WELCOME to ASERA Sydney 2017

ASERA acknowledges the Gadigal People of the Eora Nation and the Boorooberongal People of the Dharug Nation upon whose ancestral lands UTS campuses now stand.
We pay respect to the Elders both past and present, acknowledging them as the traditional custodians of knowledge for these lands.

Thank you for joining us at the University of Technology Sydney to be part of the 48th Annual Conference of the Australasian Science Education Research Association (ASERA).

The ASERA conference provides an important venue for science educators to discuss their research and share ideas about all aspects of teaching and learning of science at primary, secondary and tertiary levels. For those who are 'new' to ASERA, we hope that you find the conference to be supportive, encouraging and nurturing with someone always on hand to offer constructive advice. For the regular annual conference attendees, we hope you enjoy the opportunity to catch up with friends and to discuss ongoing issues in the educational arena.

We have a diverse range of topics this year included in both oral and poster presentations. These represent the perspectives of many different countries, researchers and purposes in relation to science education. We welcome the opportunities these perspectives bring to intellectual debate and discussion.

We thank the Faculty of Arts and Social Sciences, University of Technology Sydney for its sponsorship of the conference.

We also wish to thank the ASERA Board for its assistance and advice in our preparation for the conference.

Please enjoy the conference.

Conference Organising Committee

Dr Kimberley Pressick-Kilborn
Professor Peter Aubusson
Assoc Professor Annette Hilton
Dr Tracey-Ann Palmer
Dr Zeynep Yaseen
Assoc Professor Matthew Kearney
Jim Scott
Assoc Professor Wan Ng

ACKNOWLEDGEMENTS

The UTS ASERA 2017 Conference Organising Committee would like to thank the following people and organisations for their generous assistance

Faculty of Arts and Social Sciences for its sponsorship and support of the conference
UTS School of Education
Jan McLelland
Margaret McComb
Kathryn Burton
Sue Rohanna
Honorine Jarkey

UTS FASS Events team - Dileka Pathiratna

Science Education student volunteers from UTS School of Education:
Anna Molnar
Jeremy Seeto
Rachel Morison
Trang Nguyen
Omar Al Badri
Lalitha Plumb
Peter O'Boyle
Ria Xian
Rachel Somers
Songyan Zheng
Samantha Wong
Rafaella Spadaccini

Peter and the staff at Penny Lane Bar and Café (UTS Building 11, Level 1)

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Social media #ASERA2017

PROGRAM OVERVIEW

TUESDAY, 27 JUNE 2017		Building 10, Level 4 - School of Education
5pm	**Registration Desk Open**	
6pm – 8pm	**Welcome Reception**	

WEDNESDAY, 28 JUNE 2017		Building 10, Level 7 Aerial Function Centre
8am	Registration Desk Open	
8.30am – 9am	Official Conference Opening	Broadway Room
9am – 10.25am	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones, Harris
10.25am – 10.45am	**MORNING TEA**	**Breakout areas & Balcony**
10.25am – 11.30am	Poster Presentations – Session 1	Lobby Area
10.50am – 1pm	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones, Harris
1pm – 1.45pm	**LUNCH**	**Breakout areas & Balcony**
1.50pm – 3.15pm	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones, Harris
	AFTERNOON TEA	**Breakout areas & Balcony**
3.35pm – 5pm	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones, Harris
5.30pm – 7pm	**FIRESIDE CHAT**	**Building 10, Level 4 - School of Education**

THURSDAY, 29 JUNE 2017		Building 10, Level 7 Aerial Function Centre
8am	Registration Desk Open	
8.30am – 10.40am	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones, Harris
10.40am – 11am	**MORNING TEA**	**Breakout areas & Balcony**
10.40 – 11.45am	Poster Presentations – Session 2	Lobby Area
11.05am – 11.45am	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones, Harris
11.50am – 12.45pm	**ASERA AGM**	**ROOM - Wattle**
12.50pm – 1.45pm	**LUNCH**	**Breakout areas & Balcony**
1.50pm – 4pm	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones, Harris
4pm – 4.20pm	**AFTERNOON TEA**	**Breakout areas & Balcony**
7pm – 10pm	**CONFERENCE DINNER**	**Dockside, Cockle Bay**

CONFERENCE DINNER

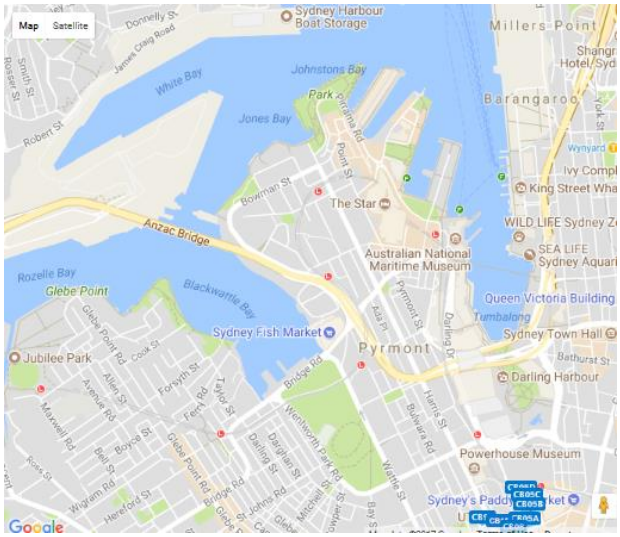
The Conference Dinner is to be held in beautiful Sydney Harbour at Dockside, Cockle Bay at the rooftop venue of L'Aqua. It is a 20 minute walk from the conference venue, along an interesting route – the old Goods Line linking Darling Harbour to Central Station and taking you past the Chinese Gardens and Sydney's new International Conference Centre.

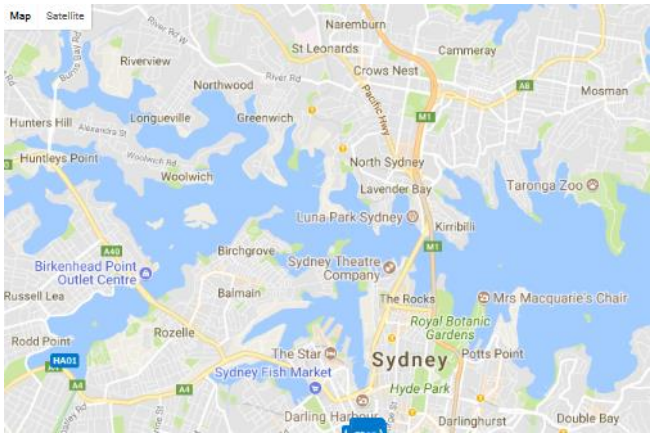
Canapes and Pre-dinner drinks will be served at 6.30pm out on the Balcony overlooking spectacular Darling Harbour. Dinner will be served at 7pm.

