads etc., it is now possible to analyse key strokes in real time and provide information about levels of confusion, to estimate collaboration across learners, and to further develop learning analytics in order to enhance teaching and learning.



PROMOTING LEARNING

The theme Promoting Learning is targeted towards developing interventions that enhance learning in a variety of environments. The new understanding of learning will be incorporated into strategies for Promoting Learning, which will be validated using the measuring learning tools and techniques emerging from the theme Measuring Learning. The three major programs within this theme are “feedback”, “learning strategies” and “collaborations”.

The first program attacks feedback from a number of perspectives, categorising feedback, investigating the effects of various categories of feedback across different age groups, the role of reinforcement in the feedback cycle, the place of intrinsic and extrinsic feedback, and optimising feedback in interactive learning environments. A key focus will be improving the manner and amount of feedback received by teachers and students about their impact.

The second major program focussed on learning strategies includes a major meta-review of the various models of learning strategies, complemented by a meta-review of programs to enhance these strategies. Knowledge gained from these studies will be used to guide policy and teacher development and training. The findings will also lead to the team focussing on the optimal strategies and interventions in a later phase of the Science of Learning research that will then aim to have major implications for practice in schools.

The third program concerns collaborative learning. Researchers will aim to develop automated measures for identifying collaborative problem solving in real-world situations, predicting learning confusion for enhanced feedback and self-regulation, and sustained attention and self-regulation in the classroom.



ADDRESSING LITERACY IN INDIGENOUS AND OTHER EDUCATIONAL CONTEXTS

The primary years are crucial in consolidating students’ early literacy skills, and laying the academic groundwork that will enable them to continue to secondary schooling and beyond. Although the skills of inferential reading, comprehension and metalinguistic concepts are generally accepted as critical to the building of strong literacy skills, they are frequently neglected in the general discourse about Indigenous literacy, which tends to get bogged down in concerns about ‘the basics’.

Until now, there has been little systematic Australian research exploring the relationship between classroom dialogue and learning in highly disadvantaged contexts. With many students experiencing low academic achievement in these settings, there is a need to know more about how their classrooms operate and to strengthen pedagogical practice in these areas.

“We are particularly interested in the settings of disadvantage in the Northern Territory (urban schools servicing low socioeconomic ethnically mixed populations, and remote schools catering for mostly Indigenous children) as we currently have little data on the interactions that take place during primary school literacy lessons in these settings,”

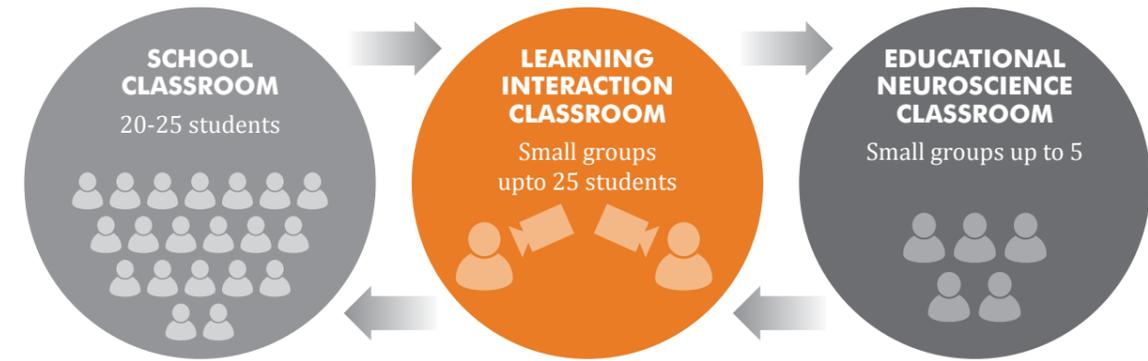
– Charles Darwin University’s Professor Sven Silburn.

One aspect of the program will be the development of evidence based strategies for enabling effective classroom dialogue in indigenous and ESL contexts.

“At the end of the day, we want to identify how teachers can be better trained in structuring pedagogical dialogue to help children think about the texts and language that they study,”

– Professor David Clarke from The University of Melbourne.

The University of Melbourne’s Professor Collette Tayler and Menzies Centre for Child Development and Education’s Professor Silburn and Helen Harper will pilot an implementation of a teacher-professional learning program in schools in the Northern Territory and far north Queensland that focusses on instructional leadership for improving literacy outcomes in these contexts



RESEARCH INFRASTRUCTURE

Researchers are combining information gathered from studies in the field with those from a classroom specially designed to study learning interactions and a classroom equipped to monitor neurological and physiological activity during learning.

Findings from neuroscience are increasingly being looked to, to provide new directions for teaching strategies in classrooms. Yet there are many acknowledged ‘neuromyths’ involving ‘findings’ that are not strongly based on quantitative evidence. The challenge has been to find theoretical and methodological constructs that can align findings on learning generated from neuroscience with insights from classroom studies, and help to translate neuroscience findings into recommendations for classroom teachers.

The unique research infrastructure provided by the experimental classrooms provides researchers within the SLRC with the opportunity to overcome these challenges. These classrooms provide the tools to measure behaviour, social interactions and neural activity during classroom learning and relate these to processes at the theoretical, methodological and practical levels. Experimental paradigms will be developed that bridge the gap between the complex learning behaviours and social interactions in real classrooms, with the more focussed perspectives afforded by studies of learning at the neural level.

It is a key mission of the SLRC research program to integrate the findings generated from these distinctive research sites in ways that render them mutually informing, thereby advancing our understanding of learning in all three settings and our capacity to measure and promote learning wherever it occurs.

EDUCATIONAL NEUROSCIENCE CLASSROOM

The Educational Neuroscience Classroom located in the School of Psychology at The University of Queensland brings together state of the art neuroscience technology for the measurement of brain activity, behaviour and physiology, allowing for the multi-modal assessment of factors that contribute to successful learning.

The Educational Neuroscience Classroom will allow for up to four research participants to be investigated simultaneously in a virtual classroom environment. A key aim of the Educational Neuroscience Classroom is to examine the extent to which cognitive factors influence and shape learning. Research participants will engage in learning-related computer tasks that will assess the effects of cognitive training, attentional demands, and other cognitive factors on successful learning. Importantly, the facility will allow for the measurement of brain activity (electroencephalography: EEG), eye tracking, and physiological responses such as skin conductance, heart rate, and respiration during learning. The combination of multi-modal neuroscience techniques with the unique virtual classroom environment will allow us to explore human learning in ways not previously possible.

The Educational Neuroscience Classroom is ideally suited for the translation of experimentally derived learning and cognitive training protocols into the classroom. Centre researchers from Education, Psychology and basic Neuroscience will be given the opportunity to transfer insights obtained from the laboratory into real-world classroom practice – and vice versa. Similarly, the Educational Neuroscience Classroom will provide an important testing ground for determining the neural and physiological correlates of key classroom success indicators, which will be derived from work in the Learning Interaction Classroom.



LEARNING INTERACTION CLASSROOM

The Learning Interaction Classroom is located within the Melbourne Graduate School of Education at The University of Melbourne. It supports the strategic configuration and documentation of social interactions between the teacher, students and classroom artefacts/resources with a level of experimental precision not previously possible. This laboratory classroom will provide a continuous record of classroom speech, written activity, use of digital tools, including iPads and laptops, and social indicators such as student facial expressions, gestures, and various verbal epistemic markers. Post-lesson video-stimulated interviews will be used to reconstruct classroom participant intentions, attentions, motivations, interpretations, and learning outcomes. An additional smaller observation room is being installed for the intensive study of dyadic and small group interactions and also to be used as an interview facility.

In addition to on-site capture, the facility will securely live-stream the lesson to allow remote participants the opportunity to view and provide comments in real-time. Essential to the Learning Interaction Classroom is the local construction of a functioning digital data management system purposefully adapted for streaming and management of the large audio and video data files generated by the Learning Interaction Classroom. Protocols for the management and mediated access to the data generated in the laboratory classroom are currently under development. These include logistical and ethical procedures regarding the individual's participation in any experimental lessons or lesson sequences. Partnerships will be formed with selected schools to facilitate the participation of their students in such experimental lessons.

The focus of studies in the Learning Interaction Classroom will include forms of student social interaction in facilitating learning in dyadic and small group learning units, when engaged in collaborative inquiry, problem solving, representational interpretation, manipulation and construction, and experimental design. The program also includes studies in the Learning Interaction Classroom focussing on fundamental learning processes associated with visual-spatial representations and the development of meta-representational competence, and student response to instructional prototypes.

The specific goal of the Learning Interaction Classroom is the documentation of learning as a social process and the instructional and contextual conditions for the optimisation of that process. Experimental design will connect experiments undertaken at the Learning Interaction Classroom with associated experiments in the Educational Neuroscience Classroom at The University of Queensland, in order to identify the neurological correlates of learning events identified through social indicators. The high level of precision with which social interactions can be documented at the Learning Interaction Classroom supports their precise replication under controlled conditions at the Educational Neuroscience Classroom. In this way, the parallel experimental work being undertaken at the Learning Interaction Classroom and at the Educational Neuroscience Classroom will be mutually informing and explanatory, contributing significantly to the understanding of learning as both a social and neurological phenomenon.

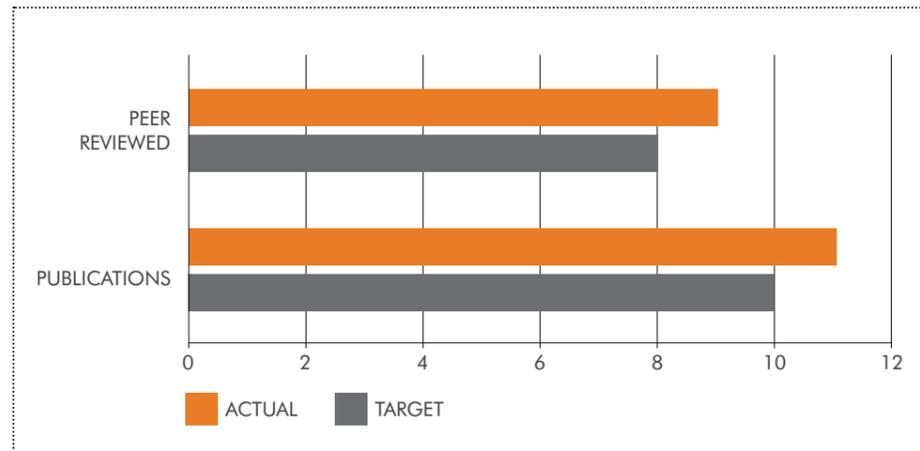
RESEARCH OUTPUT

Although having expertise in distinct fields, this group of Researchers is truly collaborating on projects to address some of the big questions in learning.

PUBLICATIONS

Already outcomes from the Centre's research are making their way into publications. From September 2013 the Centre has produced 11 publications, 9 of these in peer reviewed journals.

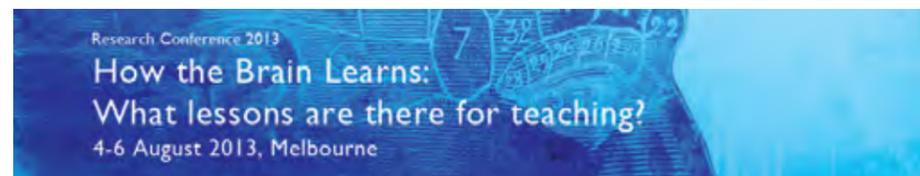
NUMBER OF RESEARCH OUTPUTS



COMMUNICATING SCIENCE

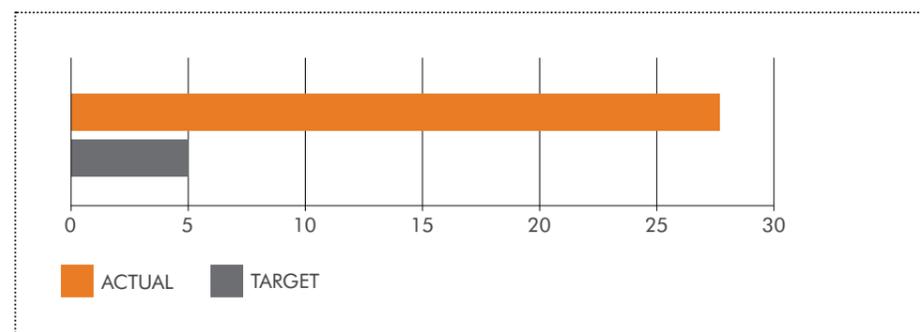
INVITED TALKS/PAPER/KEYNOTE LECTURES

For 2013 SLRC investigators were invited to present their research at a number of forums including the Annual ACER Research Conference in Melbourne, the OMEP World Early Childhood Conference in Shanghai, Society for Neuroscience Conference in California, the UNESCO Education Policy and Reform Unit and the General Assembly of the International Academy of Education in Belgium.



How the Brain Learns: What lessons are there for teaching? was the theme for the 2013 ACER Research Conference held at Melbourne in August. ACER deliberately chose this theme to coincide with the anticipated launch of the Centre, in which it is a critical partner. The conference provided the opportunity to advance the agenda of the SLRC, and commence a dialogue between the SLRC and the broader education community. SLRC Deputy Director Professor John Hattie from The University of Melbourne was a keynote presenter, addressing over 800 delegates on the importance of feedback in learning. Other SLRC members also gave presentations, including Centre Director, Professor Ottmar Lipp (The University of Queensland), Professor Pankaj Sah (The University of Queensland), Dr Mike Timms (ACER), Professor David Clarke (The University of Melbourne) and Professor John Pegg (University of New England).

NUMBER OF INVITED TALKS/PAPERS/KEYNOTE LECTURES GIVEN AT MAJOR INTERNATIONAL MEETINGS

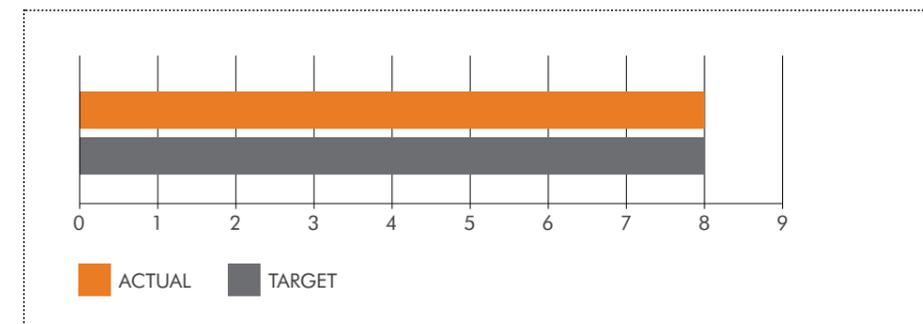


COMMENTARIES

Following the announcement of the Centre, there were a number of commentaries released around the Centre's activities and the potential impact it will make on education. SLRC's mass representation at the ACER Research Conference in August also attracted media attention. The highlight of the year was a feature story by Channel 7 about the Centre research, featuring the Educational Neuroscience Classroom.

DATE	TITLE	ORGANISATION
9 December 2013	UQ opens Learning Research Centre	PS News
5 December 2013	Science of Learning Research Centre has officially opened	Channel 7
7 May 2013	Q+A: \$16m boost to unpack the science of learning	The Conversation
8 May 2013	ACER and partners establish Science of Learning Research Centre	ACER
28 June 2013	Understanding the brain, and learning about learning	EducationViews, Queensland Government
22 May 2013	Students the subjects; Love 2 Learn	Adelaide Advertiser
9 May 2013	SLRC overview – Ottmar Lipp	4ZZZ
24 October 2013	How to study effectively - Paul Dux	Triple J

NUMBER OF COMMENTARIES ABOUT THE PROGRAM'S ACHIEVEMENTS



THE YEAR AHEAD

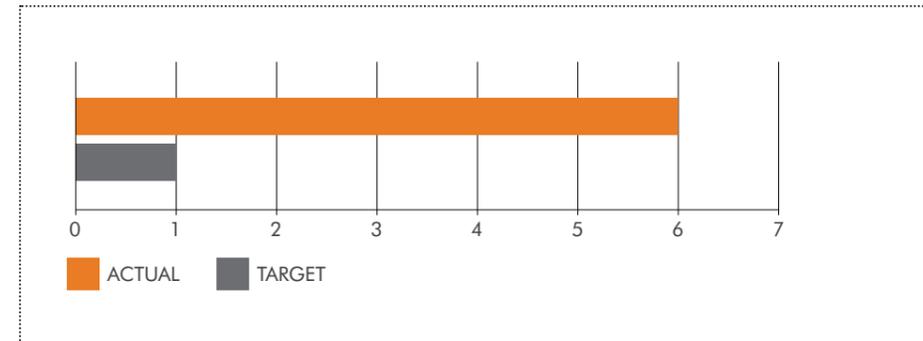
The Centre will continue to ensure its research findings are communicated to the research community both nationally and internationally in 2014, as well as to educators, policy makers and the broader community. In June several researchers will be attending and presenting at the International Cognitive Neuroscience Conference (ICON) in Brisbane. This conference, being organised by SLRC CI Associate Professor Ross Cunnington is expected to attract international researchers from multiple countries. In April CI Timms will present at the American Educational Research Association annual conference in Philadelphia, PA (USA) and at the National Council for Measurement in Education annual conference (co-located with the AERA conference). Later in the year a number of CIs will speak at the ACER Research Conference in Adelaide, the major educational research conference in Australia.