FRIDAY, 30 JUNE 2017		Building 10, Level 7 Aerial Function Centre
9am	Registration Desk Open	
9.15am – 10.40am	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones, Harris
10.45am – 11.05am	**MORNING TEA**	**Breakout areas & Balcony**
11.10am – 12.35pm	Paper Presentations	ROOMS: Wattle, Thomas, Broadway
12.40pm – 1.30pm	**LUNCH**	**Breakout areas & Balcony**
1.35pm – 2.55pm	Paper Presentations	ROOMS: Wattle, Thomas, Broadway, Jones

MAPS - UTS & SYDNEY

Local area around UTS

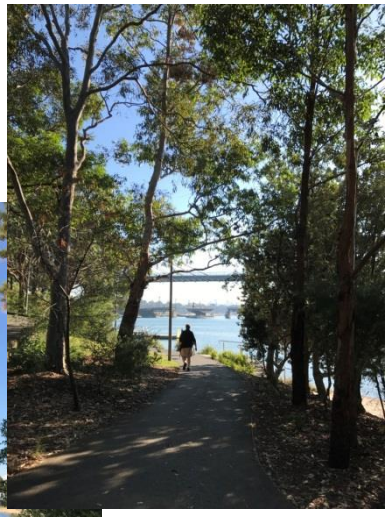




Sydney Harbour Foreshore areas

SYDNEY SECRETS

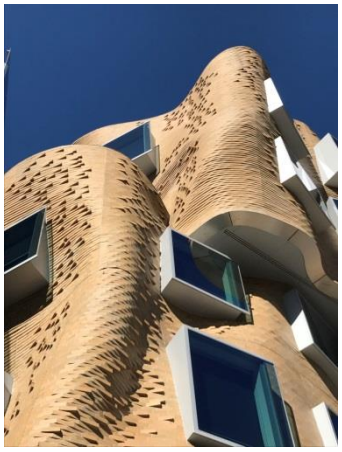
Catch the Light Rail from Central Station to Jubilee tram stop in Glebe. Grab a bite to eat from one of a number of cafes and restaurants at the Tram sheds then take a **walk around the Glebe foreshore** to the Sydney Fish Markets. There is a Light Rail stop at the Fish Markets for your return trip to Central.



Spice Alley is a vibrant hawker-style food market off **Kensington Street, Chippendale** (opposite the main UTS Tower building). Dine in cosy, lantern-lit courtyards. There are also many restaurants in the Kensington St precinct, from fine dining to Bistros and Cafes.

The 'green' 'living' building opposite the UTS Tower, **Central Park**, has received numerous international awards. There is a supermarket and pharmacy on the lower level, as well as a food court on one of the upper levels.

The Goods Line is a pedestrian-way that links Central to Darling Harbour.
Along this Line is one of UTS's most significant new buildings, the **Chau Chak Wing Building**, which was designed by internationally renowned architect, Frank Gehry. Definitely worth visiting!

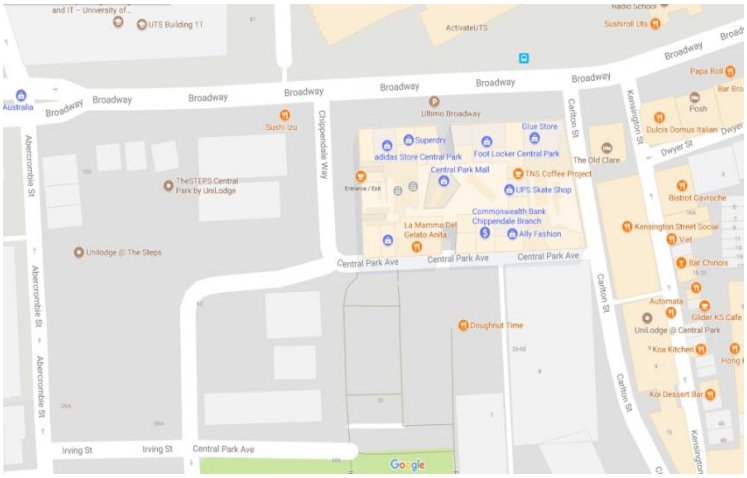


Glebe is one of Sydney's oldest suburbs and the main street, Glebe Point Road, is a short walk from the UTS campus. Alternatively, take the 431 bus route from Broadway (Central). Stop in at *Gleebooks*, one of Sydney's best independent bookshops. On a Saturday, browse the Glebe Markets, which are held in the grounds of Glebe Public School. There are numerous restaurants and cafes to suit every budget along Glebe Point Road.

If you haven't caught a public ferry before, then there are many routes to choose from that will take you to different parts of Sydney Harbour.

Catch a ferry from Circular Quay to Watson's Bay and enjoy fish and chips or a pub lunch.

Or take a ferry to Taronga Zoo or Manly.



Kensington Street

Spice Alley

ASERA Executive Board

Peter Aubusson – Managing Director
Ange Fitzgerald – Secretary/Treasurer
Bronwen Cowie – Emerging Research Support
David Treagust – International
David Geelan – Editor, Research in Science Education (RISE)
Rebecca Cooper – Early Career Researchers
Coral Campbell - Conference Support
Leah Moore - Conference Support
Kathryn Paige – Australian Policy
Deb Corrigan – Website
Alister Jones – New Zealand Policy

ASERA
AUSTRALASIAN SCIENCE EDUCATION RESEARCH ASSOCIATION

Emeritus Member, Paul Gardner
In recognition of distinguished
membership and service

PAUL GARDNER
Has become an Emeritus Member
Of the Australasian Science
Education Research Association

A Brief History of ASERA

ASERA Conferences

In 1970 Peter Fensham (Monash University), the first Professor of Science Education in Australasia (and likely the first outside USA), initiated the first conference of what was then the Australian Science Education Research Association. That beginning for ASERA (now the Australasian Science Education Research Association) makes it the second oldest science education research body in the world, after the National Association for Research in Science Teaching in USA. This was also several months before the first conference of the then newly formed Australian Association for Research in Education (AARE). It is thus likely that ASERA was the first professional body in educational research in Australia.

The New Zealand dimension of ASERA began with the attendance of the late Roger Osborne at the 1977 conference, but was not formalized in the name change to "Australasian" until 1990, 7 years after ASERA first met in New Zealand.

The general belief at the first conference was that every second meeting would need to be organized by Monash, a reflection of the fact that in 1970 Monash was the only substantial centre for science education research in Australia. The notion that Monash would be responsible for every second ASERA was part of the 'gentle coercing' that had the Macquarie organizers agree to host the second conference, and is why the third conference was held at a very different form of venue - a secondary science curriculum project headquarters in Melbourne. Such was the very rapid growth of Australian science education research and our strong association that this perspective only lasted until ASERA 5.