INTERNATIONAL, NATIONAL AND REGIONAL LINKS AND COLLABORATIONS

INTERNATIONAL VISITORS

A highlight for the SLRC was a visit in November by Japanese legend Professor Hideaki Koizumi, Fellow and Corporate Officer, Hitachi Ltd and member of the SLRC Advisory Board. His presentation, *Brain-Science-based Education and Psychiatric Diagnosis with Optical Topography*, was extremely thought provoking and opened avenues for future collaboration. Professor Koizumi spent several days at UQ meeting with SLRC researchers.

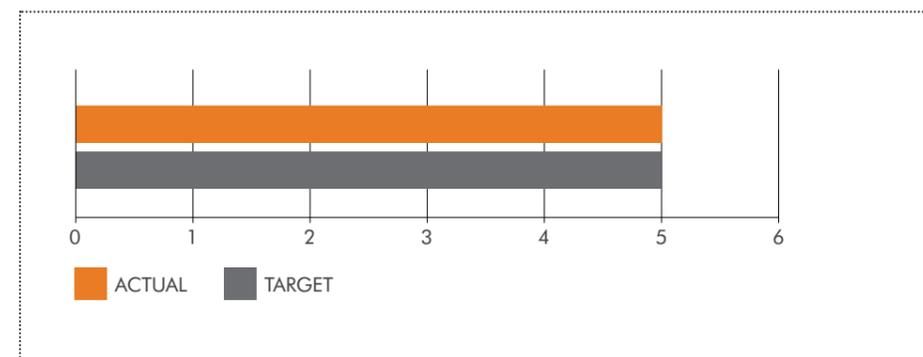
NUMBER OF INTERNATIONAL VISITORS AND VISITING FELLOWS



OVERSEAS VISITS

A number of SLRC researchers visited overseas laboratories and facilities in 2013. Professor Collette Tayler had an extended stay at the Center for Advanced Study of Teaching and Learning at the University of Virginia. During her visit she collaborated on coding of early childhood program DVDs and gave several seminar presentations. Professor Marilyn Goos spent the last three months of the year at Loughborough University in the United Kingdom working with colleagues who undertake eye-tracking studies on mathematical cognition. The knowledge gained from this collaboration will be applied to experimental design in the Educational Neuroscience Classroom. In September Dr Sacha DeVelle visited the London Knowledge Laboratory at the Institute of Education, London. She spent time with SLRC PI Professor Diana Laurillard mapping out their collaborative research program on feedback in intelligent learning environments.

NUMBER OF VISITS TO OVERSEAS LABORATORIES AND FACILITIES



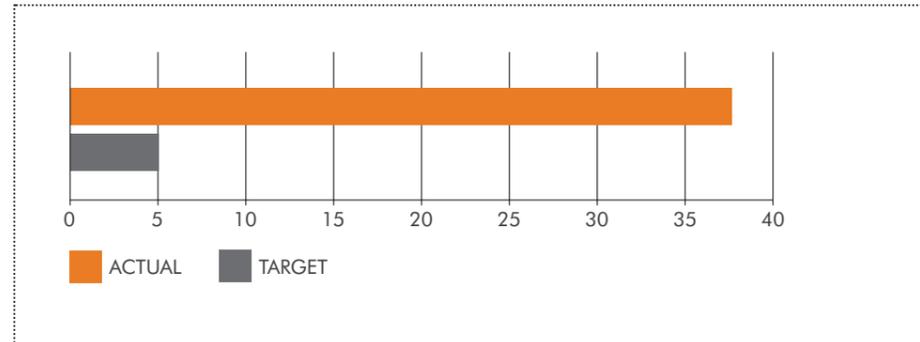
AN INTERDISCIPLINARY APPROACH

The SLRC is unique in the mix of researchers it brings together. An example of this is a program on confusion in the IT environment. The program involves researchers from The University of Melbourne, Macquarie University, Australian Council for Educational Research and The University of Queensland, including cognitive psychologists and educationalists, as well as IT experts from two Partner Organisations.

ORGANISATION PARTICIPATION

SLRC has representation on a variety of national and international organisations. These include the UNESCO (Bangkok) Education Beyond 2015 group, the Science Expert Group for the OECD PISA 2015 assessment, the Australian Children's Education and Care Quality Authority, the Victorian Curriculum and Assessment Authority and the Australian Academy of Science's National Committee for Brain and Mind.

PARTICIPATION ON NATIONAL AND INTERNATIONAL BODIES



WORKSHOPS NATIONAL/INTERNATIONAL

In November the Centre held a mini-symposium for chief investigators and members of the Advisory Board, including Hitachi Research Fellow Professor Hideaki Koizumi in Brisbane. At the mini-symposium four of the Centre CIs presented their research programs. During 2013 the Centre began planning for two International workshops. Initially it was hoped one of these would take place in 2013, however this was not logistically possible.

THE YEAR AHEAD

In 2014 the SLRC will continue to grow its national and international links. The SLRC is planning to host two workshops with international speakers in 2014, one at The University of Melbourne node on feedback in the second half of the year and the other at The University of Queensland node on attention in the first half. SLRC will continue to be represented in national and international events across a range of areas through member participation.

The SLRC will continue to support interdisciplinary research, providing travel and accommodation support for researchers to spend time at various nodes. Both the Learning Interaction Classroom and the Educational Neuroscience Classroom facilities have desk space available for visiting researchers.

In February 2014, Dr Sacha DeVelle will visit the Centre for Diagnostic Nuclear Imaging at the University of Malaysia Sabah directed by Professor Jalil Nordin. In April 2014, CI Timms will visit the IntelliMedia laboratory run by Dr James Lester at the North Carolina State University to collaborate on research in Intelligent Learning Environments. In July 2014, CIs Timms and Khoo will visit the Institute of Education and the Centre for Educational Neuroscience (CEN) at the University of London to collaborate with PIs Laurillard and Butterworth, and establish links to CEN.

COMMUNITY ENGAGEMENT, TRANSLATION & OUTREACH

The first few months of operation has seen investigators within the Centre building relations with Partner Organisations. The Centre has been scoping out a research partnership with the Benevolent Society and the Barbara Arrowsmith group.

The UQ node has formed an education engagement group comprising CIs Robyn Gillies, Annemaree Carroll and Marilyn Goos, and the COO, who meet on a bi-monthly basis with representatives of the Queensland Department of Education and Training. At the Melbourne node, Professor John Hattie leads the interaction with the Victorian Department of Education and Early Childhood Development while Professor Martin Westwell meets regularly with members of the South Australian Department of Education and Child Development.

Dr Jim Wattleston and Mr Simon Kent, from the Queensland Department of Education and Training and Victorian Department of Education of Early Childhood Development respectively, are members of the SLRC Advisory Board and provide an invaluable link into State education.



SLRC opening, left to right: Professor Perry Bartlett, Professor Peter Höj, Professor Aidan Byrne, The Hon Ian Walker MP, Mr John Story, Professor Ottmar Lipp

The Centre was officially launched by the Honourable Ian Walker, Queensland Minister for Science, Information Technology, Innovation and the Arts.

On 27 November over 25 guests from government, schools and industry were privileged to hear a presentation from distinguished educationalist and Advisory Board Chair, Professor Barry McGaw, and from Centre Director Professor Ottmar Lipp.

In addition to its Partner Organisations, the SLRC has been laying down the foundation for a number of strategic partnerships including

- The Gumala Corporation in Western Australia, with a view to forming a partnership to implement strategies in remote early childhood indigenous communities across the Pilbara region
- UNESCO (Bangoko) through the Education Beyond 2015 program and the ERI-net program
- Brisbane Catholic Education and
- Hitachi Limited.

SLRC researchers have been involved in advising policy both nationally and internationally including

- Briefing to the Hong Kong Secretary of Education to inform policy development on the provision of kindergarten education in Hong Kong and
- Presenting to UNESCO (Bangkok) Education Beyond 2015 expert meeting.

Centre researchers have presented over 20 lectures and seminars to various community groups including educators, students and the general public.

THE YEAR AHEAD

In 2014 the Centre will look to form strategic partnerships with the Australian Council of Educators, the Australian Brain Bee Challenge and the recently announced ARC Centre of Excellence for Integrative Brain Function with a view to expanding its outreach network.

The SLRC will continue to work closely with government bodies, including the Queensland, Victorian and South Australian Education Departments, who are partners. It will also work closely with the Benevolent Society to provide guidance on learning programs.

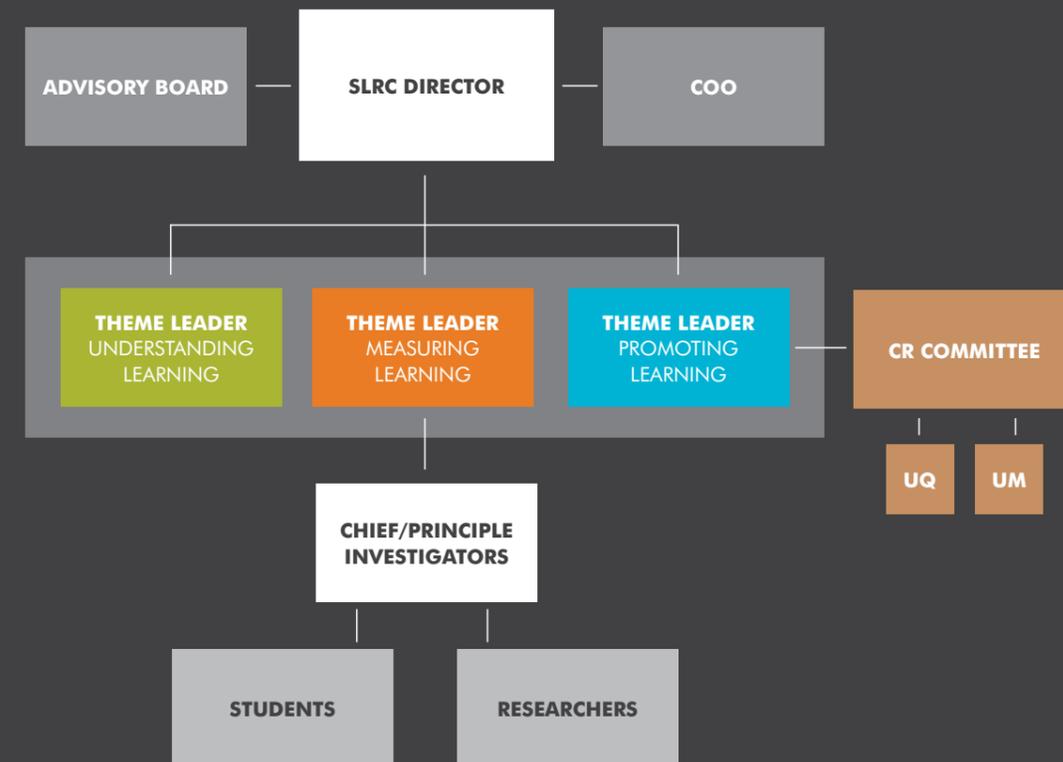
The Centre has developed a plan to proactively translate its research findings to the education community. A Calendar of Seminars at The University of Queensland has already been circulated for 2014 to engage stakeholders in the community. A similar series is planned to commence at The University of Melbourne in the first half of the year. SLRC has committed to contributing to the Solid Pathways program for Indigenous Students during April and June, a growing initiative of The University of Queensland.

Outreach events and recorded seminars will be added to the SLRC website, along with the latest research findings and reports. In 2014 we will explore developing a chat page or using Facebook as a means of generating interaction with the education and research community and the general public.

In 2014 Professor Cindy Shannon, UQ Pro-Vice Chancellor (Indigenous Education) will join the Advisory Board, providing indigenous stakeholder representation.

GOVERNANCE & PLANNING

The Executive Committee and the Advisory Board oversee Centre governance.



EXECUTIVE COMMITTEE

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

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



Exec Executive Committee, left to right: Prof Pankaj Sah, Prof Ottmar Lipp, Prof John Hattie, Dr Mike Timms

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 Ottmar Lipp** (The University of Queensland)
- **Dr Hideaki Koizumi** (Research Fellow, Hitachi Ltd, Japan)
- **Professor Rita Colwell** (Distinguished University Professor, University of Maryland, USA)
- **Dr Jim Watteston** (Director-General, Queensland Department of Education, Training and Development)
- **Mr Joe McLean** (General Manager, Consulting and Research, UniQuest)
- **Professor Perry Bartlett** (Director, Queensland Brain Institute, The University of Queensland)
- **Professor Geoff Masters** (Chief Executive Officer, Australian Council for Educational Research)
- **Mr Simon Kent** (Deputy Secretary, Strategy and Review Group, Victorian Department of Education and Early Childhood Development)
- **Professor Richard Noss** (Institute of Education, University of London)
- **Professor Field Rickards** (Director, Melbourne Graduate School of Education, The University of Melbourne)
- **Ms Annita Nugent** – Secretary (The University of Queensland)

The Advisory Board meets twice a year. The first meeting was held in November 2013 at The University of Queensland, coinciding with the official opening of SLRC.

CHIEF INVESTIGATOR MEETINGS

A meeting for all Chief Investigators is held annually. The first meeting was held in June 2013 at The University of Queensland. In future years it will be held in August to coincide with the ACER Research Conference. In addition, workshops for each of the three research themes are held on a more regular basis.

DAY-TO-DAY MANAGEMENT

The day-to-day management of the Centre is the responsibility of the Chief Operating Officer (COO). The COO manages the operations of the Centre, including finance, engagement and reporting and supports the Director in ensuring the Centre reaches its overall objectives. The COO 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. The COO is supported by classroom managers at The University of Queensland and The University of Melbourne and an Engagement Officer at The University of Melbourne.

THE YEAR AHEAD

At the end of January 2014 Professor Ottmar Lipp will depart The University of Queensland, and step aside as Director of the Centre, to take up a position at Curtin University. Professor Pankaj Sah will fill the role of Centre Director. Professor Lipp will remain a Chief Investigator within the Centre and on the Executive Committee, taking on the role of Theme Leader - Understanding Learning. Subsequently, Curtin University will join the SLRC as a Collaborating Organisation.

In Q2 of 2014, under the new leadership, the Executive Committee will have a half-day review and planning session, moderated by a member of an established ARC Centre of Excellence. The CI meeting is scheduled for August in Adelaide.

The first meeting of the Advisory Board for 2014 will be a virtual meeting in the second quarter of the year. The second meeting is scheduled for Melbourne later in the year. Professor Cindy Shannon, UQ Pro-Vice Chancellor (Indigenous Education) will join the Advisory Board in 2014.

RESOURCES	ACTIVITIES	OUTPUTS	SHORT & LONG TERM OUTCOMES	IMPACT
Eight Collaborating Organisations with 25 CIs from neuroscience/cognitive psychology/neuroscience	Enrol and supervise PhD/Masters/Honours students	Doctoral/Masters/Honours graduates in transdisciplinary Science Of Learning	A cohort of transdisciplinary researchers in the Science of Learning	Establishment of a world class transdisciplinary Science of Learning in Australia with strong connections to the international field
Nine Partner Organisations	Employ and mentor Postdoc researchers and research assistants	Experienced researchers in transdisciplinary Science Of Learning		
Advisory Board	Professional development for SLRC students and researchers in transdisciplinary topics (workshops/seminars/training/etc.)			
ARC Special Initiative grant plus Cash Contributions from Collaborators and Partners	Create a Learning Interaction Classroom research and an Educational Neuroscience Classroom research facility	Deeper understanding of aspects of learning such as Attention/Engagement/Confusion/Learning Anxiety/Feedback in the classroom/Feedback in digital learning environments and particularly for disadvantaged learners	New research designs, techniques and measurement models specific to transdisciplinary research in the Science of Learning	Growth of new research facilities for the Science of Learning that will employ discipline specific research methods
In-kind contributions from Collaborators and Partners	Conduct transdisciplinary Science of Learning research projects across three themes of Understanding Learning/Measuring Learning/Promoting Learning	Deeper understanding of the neural aspects of learning such as Neural Circuits/Role of the Amygdala/Memory Acquisition/Memory Consolidation/Reinforcement/etc.	New, research-based approaches to the design, planning and delivery of instruction to promote learning for ALL learners.	Educators will design and plan instruction based on evidence of what works from the Science of Learning.
	Outreach activities for students/teachers/school administrators/policymakers on relevant Science of Learning topics			Policymakers will make research-based decisions on the nature of education and its organisation based on research from the Science of Learning

APPENDICES

APPENDIX 1: PUBLICATIONS

JOURNAL ARTICLES

Al-Zuhairi, R., and Gillies, R. (2013). "The impact of cooperative learning in comparison to traditional learning (small groups) on EFL learners' outcomes when English is a foreign language." *Asian Social Science*, 9(13), 19-27.