VENUE	CONFERENCE CONVENER(S)
ASERA 1 Melbourne 1970	Peter Fensham, Lindsay Mackay & Dick White (Monash University)
ASERA 2 Sydney 1971	David Cohen & Neil Baumgart (Macquarie University)
ASERA 3 Melbourne1972	Probably Les Dale (ASEP) & Peter Fensham (Monash) (Australian Science Education Project headquarters, Toorak, Melb) *It has not been possible to be certain who organized the conference.*
ASERA 4 Brisbane 1973	Colin Power & Dick Tisher (University of Queensland)
ASERA 5 Melbourne 1974	Russell Linke & Leo West (Monash University)
ASERA 6 Adelaide 1975	Arthur Lucas (Flinders University)
ASERA 7 Newcastle 1976	Max Maddock (University of Newcastle)
ASERA 8 Wagga Wagga 1977	Tony Blake (Riverina CAE) (*now a campus of Charles Sturt University)*
ASERA 9 Brisbane 1978	Cam McRobbie (Mt Gravatt CAE) *(now campus of QUT)*
ASERA 10 1979 Perth	Dennis Goodrum (Churchlands CAE) *(now campus of Edith Cowan University)*
ASERA 11 Melbourne 1980	David Symington (State College of Vic, Toorak) *(now Deakin University)*
ASERA 12 Hobart 1981	Paddy Lynch & Andrew Davies (University of Tasmania)
ASERA 13 Sydney 1982	Bill Butts (Macquarie University)
ASERA 14 Hamilton, NZ 1983	Roger Osborne (University of Waikato)
ASERA 15 Melbourne 1984	Dick Gunstone & Jeff Northfield (Monash University)
ASERA 16 Rockhampton 1985	Ken Appleton (Capricornia Institute of Advanced Ed) *(now campus of UCQ)*

ASERA 17 Adelaide 1986	Chris Dawson, Mike Sullivan and Effie Best (University of Adelaide)
ASERA 18 Wagga Wagga 1987	Doug Hill (Riverina CAE) *(now campus of Charles Sturt University)*
ASERA 19 Sydney 1988	Colin Gauld & Barry Newman (University of New South Wales)
ASERA 20 Melbourne 1989	Dick Trembath (Chisholm Inst Tech, Frankston) *(now Monash University)*
ASERA 21 Perth 1990	David Treagust (Curtin University of Technology)
ASERA 22 Surfers Paradise 1991	Cam McRobbie (Queensland University of Technology)
ASERA 23 Hamilton, NZ 1992	Malcolm Carr (University of Waikato)
ASERA 24 Lismore 1993	Keith Skamp (University New England, Northern Rivers campus) (now Southern Cross University)
ASERA 25 Hobart 1994	Brian Jones & Max Walsh (University of Tasmania)
ASERA 26 Bendigo 1995	Peter Searle & Brian Hand (LaTrobe University, Bendigo campus)
ASERA 27 Canberra 1996	Tim Hardy & Marilyn Fleer (University of Canberra)
ASERA 28 Adelaide 1997	Yvonne Zeegars & Paul Strube (University of SA)
ASERA 29 Darwin 1998	Bill Palmer (Nrthern Territory University) *(now Charles Darwin University)*
ASERA 30 Rotorua, NZ 1999	Bev France & Mavis Haigh (Auckland College of Ed)
ASERA 31 Fremantle 2000	Léonie Rennie (Curtin University of Technology)
ASERA 32 Sydney 2001	Peter Aubusson (University of Western Sydney)
ASERA 33 Townsville 2002	Steve Ritchie (James Cook University)
ASERA 34 Melbourne 2003	Rod Fawns & Christine Redman (University of Melb)
ASERA 35 Armidale 2004	Debra Panizzon (University of New England)
ASERA 36 Hamilton, NZ 2005	Judy Moreland (University of Waikato)
ASERA 37 Canberra 2006	Jim Woolnough & Leah Moore (University of Canberra)
ASERA 38 Fremantle 2007	Grady Venville (University of Western Australia), Vaille Dawson & Rachel Sheffield (Edith Cowan University)
ASERA 39 Brisbane 2008	Gillian Kidman, Donna King & Steve Ritchie (Qld University of Technology)
ASERA 40 Geelong 2009	Coral Campbell (Deakin University)
ASERA 41 Newcastle 2010	Dave Palmer, Vicki Parkes & Mitch O'Toole (University of Newcastle)
ASERA 42 Adelaide 2011	Yvonne Zeegers & Kathy Paige (University of South Australia)
ASERA 43 Sunshine Coast 2012	Deborah Heck, Margaret Marshman, Beverly Lowe, John Hunt & Tim Strohfeldt (University of the Sunshine Coast)
ASERA 44 Wellington, NZ 2013	Lorraine Spiller, Rosemary Hipkins (NZCER), Azra Moeed & Dayle Andersen (Victoria University of Wellington)
ASERA 45 Melbourne 2014	Debra Panizzon, Greg Lancaster, Karen Marangio, Stephen Keast (Keasty), Rebecca Cooper, Gillian Kidman, Deborah Corrigan, & Mahbub Sarkar (Monash University)
ASERA 46 Perth 2015	Christine Howitt, Grady Venville, Vaille Dawson & Katherine Carson (The University of Western Australia)
ASERA 47 Canberra 2016	Leah Moore & Jim Woolnough (University of Canberra)
ASERA 48 Sydney 2017	Kimberley Pressick-Kilborn, Peter Aubusson, Tracey-Ann Palmer, Annette Hilton, Matthew Kearney, Wan Ng, Zeynep Yaseen, & Jim Scott (University of Technology Sydney)

Research In Science Education

In 1971, after the second ASERA conference, papers presented at ASERA 2 were published. The publication was titled *Research 1971*, and was the first of an ongoing series of annual publications of some of the papers presented at ASERA that continued until 1994. In 1972 the journal was titled *Research 1972*, in 1973 *Science Education: Research 1973*, and then in 1974 a permanent name was adopted - *Research in Science Education*. The 1974 edition of *Research in Science Education* was designated Volume 4, in recognition of the preceding three years. Over the period 1971 - 1994 the extent of reviewing of submissions for *RISE* increased substantially. In 1995, through Cam McRobbie's initiative and drive, *RISE* was transformed into the journal of more usual form that we know today, and was no longer linked to the ASERA conference. In 2003 *RISE* became an ISI listed journal, and thus joined *JRST*, *Science Education*, and *IJSE* as the major international science education research journals.

For the period 1974 - 1979 *RISE* had an editorship structure involving both the conference organizer(s) and a 'general editor' who maintained consistencies from one year to the next.

RISE Editors

1971-3	Richard Tisher (University Queensland)
1974	Richard Tisher, Russell Linke & Leo West (Monash University)
1975	Colin Power (University Queensland) & Arthur Lucas (Flinders University)
1976	Colin Power (University Queensland) & Max Maddock (University Newcastle)
1977	Colin Power (Flinders University) & Tony Blake (Riverina CAE)
1978	Colin Power (Flinders University) & Cam McRobbie (Mt Gravatt CAE)
1979	Colin Power (Flinders University) & Dennis Goodrum (Churchlands CAE)
1980	Colin Power (Flinders University)
1981-82	Laurie Rattray-Wood & Peter Ferguson (Deakin University)
1983-88	Richard Tisher (Monash University)
1989	Richard Tisher & Paul Gardner (Monash University)
1990	Paul Gardner (Monash University)
1991	Paul Gardner, Helen Forgasz & Jeff Northfield (Monash University)
1992-94	Paul Gardner (Monash University)
1995-2007	Cam McRobbie (Queensland University of Technology)
2008-12	Steve Ritchie (Queensland University of Technology)
2012	Deborah Corrigan (Monash University)

ASERA Pre-Conference Workshop For Research Students and Other Early Career Researchers

In 2002, ASERA accepted a proposal from Peter Fensham and Dick Gunstone that the organization sponsor a biennial research workshop for research students and other early career researchers, to be held just prior to the ASERA conference, but conducted by researchers not involved in the conference organization and administration. Highly successful Workshops were held in 2003 and 2005.
The Workshop resumed in 2008.