Filmer, H. L., Mattingley, J. B., Marois, R., and Dux, P. E. (2013) Disrupting prefrontal cortex prevent performance gains from sensory-motor training. *Journal of Neuroscience*, 33(47): 18654-18660.

Filmer, H. L., Mattingley, J. B., and Dux, P. E. (2013) Improved multitasking following prefrontal tDCS. *Cortex*, 49(10): 2845-52.

Flavell, C. R., Lambert, E. A., Winters, B. D., and Bredy, T. W. (2013). "Mechanisms governing the reactivation-dependent destabilization of memories and their role in extinction." *Frontiers in Behavioral Neuroscience*, 7.

Ishimine, K., and Tayler, C. (2013). "Assessing Quality in Early Childhood Education and Care." *European Journal of Education*, n/a-n/a.

Li, X., Wei, W., Ratnu, V. S., and Bredy, T. W. (2013). "On the potential role of active DNA demethylation in establishing epigenetic states associated with neural plasticity and memory." *Neurobiology of Learning and Memory*, 105, 125-132.

Lockyer, L., Heathcote, E., and Dawson, S. (2013). "Informing Pedagogical Action: Aligning Learning Analytics With Learning Design." *American Behavioral Scientist*, 57(10), 1439-1459.

Quellmalz, E. S., Davenport, J. L., Timms, M. J., DeBoer, G. E., Jordan, K. A., Livang, C. W., and Buckley, B. C. (2013). "Next-Generation Environments for Assessing and Promoting Complex Science Learning." *Journal of Educational Psychology*, 105(4), 1100-1114.

Seah, L. H., Clarke, D. J., and Hart, C. E. (2013). Understanding the Language Demands on Science Students from an Integrated Science and Language Perspective. *International Journal of Science Education*, DOI: 10.1080/09500693.2013.832003.

BOOKS/BOOK CHAPTERS

Clarke, D. J. (2013). "International comparative research into educational interaction: Constructing and concealing difference." In K. Tirri and E. Kuusisto (Eds.) *Interaction in Educational Settings*, (pp. 5-22), Rotterdam: Sense Publishers.

Hattie, J.A.C. & Yates, G. (2013). *Visible Learning and the Science of how we Learn*. Routledge, UK.

APPENDIX 2: FINANCIAL STATEMENTS

INCOME

SOURCE	AMOUNT
ARC	\$4,487,229
Administering Organisation	\$440,000
Collaborating Organisations	\$0
Partner Organisations	\$0
Total	\$4,927,229

EXPENDITURE

	UQ	UM	ACER	CDU	MQ	UNE	DEAKIN	FLINDERS	TOTAL
Purchased equipment	\$413,631	\$100,242	0		0	0	0	0	\$513,873
Travel	\$19,451	0	\$1,570	\$1,290	0	0	0	0	\$22,311
Salaries	\$73,035	\$19,138	\$37,027	\$56,568	0	0	0	0	\$185,768
Scholarship- top/up summer/living/other	0	0	0	0	0	0	0	0	0
Other expenditure	\$3,511	\$29,189	\$1,136	0	0	0	0	0	\$33,836
Total	\$509,628	\$148,569	\$40,279	\$57,858	0	0	0	0	\$755,788

Note, the Collaborative Research Agreement between the 17 Partner and Collaborating Organisations was signed on 27 November, three months after the award of the grant and six months after the ARC official commencement of the grant. Consequently, organisational contributions were not invoiced and received in 2013.

APPENDIX 3: PERFORMANCE INDICATORS

PERFORMANCE MEASURE	TARGET 2013	OUTCOME 2013
RESEARCH FINDINGS		
Number of research outputs (research outputs may include journal articles, books, book chapters, conference publications and patents)	10	11
Quality of research outputs: At least 80% of papers will be: - peer reviewed (remaining in professional journals) - in top 20% of journals per discipline (ISI impact factor)	8	9
Number of invited talks/papers/keynote lectures given at major international meetings (include international conferences held in Australia)	5-15	27
Number of nature of commentaries about the Program's achievements (list media releases and articles separately)	8	8
RESEARCH TRAINING AND PROFESSIONAL DEVELOPMENT		
Number of professional training courses for staff and postgraduate students attend - professional development is standard requirement for all researchers	7-15	10
Number of Program participants who have attended professional training/development courses offered by the Program (include courses offered for external stakeholders and clients)	4-10	4
Number of new PhD students working on core Program research and supervised by Program staff	1-3	9
Number of PhD student completions and completion times, by students working on core program research and supervised by program staff	0	0
Number of new Masters by research and Masters by coursework students working on core Program research and supervised by Program staff	1-3	0
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	0	0
Number of new Honours students working on core Program research and supervised by Program staff	1-3	1
Number of Honours student completions and completion times, by students working on core Program research and supervised by Program staff	1-3	1
Number of new postdoctoral researchers recruited to the Program working on core Program research	5	10
Number of Early Career Researchers (within five years of completing PhD) working on core program research	5	7
Number of students mentored: Summer and winter research placements; International exchange programs; Honours and PhD students	3-15	12
Number of mentoring programs offered by the program (include programs for students, new staff, external stakeholders and clients)	2-6	0
INTERNATIONAL, NATIONAL AND REGIONAL LINKS AND COLLABORATION		
Number of international visitors and visiting fellows	1-5	6
Number of national and international workshops held/organised by the program	1	0
Number of visits to overseas laboratories and facilities	5-15	5
Examples of relevant interdisciplinary research supported by the Program: • Aligning teaching to attention • Classroom instruction to maximize memory consolidation • Benchmarking the learning state and process • Measuring learning with digital tools • Learning from example • The role of feedback in learning	1	Example provided on page 19 of report

Participation on national and international bodies, including Government and community groups	5-15	38
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	2-8	4
Number of government, industry, business and community briefings to inform policy	2-6	2
Number and nature of industry awareness/outreach programs	Lectures: 2-8 Visits: 1-5 Events: 1-4	2 1 2
Number and nature of public awareness/outreach programs	Lectures: 1-5 Visits: 1-5 Events: 1-2	2 1 2
Currency of information on the program's website	Weekly updates	Weekly review
Number of website hits	300	Avg 900/month
Number of talks given by program staff open to the public	7-20	19
Number of Indigenous stakeholders consulted	1	1
Number of Indigenous stakeholders on boards and committees	1-2	1
GOVERNANCE		
Frequency of meetings on the Program's Advisory Board	Annually	Annually
Attendance rate of members at the Program's Advisory Board	75%	75%
ORGANISATIONAL SUPPORT		
Annual cash contributions from Administering and Collaborating Organisations (\$)	UQ: 440,000 UniMelb: 240,000 ACER: 120,000 CDU: 40,000 Macquarie: 40,000 UNE: 40,000 Deakin: 40,000	440,000 0 0 0 0 0
Annual In-kind contributions from Administering and Collaborating Organisations (\$)	UQ: 548,400 UniMelb: 372,754 ACER: 301,830 CDU: 35,000 Flinders: 18,271 Macquarie: 20,000 UNE: 40,314 Deakin: 40,000	182,800 213,171 153,111 8,175 6,090 6,666 13,438 13,337
Annual cash contributions from Partner Organisations (\$)	DEECD Vic: 100,000 QLD DETE: 0 SADECD: 0 BenSoc: 0 Questacon: 5,000 Carnegie M Uni: 0 NCSU: 0 IOE: 0 UCL: 0	0 0 0 0 0 0 0 0
Annual in-kind contributions from Partner Organisations (\$)	DEECD Vic: 170,000 QLD DETE: 50,000 SADECD: 25,600 Bensoc: 10,007 Questacon: 0 Carnegie M Uni: 10,000 NCSU: 20,000 IOE: 11,000 UCL: 11,000	N/R#

As the Collaborative Research Agreement was signed off at the end of 2013, this information was not collected from Partner Organisations.