VENUE	WORKSHOP LEADERS
Workshop 1 Melbourne 2003	Peter Fensham, Dick Gunstone & Dick White (Monash University)
Workshop 2 Hamilton, NZ 2005	Léonie Rennie (Curtin University of Technology), Cam McRobbie (Queensland University of Technology) and David Treagust (Curtin University of Technology)
Workshop 3 Brisbane 2008	Grady Venville (University of Western Australia) & Vaille Dawson (Curtin University of Technology)
Workshop 4 Port Stephens 2010 (University of Newcastle)	Garry Hoban (University of Wollongong), Keith Skamp (Southern Cross University) & Wendy Neilsen (University of Wollongong)
Workshop 5 University of the Sunshine Coast 2012	Steve Ritchie, Peter Fensham, Donna King, Alberto Bellocchi (Queensland University of Technology) & Ken Tobin (City University of New York)
Workshop 6 Melbourne 2014	Léonie Rennie (Curtin University of Technology) & Richard Gunstone (Monash University)
Workshop 7 Canberra 2016	Christine Howitt (University of Western Australia), Bronwen Cowie (Waikato University), Leonie Rennie (Curtin University of Technology), Richard Gunstone, Deborah Corrigan (Monash University) & Sue Stocklmeyer (Australian National University)

ASERA Fireside Chat for Research Students and Other Early Career Researchers

VENUE	CHAT LEADERS
2015 Perth	Leonie Rennie, Mark Hacking & Linda Hobbs
2017 Sydney	Vaille Dawson & Keith Skamp

ABSTRACTS

"It was Interesting, But Some of It Almost Killed My Brain": Student Responses to Senior Secondary Physics Curriculum in New South Wales

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Among physics teachers at both high school and university levels there is a widespread concern that the current Stage 6 New South Wales physics curriculum does not adequately prepare students for university study. It has been described as a 'soft' curriculum that gives undue emphasis to social and historical contexts of physics. In contrast, the new curriculum is perceived as a 'return to more traditional content' that has a strong emphasis on mathematical applications and practical investigations. Although expert consultations and curricular reforms have been put in place to address this primary concern, student voices have not been sought. This paper argues that student voices are also important and authoritative, and should be included when reviewing concerns about the physics curriculum. This paper examines the sustained enrolment intentions in relation to physics of 245 Year 11 students in the Sydney metropolitan area, using an Expectancy-Value theoretical framework. It also provides an analysis of these students' views of the current physics curriculum. Using a mixed methods approach, the paper concludes that majority of students find Year 11 physics interesting, related to the world and to everyday phenomena, nevertheless difficult and work-intensive. While the students were generally pleased with the physics curriculum, they also shared the concern that there was a lack of mathematical applications in descriptive topics such as *The Cosmic Engine* and that the historical references included in the curriculum were substantially irrelevant.

Saudi Year 10 Physics Teacher and Student Perceptions of Recent Reforms in Secondary Science Education

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The purpose of this predominately qualitative study was to describe the perceptions of recent and substantial changes in science education expressed by six year 10 Physics teachers and 360 year 10 Physics learners in two cities in Saudi Arabia. The recent Ministry of Education effort to develop the secondary science curriculum has included translation of American science textbooks from English into Arabic and these teacher and learner perceptions were focussed on the new mandatory Physics textbook. The results of this study are of potential use in other educational jurisdictions that make use of translated textbooks. Teacher perceptions were gathered through semi-structured interviews. The interview protocol was organised around three themes (curriculum, language and the use of external references). Student perceptions were gathered through a more quantitative approach based on their responses to a 50 item questionnaire. Factor analysis allowed underlying constructs from the student responses to be compared with themes emerging from the teacher interviews. The thematic analysis of the interviews revealed teacher ambivalence toward their new textbook and the broader changes that it embodied. Teacher participants recognised the prevailing traditional style of teaching and referred to complications in adopting the newly mandated student-centered style of teaching due to deficiencies in teacher preparation, school and classroom equipment, class times and language difficulties associated with the density of textbook content. Student perceptions mirrored some of the

teacher concerns and introduced some particular perspectives. The results of this study suggest that policy makers in cross national contexts should consider all components of constructive alignment if they wish to achieve the goals of science education reform that they set for themselves.

Boundary Crossing, STEM Industry Engagement and Communities of Practice: Bridging the Gap between Theoretical Science Knowledge and its Application in Society ~ Preliminary Findings

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This paper describes the strategies used to bridge the gap between different communities of practice associated with encouraging secondary school students to enter the world of Science, Technology, Engineering and Mathematics (STEM). These communities involved University (teacher education and commercialization entities), Government (departments of education and state development) and industry. In its initial stages, the project called *Bridging the Gap: Connecting science education to the real world* enabled 19 pre-service teachers of secondary science to cross the boundary of teacher education into the world of business and industry and back through three short industry placements, one of which involved the industry outreach arm of the university. During this border crossing activity student teachers were required to identify, translate and communicate an industry issue to an authentic audience. The purpose of the industry engagement was to assist future teachers of science make meaningful connections between theoretical science knowledge, and its application in society with a flow on effect to students in schools. Boundary theory (Akkerman and Bakker 2011) was engaged to explicate both the learning mechanisms involved and the learning objects used in each of the boundary crossing strategies employed in which ongoing connections between different communities of practice were made.

Investigating Experienced Teachers' Pedagogical Content Knowledge (PCK) in Representation-based Instruction: A Sociocultural Perspective

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Research has shown that teachers can develop PCK in subject matter and teaching innovations from instructional planning and practice. While PCK in science subjects and topics has been widely studied, PCK development in teaching innovations has not gain sufficient attention. In this paper, we present findings from an intervention study on representation-based approaches in science. Using a case study methodology, we examine two primary school teachers' representation-based instruction (video-recorded) on heat and temperature. In order to understand the teachers' practice in their respective school and classroom context, we employ activity theory as a framework to examine

sociocultural interactions. We found that both teachers developed PCK in illustrating and explaining representations in relation to science concepts and discussing students' ideas of representations and salient learning points. However, the teachers differed significantly in evaluating students' representations and facilitating students' reasoning about representations. Interview findings suggest that the teachers' instructional strategies appeared to be shaped by their perception of students' learning difficulties. Our findings support the recent notion of PCK&S which emphasizes the role of teachers' beliefs in shaping classroom practice. Additionally, we highlight the utility of activity theory as a sociocultural lens to examine development of teacher PCK in representation-based instruction.

The Roles of Drawing in Reasoning and Learning in the Science Classroom

George Aranda, Joseph Ferguson, Russell Tytler and Radhika Gorur

Studies of drawing to learn and reason have identified a range of advantages, but have yielded ambiguous results regarding learning outcomes directly flowing from drawing. This study posits that drawing is fundamental to reasoning as a key epistemic practice that students must develop as they are inducted into the discursive practices of science.

This project was part of the ARC-funded program, *The Science of Learning Research Centre*, and specifically explored inquiry based science learning in a collaborative environment. Over six lessons in distinct topics, Year 7 students were challenged to explore and collaboratively create explanatory representations of phenomena including through drawing. The lessons were conducted in a classroom with multi-tracked video and audio facilities that allowed capture and analysis of students' talk and gestures.

Through an iterative process of viewing the extensive video record, we developed categories consistent with the literature to establish a set of core roles that drawing played in assisting students to reason and learn in an inquiry setting. We argue for an important distinction between the role of drawing in the *generation* and the *consolidation* of knowledge, and propose drawing needs to be considered as a central component of reasoning and learning in the science classroom.

Metarepresentational Practices in an Inquiry Science Classroom

George Aranda, Joseph Ferguson

Research to date on students' metarepresentational practices has most often taken place in school classrooms and focused on tracking the development of metarepresentational competence over time. This research instead focuses on exploring in detail the nature of science students' metarepresentational practices as they engage with complex representational challenges in one-hour sessions in a purpose-built 'Science of Learning Research Classroom'.

This project was part of the ARC-funded program, *The Science of Learning Research Centre*, and specifically explored inquiry based science learning in a collaborative environment. Over six lessons in distinct topics, Year 7 students undertook a series of inquiry challenges involving reasoning through constructing representations. The lessons were conducted in a classroom with multi tracked video and audio facilities that allowed capture and analysis of the talk and gesture of each student group.

We analysed video data of episodes where students co-ordinated their use of representations that was central to solving the challenge. We identified moments where students: co-constructed, manipulated, explained and critiqued their representations; shifted between representations, taking into account the affordances of their modality; and spontaneously developed new representations.

We argue that micro-analytical studies over short time periods can provide fresh new insights into the nature and importance for learning of metarepresentational practices that advance our understanding of developmental trajectories.

Barriers to Teaching of Primary Science and Technology

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This paper examines barriers to effective teaching of primary science and technology as perceived by NSW primary school teachers. This report is part of a larger research program examining the question: How can teachers and schools build good practice, rich learning experiences and improved learning outcomes for students in primary science and technology? A review of literature and several rounds of consultation with key stakeholders (teachers, consultants, administrators, academics) identified a list of 42 barriers. A survey that included a best-worst scaling (BWS) task and measures of school science and technology capability was completed by 215 teachers. The BWS task allowed the ranking the barriers to effective Science and Technology teaching and learning. Major factors inhibiting effective teaching of Science and Technology included: prioritising of other to be taught, the need for large blocks of time for Science and Technology lessons, time to collaborate with colleagues, space to store student work in progress, organisation and maintenance of resources. The survey also provided data raising questions about the science and technology capability of primary schools, which has implications for attempts to enhance the teaching and learning of science and technology.

Optimising Mobile Learning in Science Education – Part 2

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University of Technology Sydney

This session presents selected findings from a current ARC Discovery project: *Optimising teaching and learning with mobile intensive pedagogies.* Mobile technologies are ubiquitous in Australia but knowledge about their widespread effective application for school education is patchy. The project investigates the complex factors that promote or inhibit quality teaching and learning with mobile technologies in secondary school mathematics and science education. The session presents results from case studies of two secondary schools adopting "mobile intensive pedagogies". It particularly focuses on data from science lesson observations, student and teacher surveys, science teacher interviews, and student focus groups. The session also presents a 'software useability' analysis of science education apps. A new technique for evaluating mobile apps was used to exploit sentiment analysis to analyse the feedback of past app users through the lens of a mobile pedagogical perspective. Trials have provided initial confirmation of the powerful utility of the feature based sentiment analysis technique for evaluating the mobile pedagogical affordances of learning apps in science education.

Pre-service Teachers' Conceptions of How to Increase Students' Interest in Science

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A number of previous authors have expressed a concern about the decline in interest in science among school students, particularly at the secondary level. Both the primary and secondary science syllabi state that one of the aims is that students would develop an interest in science. This suggests that secondary and primary teachers should understand how to increase student interest in science. However, there has been no previous study to investigate pre-service teachers' understanding of how to increase students' long-term interest in science. In this study, 231 pre-service primary teachers and 32 pre-service secondary science teachers were surveyed to identify their confidence that they could increase students' long term interest in science and the methods they would use to do so. Data collection also included individual interviews with students and instructors, classroom observations, and document analysis. It was found that there were few differences between the primary and secondary groups and very few of the pre-service teachers gave responses that were in line with the widely accepted theoretical model of how to increase students' long term interest.

Students' Beliefs About Pest Animals: An International Comparative Study

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Reversing the decline of New Zealand's unique flora and fauna through pest eradication will require the concerted efforts of everyone. A key group that will play an important role in realising the aspiration of NZ becoming pest-free by 2050 are today's teenagers. Not only are they capable of making contributions now, they will also be our future citizens.

This presentation will examine the beliefs of students aged 14-15 years towards one pest animal – the brush-tailed possum. Individual and groups of students from four secondary schools took part in online asynchronous exchanges about the possum (two in New Zealand, one in England and one in France). Data from these exchanges were analysed using Kellert & Berry's typology. The New Zealand students showed strongly dominionistic and negativistic beliefs about the possum. Their exchanges revealed that people should control possums because of their detrimental effect on New Zealand's unique biodiversity. French students adopted more moralistic beliefs, wanting possums to be killed "nicely", or naturalistic beliefs as possums were "part of nature". English students seemed more measured with small numbers expressing both dominionistic and negativistic beliefs but also utilitarian ones when suggesting that possums should be hunted for their pelts. These results will then be interpreted using an identity lens.

When is a Chemistry Experiment an Investigation?

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Historically, practical activities, experiments and investigations have been considered to be the pinnacle of the best learning for science students. In fact, a student directed investigation was considered to be of the utmost value for students, where students are required to use conceptual and

procedural knowledge. At this point in time, when investigations and student inquiry are important teaching practices in education, investigations have been incorporated into the Year 11 Chemistry Study Design (VCAA, 2016 - 2021). The students' perceived learning and understanding in these investigations is addressed in this study. Eighteen Year 11 chemistry students were selected to take part in this study to review their learning during a chemistry investigation. An open-ended questionnaire was emailed to each student. Students were given an opportunity to describe their learning in experiments compared to an investigation. This paper will explore the similarities and differences in the definitions of investigations and experiments as they are perceived by students and the ramifications of these are linked to the different learning outcomes of the students.

Case Studies of Excellent Science Teachers' Beliefs and Practice

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Just as science teachers have knowledge about science, teaching and learning and students, they also have beliefs about these matters. The purpose of my study was to investigate the interdependent relationship between beliefs and knowledge of excellent science teachers and how these factors influence teachers' pedagogical reasoning and ultimately their classroom practice. Three teachers were selected based on reputation amongst science teacher educators and confirmed by members of the school community.

This presentation shares the preliminary findings from 3 case studies of excellent secondary science teachers. Teachers were interviewed about their beliefs, observed during a series of science lessons and then asked to reflect on their pedagogical reasoning. In addition, a sample of their students were interviewed about their science class and various supporting artifacts were collected. The Australian Science Teachers Association's (ASTA) *National professional standards for highly accomplished science teachers* (2009) was used as a preliminary framework to analyse the data. Similarities and differences across contexts are discussed and what this might mean for science teacher education is explored.

Exploring the Relations of Teacher-Directed Instruction, Adaptive Instruction and Enquiry-Based Instruction to Science Achievement and Dispositions in 68 Countries

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This study, drawing on data from the Programme for International Student Assessment (PISA) 2015 database and employing multilevel structural equation modelling (MSEM), examined the direct effects of instructional practices such as teacher-directed instruction, adaptive instruction, and enquiry-based instruction in over 60 countries on 15-year-olds'science achievement and dispositions. The study also investigated the indirect effects of these instructional practices on science achievement through science dispositions. Results of the MSEM revealed significant positive effects of adaptive instruction and teacher-directed instruction on science achievement and dispositions, and enquiry-based instruction had significant negative effects on science achievement. However, enquiry-based learning had significant positive effects on science dispositions. These results have considerable implications for policy makers and practitioners and are discussed in terms of the effectiveness of implicit and explicit instructional methods, the need for specificity when comparing these methods, the importance

of teacher responsiveness to student learning needs and, the importance of developing students' and teachers' epistemic beliefs about science for effective conceptual development.