APPENDIX 4 - CHIEF INVESTIGATORS

DR TIMOTHY BREDY

Dr Timothy Bredy is a Neuroscientist; the main aim of his research is to understand how epigenetic mechanisms contribute to the formation and maintenance of long-term memories. Dr Bredy is an Australian Research Fellow, Group Leader and member of Faculty at the Queensland Brain Institute, The University of Queensland.

Dr Bredy's work in cognitive neuroepigenetics has been driven by a strong interest in understanding and elucidating the molecular mechanisms of how environmental stimuli and experience translate into long-term memories. Epigenetics, broadly defined, refers to all genetic information not encoded in the DNA sequence, with the best-understood consequence of epigenetic modifications being the regulation of gene expression. His research program, supported by the SLRC, aims to develop a deeper understanding of what precisely happens in the neurons of the brain during learning. In collaboration with Professors Pankaj Sah and David Reutens of the SLRC, he will elucidate the conditions under which optimal learning takes place, such as that which occurs during reinforcement learning, and determine the molecular mechanisms underpinning the persistence memory related to this kind of learning. He hopes to develop new ways to promote cognitive enhancement, which will be particularly important for situations in which normal cognitive processes begin to fail, which include but are not limited to developmental disorders and ageing.

ASSOCIATE PROFESSOR ANNEMAREE CARROLL

Annemaree Carroll PhD is Associate Professor of educational psychology in the School of Education at The University of Queensland. She has been particularly concerned with developing innovative multimedia self-regulatory methods and strategies for enhancing the engagement and motivation of at-risk children and youth to bring about positive change in their lives. She has conceptualised and coordinated the development of Mindfields, a self-regulatory intervention to help adolescents take control of their lives and KoolKIDS, a primary-based program to help young children develop emotional resilience.

She has also been concerned with children with neurodevelopmental disorders (e.g., ADHD, Tourette Syndrome) to examine information processing tasks that may demand intact executive functioning and that require dual task performance and control of impulsive reactions. Her current ARC funded research focusses on improving the social connectedness and the emotional self-regulatory capacities of high schools students. Other current Healthway-funded research is concerned with the development of a new multidimensional scale and interactive multimedia program (i-Connect) for early adolescents designed to alleviate aloneness and develop self-awareness and empathy.

Associate Professor Carroll's research directions within the SLRC are focussed on the nature of sustained attention and self-regulation in the classroom, the role of feedback in the learning of children and adolescents with typical and atypical developmental trajectories, and the link between emotion and learning.

PROFESSOR DAVID CLARKE

David Clarke is Professor in the Melbourne Graduate School of Education at The University of Melbourne and Director of the International Centre for Classroom Research (ICCR). Current research activities involve multi-theoretic research designs, cross-cultural analyses, discourse in and about classrooms internationally, curricular alignment, and the challenge of research synthesis in education.

As part of the SLRC Professor Clarke's research will address three specific challenges, each with neurological implications: (i) the contribution of participation in different social interactive units (dyadic, small group and large group) to learning process and outcomes; (ii) the identification of differences in both process and product of learning catalysed by particular instructional approaches (where the approaches have been identified in international research as conducive to high levels of consequent student achievement); and, (iii) the nature of teacher decision-making, the knowledge base accessed by teachers in classroom settings, and teacher instruction as an adaptive process of professional learning in context. A general approach will be to pilot the experimental situation in microcosm in the Learning Interaction Classroom before implementing the experimental design under full class conditions. In parallel, behaviours and the learning products associated with significant learning identified in the Learning Interaction Classroom will be investigated for neurological correlates in the Educational Neuroscience Classroom.



ASSOCIATE PROFESSOR ROSS CUNNINGTON

Associate Professor Ross Cunnington is a cognitive neuroscience researcher and Principal Research Fellow at the Queensland Brain Institute and School of Psychology, The University of Queensland. Associate Professor Cunnington's research group uses brain imaging methods to examine and understand the brain processes involved in the planning and preparation for action and in the perception and imitation of others' actions. His research also extends to understanding the role of the "mirror" system of the brain in empathy and examining how these mirroring processes are influenced by inter-personal relationships.

Associate Professor Cunnington is an expert on attention and motor learning and on the human mirror neuron system. He extensively uses fMRI and EEG for understanding the neural bases for cognition. As part of the SLRC, he works closely with education researchers in designing experiments that effectively utilise such technologies to track classroom learning

ASSOCIATE PROFESSOR PAUL E. DUX

Associate Professor Paul E. Dux is a psychologist and neuroscientist. He is a member of Faculty in the School of Psychology at The University of Queensland, where he is currently an ARC Future Fellow. Associate Professor Dux leads a group that uses cutting edge techniques to study the cognitive and neural underpinnings of human information-processing capacity limitations in health and disease. Specific interests are the mechanisms of attention and the efficacy of cognitive training and how it changes the brain to improve performance.

The ability to selectively attend to important information plays a vital role in learning and classroom performance. In addition, attention is impaired in a range of groups who are characterised as having learning difficulties. As part of his research in the Centre, Associate Professor Dux will employ psychophysics, brain imaging and stimulation and patient work to understand the cognitive and neural underpinnings of attentional capacity limitations and how these can be reduced with training. He will apply the knowledge gained from these studies to investigate how attention can be improved in healthy individuals.

PROFESSOR ROBYN M. GILLIES

Robyn M. Gillies PhD is a Professor of Education at The University of Queensland. Her research focusses on the social and cognitive aspects of learning through social interaction. Her research to date has focussed on inquiry learning in science and mathematics education, teacher and peer-mediated learning, student-centred learning, and classroom discourses and processes related to learning outcomes. These projects have been implemented in primary and secondary schools in science, mathematics, English, and social studies content areas.

As part of the SLRC, Professor Gillies will study the aligning of socio-cultural, classroom perspectives on learning with neuroscience perspectives and findings. One auspice of this research is the use of representations. Teaching students to use and interpret representations is critically important in science if they are to become scientifically literate and understand how scientists represent their work. Being scientifically literate includes being able to interpret and use texts, tables, diagrams, graphs, models, drawings, portfolios, artefacts, and embodied forms such as gesture, role play, and exhibitions of performance. There is also evidence emerging that students not only need to be competent at using and explaining representations but they also need to be able to learn new representations quickly and with minimal instruction or to be able to demonstrate meta-representational competencies. Professor Gillies will investigate how students use different representations, including meta-representations while engaged in various forms of cooperative inquiry-based activities in science.

PROFESSOR MERRILYN GOOS

Merrilyn Goos has worked in mathematics education for 25 years as a teacher, researcher, and teacher educator. She is a Professor in the School of Education, and from 2008-2012 was Director of the Teaching and Educational Development Institute at The University of Queensland. Previously she taught pre-service and postgraduate courses in mathematics education. Her research has been guided by sociocultural theories of learning in investigating metacognition and mathematical thinking, analysing pedagogical issues in introducing educational technologies into mathematics teaching and learning, and studying how communities of practice are established and maintained in secondary mathematics classrooms and teacher education contexts.

Professor Goos is interested in the role of cross-disciplinary collaboration in learning. Using the SLRC as a model, her aim is to seek empirical evidence of (i) conditions that favour or hinder productive collaboration between researchers from different disciplines and (ii) the process of learning that the researchers experience through exchange of expertise across disciplinary boundaries. The outcomes will also provide new insights into what forms of cross-disciplinary research collaboration work, why, and under what circumstances.





PROFESSOR PATRICK GRIFFIN

Professor Patrick Griffin is an educationalist with research interests in the areas of assessment and evaluation. He holds a PhD in education from Florida State University. Professor Griffin holds the Chair of Education (Assessment) at The University of Melbourne and is Director of the Assessment Research Centre.