Early Childhood Teachers' STEM Pedagogy and Practices – A Snapshot

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In 2016, a pilot survey was conducted with early childhood (EC) teachers in Western Australia, New South Wales and Victoria, to understand how Science, Technology, Engineering, and Mathematics (STEM) education is incorporated in teachers' programming and planning, pedagogy and knowledge. Emerging research signals that laying foundations for future STEM learning needs to occur in EC years, as meaningful STEM experiences have been found to increase young children's STEM self-efficacy and early development. EC STEM pedagogies are informed by play-based approaches which are child-instigated but with purposeful intentional teacher scaffolding. A qualitative survey was used, allowing open responses and consisting of questions relating to EC teachers' understandings of STEM pedagogy and practice. An analysis was undertaken and responses scrutinised for common themes. Findings indicated that EC teachers acknowledged that STEM formed part of their program and was embedded in regular program planning - supported by intentional planned activities. STEM pedagogies included: working with children's interests, working from children's prior understanding and learning through play pedagogy. Findings from this research help to articulate STEM learning foundations in early childhood, although further research is required to better understand STEM pedagogy and methods to engage children in STEM learning.

Science Practical Work of IER: Nature, Impact and Improvement

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Institute of Education and Research (IER) is leading the way for preparing science teachers and teacher educators in Bangladesh for over last 60 years. Science practical work is a major element of IER science curriculum and mandatory for all science stream students in its undergraduate program. This research examined the existing nature of science practical work in this program, its impact on student learning and ways of improving the existing situation. Qualitative data were collected from seven science teachers and thirty students through semi-structured interview and focus group discussion. The findings revealed that the existing science practical work is recipe in nature and it does not allow students the opportunity to develop investigation skills. Students also responded that they do not feel interested in doing this kind of practical activity. Moreover, it is found that students do not able to relate practical work with theories. Participant science teachers agreed that open investigation with scaffolding could be integrated in the science practical work to improve the existing situation. The implications of this research may guide the curriculum developers of IER to rethink about the ways practical work is intended and the teachers to implement the recommendations in this research and it would help to prepare the science teacher educators.

Drawings as a Vehicle for Student Generated Representations to Learning of Sciences in Fijian Primary Schools

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Curiosity and creativity come naturally to most students. It can be used to create visual representations to develop critical thinking of a scientific concept. Drawings are a powerful pedagogical tool which if appropriately scaffolded will enhance conceptual reasoning in science. The aim of the study was to strengthen conceptual understanding of science through student generated representations. The study explored a group of six students' ages 9-10, who produced drawings to explain the phenomenon of increased flooding during the rainy seasons in Fiji. The students created drawings with written explanations followed by a verbal presentation. The study involved learning space observation focussing on teacher-student interactions and children's activities, followed by *Talanoa,* an informal conversation commonly used and culturally appropriate in Pacific context with the case study group. The study found that doing drawings in science can encourage students to engage, enhance their ability to select useful information from a variety of sources, apply scientific learning to the local context and communicate their thinking effectively. The study also highlighted the critical role of teachers in scaffolding student learning, by using probing questions about their drawings and diverse cultural experiences to challenge their thinking.

Examining the Impacts of Science Teachers' Practice and beliefs about Technology-based Assessments on Students' Performances: A Hierarchical Linear Modelling Approach

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Many studies have indicated that teachers' beliefs and practice could affect students' learning. However, the way of how teachers' beliefs and practice influence students' performances is rarely investigated. This study was designed to fill this gap by using a hierarchical linear modelling technique and aims at investigating the relations between science teachers' beliefs about technology-based assessments (TBAs), their usage of TBAs, students' engagement in inquiry activities, and students' performances on a TBA of inquiry abilities. The former two variables were categorized as school-level while the latter ones were student-level variables. Data sources included teachers' and students' questionnaires and students' responses to the TBA. 494 science teachers and 1984 students from 32 secondary schools participated in this study. Results show that there was significant variation between schools in terms of student performances and that students who had higher engagement had better performances on the TBA. Additionally, the more frequently teachers used TBAs, the better performances their students demonstrated. Yet, teachers' usage of TBAs also negatively moderated the relationship between students' engagement and their performances. Teachers' beliefs had neither a direct nor a moderating effect on students' performances. The results highlight the role of teachers' practice and its impact on students' performances.

Investigating Factors for Implementing Assessment Innovation in the Science Classroom

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The aim of this research is to investigate those factors in assessment innovation that impact upon students' achievement and changes in their epistemological beliefs about science learning. The assessment innovation emphasizes implementation of various types of assessments to monitor and evaluate students' progress in classrooms. The specific research objectives were to: 1) identify the teachers' beliefs about student learning and assessment that influence teachers' choice of assessment strategies, and 2) measure the impact of different types of assessment approaches on students' conceptual understanding and beliefs about science learning. Participants in the study were 265 Year 9 students from 3 schools and 5 teachers with varying length of teaching experience and different degrees of exposure to the theory and practice of assessment innovation. The findings revealed that inquiry-based formative assessment had a positive influence on students' conceptual development in science, and resulted in changes in epistemological beliefs about science that were conducive to science learning. The research also found that teacher beliefs about teaching/learning and assessment and teachers' professional development experience had a significant influence on the success of their implementation of assessment innovation.

Using a Context-Based Approach to Develop Grade 10th Students' Scientific Explanation Ability in an Equilibrium Unit

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This study intended to explore my best practices in using Context-Based Approach to Develop Grade 10th students' Scientific Explanation Ability in the Equilibrium Unit. The participants were 24 grade tenth students. The data was collected through teacher's journal, students' journal and videos of classroom instruction. Data were analyzed by content analysis. The result showed that for the effective use of Context-Based Approach in developing students' scientific explanation ability were 1) engaged students with interesting issue or situation to set the focal event. 2) organized the learning activities that related to the focal event and encouraged the students to find the explanation of the situation. 3) urged the students to present and compare the results between groups for learning key concept, and 4) stimulated the students to apply their knowledge for explaining other similar situations. The finding also showed that the students could make scientific explanation but their scientific explanation ability was vary, depends on their prior knowledge and experiences in each topic.

Making Connections

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Participation and achievement in Science for Pasifika learners, particularly those from low socio-economic backgrounds, is a matter of ongoing concern for New Zealand Science education. We present case study research using learning strategies that increased the participation and achievement of Year 9 and Year 12 Pasifika students, in a coeducational state school, in a low socio-economic community. The learning strategies were S*parklers* to build science vocabulary with Year 9 students,

and concept maps to connect Science ideas and construct paragraphs with Year 12 students. Participants were five Science teachers and their Year 9 classes, and three Year 12 teachers and their Physics, Chemistry, and Biology classes. Year 9 data sources were: Science Thinking with Evidence assessment; pre- and post-topic mind maps and tests; student surveys and student interviews. Year 12 data sources were: initial and final concept maps; student interviews; student writing and examination results. Findings suggest that Year 9 engagement and participation levels improved as students experienced success with the Sparklers and gained Science words to support their discussion and writing. Year 12 results improved as students learned to create concept maps, to use them to make connections between Science ideas, and to construct explanatory paragraphs.