Professor Griffin has been involved in research and development of educational measurement for over 40 years, his work in developing internet based assessment of collaborative problem solving has received global recognition. As part of his work in the SLRC, Professor Griffin will develop tools that aid in clearer identification of learning and scoring protocols.



PROFESSOR JOHN HATTIE

Professor John Hattie is an educationalist with research interests in education assessment and evaluation. He was awarded a PhD in education from the University of Toronto in 1981. He is currently the Director of the Melbourne Education Research Institute at The University of Melbourne and is an Honorary Professor at the University of Auckland, New Zealand, and University of Durham, England.

Professor Hattie is of the opinion that nearly every act of a teacher has a positive outcome on learning; of course there are some that have a negative impact. Professor Hattie is excited by the opportunity the Centre provides to carry out a meta-review of various models of learning, to identify which have the biggest impact. The two SLRC classrooms provide a means to scientifically validate these observations and test newly developed teaching strategies. In particular Professor Hattie is interested in the importance feedback in learning, a phenomena also being investigated at a molecular level by fellow investigators in the Centre.



ASSOCIATE PROFESSOR ROB HESTER

Associate Professor Rob Hester is a cognitive neuroscientist in the School of Psychological Sciences at the University of Melbourne, where he currently holds an ARC Future Fellowship. His research uses cognitive neuroscience methods (particularly fMRI and EEG) to examine the neural and behavioural mechanisms underlying cognitive control (e.g., impulse control) and performance monitoring (e.g., error awareness) in healthy adults, as well as applying these methods to understanding disorders of control and insight in clinical conditions such as drug dependence.

Within the SLRC, Associate Professor Hester will work with collaborators on projects examining learning and attention. For example, cognitive neuroscience methods will be used to examine how feedback influences self-directed learning. In particular, to utilise behavioural changes associated with error awareness to produce a more efficient and adaptive learning experience within tools such as self-directed learning software. With collaborators he will examine attentional processing in the Educational Neuroscience Classroom using EEG and eye-movement tracking. Having developed these methods, it will also be possible to examine how such processes can be positively influenced by interventions such as cognitive training.



PROFESSOR TIANZI JIANG

Professor Tianzi Jiang is a neuroscientist with research interests in neuroimaging and the 'Brainnetome'. In 1994 Professor Jiang was awarded a PhD in Computational Mathematics from Zhejiang University. He holds a joint appointment with The University of Queensland's Centre for Advanced Imaging and Queensland Brain Institute and the Chinese Academy of Sciences' Institute of Automation.

Professor Jiang studies basic theory, methodologies and algorithms underpinning the Brainnetome, a platform for integrating brain research across different scales: cell level, networks and anatomy. The integration of information about the structural connectivity of brain regions and how this is modulated by cellular properties of individual neurons has led to important insights about intelligence and other cognitive behaviour.



PROFESSOR GREGOR KENNEDY

Professor Gregor Kennedy is Director of eLearning at The University of Melbourne and a Professor in the Centre for the Study of Higher Education. He is an international leader in educational technology research and development, particularly in the context of higher education. His critical, evidence-based investigations of 'Net Generation' students have provided significant insight into how staff and students use technology and emerging technology based-tools in higher education. He has longstanding research interests in contemporary learning design and emerging technologies, educational technology research and evaluation, interactivity and engagement in digital learning, 3D immersive virtual environments, and the use of learning analytics in digital learning environments. He has published widely in these areas and is a regular keynote and invited presenter at local and international conferences. He is currently the Lead Co-Editor of the *Australasian Journal of Educational Technology*.

Within the Centre Professor Kennedy's research will focus on digital, self-directed learning environments and particularly learner confusion in these environments. This research will lead to an understanding of when and how to provide feedback and provide guidance for developing self-directed online learning environments.



DR SIEK-TOON KHOO

Dr Siek-Toon Khoo is the Director of the Psychometrics and Methodology Research Program at ACER. She is a quantitative methodologist who specialises in psychometrics, measurement issues of educational and psychological constructs, structural equation modelling, multilevel modelling and modelling of longitudinal developmental growth curves. Her specific research interests are in the psychometrics of measuring change, growth curve methodology, prevention science methodology and modelling of mediation and moderation effects. Areas of research in collaboration with substantive researchers include modelling of educational progress, development of addiction problems in young adults over time, longitudinal family research and longitudinal studies of at-risk children.

Dr Khoo's research in the SLRC is focussed on developing improved methodology for monitoring learning behaviour to measure learning gains and to model factors influencing trajectory of learning, particularly in relation to digital learning environments. Digital learning environments have created opportunities for tailoring individualised instruction and learning. It is a challenge for psychometricians to develop measurement methodology to dynamically estimate trajectory of learning, to monitor learning behaviour and learning gain, and to provide useful and timely feedback.



PROFESSOR OTTMAR LIPP

Ottmar Lipp is Professor of Psychology in the School of Psychology at The University of Queensland. His research, both basic and applied, is concerned with human learning and emotion, attention and their interactions. In particular, he is interested in the acquisition of likes and dislikes and in the manner in which emotionally salient or neutral events are processed.

Professor Lipp brings to the Centre his expertise in the measurement of autonomic responses as indicators of cognitive load and information processing. This expertise will aid the researchers who want to conduct studies using the Educational Neuroscience Classroom located at The University of Queensland. In particular, Professor Lipp will contribute to two current projects. The first is concerned with the effects of emotional states on learning, in particular the effects of anxiety in the context of mathematics teaching. In collaboration with researchers from ACER, he will investigate whether emotion regulation techniques can alleviate some of the detrimental effects of anxiety on learning. The second project is concerned with the detection and prediction of confusion as students progress through electronic learning settings. Early detection of signs of confusion can aid the timing of interventions and preventing the interruption or discontinuation of the self-guided learning activities.



PROFESSOR LORI LOCKYER

Professor Lori Lockyer is the Vincent Fairfax Family Foundation Chair in Teacher Education and Head of the School of Education at Macquarie University.

Professor Lockyer is an expert in educational technology. Professor Lockyer has been recognised by national and international awards including the 2008 Platinum Learning Impact Award by the IMS Global Learning Consortium. Her research focusses on teaching and learning with technology in school, university and professional learning environments. Professor Lockyer is interested in understanding the learning processes and outcomes for learners engaged in technology-supported tasks – particularly collaborative and problem-based tasks. Professor Lockyer investigates how learners learn and how teachers teach with technology through the integration of concepts and approaches from the fields of learning design and learning analytics.

Within the SLRC, Professor Lockyer will work with collaborators to investigate learning in learner-directed, digital environments. The research team will identify when and how learners experience confusion in these environments. This research base will then be expanded upon to investigate how feedback and techniques of self-regulated learning can help learners avoid and/or overcome such learning difficulties. The outcomes of this research will help teachers and instructional designers develop effective digital learning environments.



PROFESSOR JASON MATTINGLEY

Professor Jason Mattingley is Foundation Chair in Cognitive Neuroscience at The University of Queensland, where he holds joint appointments at the Queensland Brain Institute and School of Psychology. Professor Mattingley is interested in understanding the mechanisms of selective attention, in health and disease, with a particular focus on how attentional processes influence learning, multisensory integration, motor behaviour, neural plasticity and consciousness. His work has appeared in many of the world's top scientific journals, including *Science*, *Nature*, *Neuron*, *Current Biology* and *Nature Neuroscience*.

He has received Early Career Awards from the Academy of Social Sciences in Australia and the Australian Psychological Society. In 2007 he was elected a Fellow of the Academy of Social Sciences in Australia, and in 2012 he was awarded the Australian Psychological Society's Distinguished Contribution to Psychological Science Award.

Professor Mattingley is the Co-ordinator of the Educational Neuroscience Classroom. This is a state-of-the-art facility for measuring brain activity and physiological responses in small groups of learners as they engage in a range of carefully controlled cognitive tasks. He has a particular interest in understanding the role played by attention in learning, and in the brain mechanisms that underlie this process.



PROFESSOR JOHN PEGG

Professor John Pegg is an educationalist. His research interests focus on two main areas: (1) the development of learners' understanding, and (2) teacher professional growth. In 2004, he was made Foundation Director of the National Centre of Science, ICT and Mathematics Education for Rural and Regional Australia (SiMERR National Research Centre) located at UNE, a post he currently holds.

His work is known for his contribution to theory-based cognition research in Mathematics Education and Assessment. He advocates for equality of educational learning outcomes for students and teachers regardless of their geographic circumstance. He has strong links with schools, professional teaching associations, and educational authorities in Australia and overseas, being used as a consultant/researcher/evaluator in a diverse range of educational contexts.

Professor Pegg will be pursuing two main research questions in the SLRC, *what are the neuro-correlates of 'Automaticity' when students acquire specific skills* and *what is being activated in the brain and how is this different from when a student receives poor or low-level feedback?* In another line of research, Professor Pegg will also be investigating the *SOLO Model*, a powerful cognitive framework used internationally since the late 1970s with a huge empirical data-base developed by two Australians, Biggs and Collis.



PROFESSOR DAVID REUTENS

Professor David Reutens is a clinical neurologist with research interests in the neuroscience of memory. He received his Doctor of Medicine from the University of Melbourne in 1993. Professor Reutens was appointed as the inaugural director of the Centre for Advanced Imaging at The University of Queensland in 2008.

Professor Reutens is an internationally recognised expert on utilising brain imaging techniques for understanding complex behaviour. As Director of the largest brain imaging facility in Australia, he plays a crucial role in the Centre in designing experiments and interpreting changes in brain activity that reflect on learning.



PROFESSOR PANKAJ SAH

Professor Pankaj Sah's main research interest is in understanding the neural mechanisms that underpin learning and memory formation. He is known for his work in understanding the neural circuits and synaptic plasticity in the amygdala, an area of the brain involved in emotional processing and learning. He is currently Deputy Director (Research) at the Queensland Brain Institute. Previously he was group leader at the John Curtin School of Medical Research at the Australian National University and moved as a founding member of the Queensland Brain Institute in 2003. His laboratory continues to study the amygdala using a combination of molecular tools, electrophysiology, anatomical reconstruction and calcium imaging.

More recently his laboratory has begun to investigate the role of reinforcement in learning using rodent models. This research suggests that partial reinforcement, as opposed to full reinforcement, increases the number of neurons in the brain and also improves behavioural outcomes. The Centre offers a forum for these basic neuroscience findings to be translated into improved learning outcomes in humans.



PROFESSOR SVEN SILBURN

Professor Sven Silburn heads the Centre for Child Development and Education (CCDE) at the Menzies School of Health Research in Darwin. He holds an adjunct position with the Telethon Institute for Child Health Research in Perth. He has a clinical background in child and adolescent mental health and research career spanning 25 years with several influential publications. These include large-scale studies in the areas of child health and development, school education and adolescent mental health including the WA Aboriginal Child Health Survey and the Australian Early Development Index. He was the lead author of the expert group which produced the latest Australian Medical Association's annual report card on Aboriginal and Torres Strait Islander Health "The Healthy Early Years – Getting the Right Start in Life (2013).

As part of his research in the SLRC, Professor Sven will lead quantitative and qualitative studies of the teaching of language and literacy in Indigenous school settings. This research is focussing on Indigenous primary students' development of inferential reading, comprehension and meta-linguistic concepts and how teachers can be better trained in structuring pedagogical dialogue to help children think about the texts and language that they study. Although these skills have been shown to be fundamental to building strong literacy skills, they have been neglected in the general discourse on Indigenous literacy and in teacher education.



PROFESSOR COLLETTE TAYLER

Collette Tayler is an educational researcher specialising in early childhood education and care. She is interested in the ways that educators and families direct, support and affect children's early learning, and how social, family and educational policies and practices affect program quality and early education and care outcomes. She currently holds the chair of Early Childhood Education and Care at The University of Melbourne. Her studies involve home-, centre- and school-based programs in culturally and linguistically diverse communities. Her research seeks to explain both universal principles and contextual variations needed to promote exemplary education and care experiences in order to advance early learning and development.

Child-initiated and adult-mediated conversations, playful interactions and learning through involvement are integral to young children's learning and development. As part of her research in the SLRC, Professor Tayler's research is concerned with the implementation and effects of adult-led, child-led and guided-learning events on the growth of children's learning and achievement within home-based and early childhood centre-based settings. Her work focusses on adult-child interaction: the implementation by parents and early educators of specific teaching and learning strategies, and the learning pathways of very young children (birth-to eight years). Research participants will be located within regional and remote Indigenous communities in the Northern Territory and Western Australia and within culturally and linguistically diverse regions of urban and regional Victoria.



DR SUE THOMSON

Dr Sue Thomson has worked in the field of mathematics education in many different situations – teaching at secondary, TAFE and tertiary level over a number of years. In 2010 Dr Thomson was appointed as the Director of the Educational Monitoring and Research Division at the ACER, managing five research programs covering education across the lifespan. She also remains as the Research Director for the National Surveys research program at ACER, overseeing Australia's participation in all international and national sample surveys.

Dr Thomson's research at ACER has involved extensive analysis of large-scale national and international data sets - the Longitudinal Surveys of Australian Youth (LSAY), as well as TIMSS and PISA, and she is also involved in several projects involving analysis of the longitudinal data collection associated with the PISA surveys. She was engaged as an expert writer on the National Numeracy Review, and has consulted with a variety of government departments at both Commonwealth and state level, as well as with the Catholic Education Commission, on a variety of data analysis projects related to TIMSS and PISA. Her broad research interests lie in the area of motivation and learning in mathematics.



DR MICHAEL TIMMS

Dr Michael Timms is an education researcher specialising in the measurement of learning in interactive learning environments. He has a background in the development of high quality assessments and educational measurement in a range of settings. He joined ACER in 2011 as Director of Assessment and Psychometric Research.

Dr Timms is interested in how to track and support learning in intelligent learning environments (ILEs) and, in particular, how students receive and process feedback. Over the last 20 years the field of Artificial Intelligence in Education has developed approaches to providing feedback to learners using computer based intelligent learning environments. Typical intelligent learning environments present students with a set of tasks, sometimes set in a scenario or simulation, within which students can apply newly acquired knowledge and practice skills that they have just developed. Research studies of the affective state of learners as they interact with ILEs have found markers for the emotional states of learners, such as frustration, during learning sequences. Through this research a better understanding of how feedback assists students is being obtained. However, there is scant research to date that examines what happens at a neural level as a learner receives and acts upon feedback provided by such systems. Dr Timms' research in the SLRC will build a body of knowledge that will inform the design of feedback systems for future ILEs to optimise student learning.



PROFESSOR RUSSELL TYTLER

Professor Russell Tytler is the Chair in Science Education at Deakin University, Coordinator of the "Re-imagining futures in Science, Technology, Environmental and Mathematics (STEME)" research group and Deputy Director of the Centre for Research in Educational Futures and Innovation at Deakin University. He has researched and written extensively on student learning and reasoning in science, and science investigations. His recent research interests include the role of representation in learning science, public understanding of science, teacher and school change, and international perspectives on science and environmental education. He has undertaken a number of influential studies concerning student engagement with science and mathematics, and STEM policy.

Professor Tytler's overarching research within the SLRC is directed to aligning socio-cultural, classroom perspectives on learning with neuroscience perspectives and findings. This program is dedicated to exploring how neuroscience methods and findings can be effectively aligned with socio-cultural classroom research to provide complementary insights that can inform classroom processes. The Learning Interaction Classroom at The University of Melbourne, with its capability to generate high quality video and audio data of student and teacher interactions and focus group tasks, will be a central methodological tool in bridging between the disciplines.



PROFESSOR MARTIN WESTWELL

Professor Martin Westwell is the Director of the Flinders Centre for Science Education in the 21st Century and a Strategic Professor in the Science of Learning at Flinders University. The Centre applies an evidence-based approach to teaching and learning, with a focus on mathematics and science education.

Professor Westwell's research program looks at the cognitive processes that underpin successful learning and, in particular, supports learners' problem solving, decision-making, reasoning and conceptual development. For example, executive functions are crucially important for academic success but how do they interact with students' automaticity of mental arithmetic or word recognition? Can working memory capacity be developed? If not, how can we help young people to more effectively use their working memory? If we intervene to develop young people's executive function skills in a variety of ways, does it improve their academic performance and, if so, how does it improve their academic performance? In this context, the characteristics of the environment in which young people learn can have a profound impact upon the ways in which they use their cognitive skills such as executive functions. What role does feedback play in shaping students' ability to wield these skills effectively? These findings will add to the ongoing work that is directly influencing educational practice and policy. Through translation in professional learning activities, it can impact the decisions that education leaders and teachers make both in terms of strategic intent and tactical actions.

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