Establishing A School and Science Education Partnership: A Science Teacher Education Perspective

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Professional experience plays a significant role in the development of all pre-service teachers. In an effort to better support the development of high quality science teachers, a partnership has been formed between the Faculty of Education and a Secondary School that connects professional experience and science education university experiences. In this paper, we will outline the partnership, consider the impact of the partnership from the perspective of science teacher educators and consider the influence this partnership has had on both the planning and delivery of our unit. The research was shaped by the overarching questions; how can we use this partnership to better support science pre-service teachers learning? And how has this supported our learning as science teacher educators? Data was collected from pre-service science teachers during their experience at the school, immediately after their experience at the school and at the end of the university year, through written feedback and focus group interviews. Data was also collected from the secondary school science teacher and the university science teacher educators'. The data was analysed to highlight the challenges and opportunities for our learning, always with a lens of how can we better support pre-service science teacher learning.

Exploring the Role of STEM Education in Relation to Innovation and Entrepreneurship as Economic Change Agents

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Science, technology, engineering and mathematics (STEM) are considered by most western countries as the key areas for ensuring future economic prosperity in a competitive global economy. The recent establishment in Australia of the Department of Industry, Innovation and Science (DIIS) along with a new *National Innovation and Science Agenda* indicate that political goodwill and policy is aligned to create and drive innovation and entrepreneurship. So what is the role of STEM education in this emerging directive? In our view, STEM education is pivotal in ensuring that our future thinkers are responsive and adaptable to emerging opportunities and challenges. Yet, an analysis of government policy highlights that there are not new but merely the strengthening of already existing actions and strategies. While this is positive in one sense in that there is continuing support for initiatives that are already 'up and running' it raises the question: How do these actions align to the focus on creativity, innovation and entrepreneurship as articulated in the *National Innovation and Science Agenda?* This

presentation interrogates emerging Australian policy to explore how the role of STEM education is conceived in these new government directives.

A Comparison Between the Knowledge Bases of Chemists and Teachers for Teaching Organic Chemistry

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In 1986 Shulman defined pedagogical content knowledge, PCK, as the transformation of content knowledge from teachers' personal conceptual understanding into various forms that could enhance students' understanding of content. PCK is now well established as a useful construct in the education research community and there is general consensus that PCK is knowledge unique to teachers and different from, but supported by content knowledge, CK. This study compares the performance of subject specialists (postgraduate teaching assistants) with chemistry teachers on two validated paper and pencil tests, one on CK and a second to measure PCK in organic chemistry. In the CK test the mean performance of both groups was high and at about the same level but the two groups performed differently in some sub-topics. There was differential performance in the PCK test where the chemists were superior at describing and motivating for the use of a variety of structural representations of pentane and showed unanticipated competence in the selection and sequencing of big ideas for teaching. However, they were not proficient in recognising and confronting misconceptions or suggesting conceptual teaching strategies. Further research is required to determine whether these findings are unique to the topic of organic chemistry.

Using a Sketch Map as a Conceptual Metaphor: A Micro-Sociological Perspective

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The shift toward embodied cognition to understand conceptual metaphor in science education illustrates an acceptance that the theoretical foundations of conceptual change and analogical reasoning are in need of revision. This need is in part, due to the recognition that there is more happening in cognitive processes than is represented in contemporary theories adopted by the field of science education. We identify this *something more* in terms of contextual factors in science classrooms that contribute to cognition, such as emotional experiences. The aim of this study is to understand better the inter-play between cognition and emotion in situations of conceptual metaphor. This aim is achieved by shifting the researcher's frame of reference away from the individual, psychological mind that may be integrated with the individual body, to focus on episodes of social interaction where multiple minds and bodies contribute to the construction of conceptual metaphor. This original investigation of empirical data in school science inquiry situations uses a micro-sociological approach to understand the performance of embodied reasoning and emotional experiences of those performances where conceptual metaphor is evident as an outcome. This study points to the possibility for a re-theorization of conceptual metaphor in school science, from a micro-sociological perspective.

Pre-service Teachers' Conceptions of How to Increase Students' Interest in Science

Jn. Baptiste Davis, Palmer David, Archer Jennifer

A number of previous authors have expressed a concern about the decline in interest in science among school students, particularly at the secondary level. Both the primary and secondary science syllabi state that one of the aims is that students would develop an interest in science. This suggests that secondary and primary teachers should understand how to increase student interest in science. However, there has been no previous study to investigate pre-service teachers' understanding of how to increase students' long-term interest in science. In this study, 231 pre-service primary teachers and 32 pre-service secondary science teachers were surveyed to identify their confidence that they could increase students' long term interest in science and the methods they would use to do so. Data collection also included individual interviews with students and instructors, classroom observations, and document analysis. It was found that there were few differences between the primary and secondary groups and very few of the pre-service teachers gave responses that were in line with the widely accepted theoretical model of how to increase students' long term interest.

Teaching of Argumentation and Socio-scientific Issues in Three Diverse Schools

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An important aspect of scientific literacy is the ability to use scientific evidence to construct and evaluate evidence-based decisions about scientific issues. The aim of this study was to evaluate the effect of explicitly introducing decision-making skills through argumentation in the context of climate change socio-scientific issues. Using a multiple case method approach, quantitative and qualitative data was collected from three diverse (based on ICSEA) schools. In each school, a science teacher introduced their Year 10 students to argumentation skills as a framework for constructing and evaluating decisions. The argumentation lessons comprised one to four lessons and, in each case, were incorporated into an Earth sciences topic. Data sources included a pre and post-instruction questionnaire on students' understanding of climate change and their argumentation skills, classroom observations, lesson audiotapes, student work samples and teacher and student interviews. Argumentation quality was determined using Toulmin's argument structure and the content of the argument. There were variable findings across the cases which were associated with the emphasis of the teachers and their focus on argumentation and/or content. It is concluded that instruction on argumentation can improve students' argumentation skills, which are an aspect of scientific literacy.

Beyond Content Knowledge – How Modeling Skills and Student Concepts Interrelate in Context-Based Tasks

Susanne Digel - DFG Graduate School Teaching and Learning Processes, University of Koblenz-Landau,
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The positive influence of context on interest makes the use of real-world problems desirable in physics classroom. Although students prefer contextualized tasks, they perceive them more difficult to solve. Furthermore, it is in context-based tasks where variations in students' performance manifest. One might conclude that physics content knowledge and problem solving strategies account for disparate performance, but students with appropriate strategies seem to fail to make use of it in context.

Moreover, recent research shows limited influence of content knowledge on performance in context-based tasks, while the attempt to apply a scientific model in the problem solving process seems to be promising.
Hence this project aims at answering the question how scientific modeling skills foster the problem solving performance in context-based tasks.
To make scientific modeling tangible, we developed a competence model and the corresponding assessment tool for scientific modeling in the physics domains optics and kinematics. The empirical verification (N = 200, students grade 9-13) showed good EAP/PV-reliabilities (optics 0.798, kinematics 0.908) along with a satisfying item fit. A model comparison gave favor to a three-dimensional model in both domains. Further analyses will help to clarify the relation between students' concepts and their scientific modeling skills in contexts.

Should Primary Children be Taught the Atomic–Molecular Theory of Matter?

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Research indicates children's interest in science peaks at age 10, yet the Australian science curriculum leaves many exciting science topics, including particle theory, atomic-molecular theory and the language of the Universe, the Periodic Table of Elements, until middle school. Thus, primary children's alternate views remain unchallenged due to absence of explanatory frameworks for observed phenomena such as changes of state. Research further indicates that children do not view matter as particulate without formal instruction. Traditionally, such topics are considered too difficult for primary students, but our research leads us to a provocative idea – perhaps we are teaching these topics too late. Recently published research by the authors provided evidence that Year 4 children are able to understand and apply basic atomic-molecular theory in simple contexts. This paper describes further research documenting changes in Years 3 and 4 children's understanding about the states of matter, following a 10-hour teaching intervention by a generalist primary teacher about basic atomic-molecular theory. Data sources are pre-, post- and retention interview data, children's artefacts and teacher reflections. Findings indicate 82% of the class understood the particulate nature of one or more states of matter, with 62% understanding this for all of solids, liquids and gases.

Analysing Science Teachers' Pedagogical Content Knowledge: The Second PCK Summit

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Since its introduction, pedagogical content knowledge (PCK) has been widely written about in the science education research literature. This paper reviews and draws together the discussions from the second PCK summit that was held in Leiden, the Netherlands, December 2016. This PCK summit was designed to provide international researchers working on PCK in biology, chemistry and physics education the opportunity to share 1) how their data from PCK studies were collected, 2) the different kinds of instruments used to collect these data, and 3) the procedures used to infer PCK from these data. The aims of the summit were to develop a shared set of criteria to identify PCK for each kind of instrument through collectively analysing data that were obtained with the respective instrument; make accessible and comprehensible these instruments to the wider PCK research community and reach consensus on a model of PCK that is strongly connected with empirical data of varying nature, and can be used as a framework for the design of future PCK studies. This paper reflects on the PCK

summit and presents a Revised Consensus Model of PCK, following up on the one which was designed at the first PCK summit (Colorado, 2012).

Educator Self-Efficacy in Informal Science Centers

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Learning in out-of-school settings such as informal science centers plays an important role in increasing public understanding of science. The number of informal science educators is growing every year. However, little is known about their preparation and professional development. An exploratory study surveyed 299 informal science educators in the United States to examine their levels of perceived self-efficacy in skills related to pedagogy and science content. High levels of self-efficacy have been shown to influence educators' decision making and teaching skills. Our research questions asked what are informal science educators' perceptions of their facilitation skills and areas of need for more professional development? The results showed that participants' areas of greatest need for professional development were facilitation and science content knowledge. Over 40% of respondents indicated they needed help encouraging visitors to engage in science policy and decision-making, engaging visitors disrupting the visitor/staff interaction, and recognizing how people of different cultures interact and communicate. Sixty percent of respondents expressed a need for increased skillfulness in helping visitors understand physical sciences concepts. Identifying areas where informal science educators feel the need for more professional development provides critical information needed to tailor professional development to target these areas and help improve self-efficacy.

Inspiring Primary Science Pre-service Teachers as Researchers

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Self-study encourages teachers to reflect on their teaching practices and subsequent impact on student learning. Through promoting reflective practice, this approach has the potential to deepen the pedagogical understandings of those learning to teach. This research explored pre-service primary science teachers perceptions of researching their own teaching practice using self-study, and documented how this experience impacts on their understandings of children's science learning and their own science teaching. This research involved 80 pre-service teachers enrolled in a first year science education unit, which ran as two-hour weekly workshops for 12 weeks with six of these workshops taking place on campus and the other six taking place in a local primary school. Preliminary analysis highlights that this approach: (1) modelled a way to embed research in practice in a meaningful way, (2) fostered an enjoyment of the research process, (3) increased the pre-service teachers confidence and competence in teaching primary science, and (4) highlighted the difficulties inherent in the research process. The findings of this study contribute to understandings of how inspiring pre-service teachers to be researchers of their own teaching practice may contribute to deeper understandings of the act and art of learning to teach science in primary classrooms.

Exploring the Nature of Science Students' Computer-mediated Abductive Reasoning

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Computer models have become increasingly available as a means for science students to explore scientific phenomena and researchers have sought to define in detail these student-computer interactions. This research involved the design and implementation of an activity at a science education centre in Australia that focused on improving year 10 science students' understandings of natural selection and the development of their ability to explore and refine these ideas through computer models. The students interacted with three purpose-built computer models (NetLogo software) to explore the possible role of malaria as a selection pressure on the human genome. Extensive and rich video data enabled analysis of the multi-modal and distributed nature of students' reasoning. It was determined that their reasoning was abductive in nature, with the students interacting with the computer models to engage in a complex and creative process of hypothesising to solve the model-based anomalies they encountered. By constructing and interrogating Studiocode timelines of three episodes of such reasoning it was established that the students executed manipulative, visual and sentential abductive reasoning moves that formed distinctive patterns that are proposed as nine principles to define, in a logical manner, this computer-mediated abductive reasoning.

Studying Teacher Intervention Through Example: Purposeful Selection from Rich Video Data Sets

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In this paper we discuss the methodological challenges and affordances of rich and extensive video data sets when using micro-ethnographic research methods. Our research involved exploring how Year 7 students engaged in collaborative reasoning in science, with a particular interest in the modes of representation they used in reasoning. The students engaged in purposefully designed science activities in the purpose-built Science of Learning Research Classroom equipped with wall and ceiling mounted cameras and radio microphones capable of capturing in comprehensive detail the interactions of students and teachers. This rich and extensive video record provided us with the advantage of choice about which groups and events to focus on in our analysis, but it raised questions around how to make useful and productive choices as well as how to justify these choices as scientific practice. We developed a process of 'purposeful partiality' achieved through 'active viewing', selecting an 'example' and understanding a video data set as a 'field'. We illustrate the value of this process, in particular the 'example', in generating insights into the highly contextual, relational, layered and responsive nature of teacher interventions in group inquiry processes.

Student Generated Analogies – Windows Towards Canonical Understandings of Science

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This research was conducted as a series of teaching experiments, over a four year period with students 16-18 years of age. It investigated 24 episodes in which the co-generation of analogies was used as a teaching methodology in senior chemistry and physics classes.
The students shared their ideas with each other and with their teacher when developing and refining their ideas. The final products were developed through interactive discourse and so were not entirely owned by any individual.

It is not, however, the analogies that are important per se, it is the canonical scientific understanding of the target concepts that results. Student generated analogies provide a window through which students' understandings become visible. They are a tool that, used appropriately, can interest and actively engage students in science. The process of co-developing analogies facilitates teacher involvement and awareness of students' alternative conceptions. The discourse associated with the correction of the imperfections of students' analogies, helps to address alternative conceptions and leads to deep and therefore lasting understanding of the targeted science.
This presentation discusses how the guided use of student generated analogies can be a useful pedagogical tool in science education.

Contemporary Science in Chemistry Teacher Education

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Students who are going to be chemistry teachers in Germany often don´t study chemistry in such a depth that they can understand current research. By contrast, studies show that the higher the content knowledge is, the higher the skills for teaching are. Our research project therefore focuses on the professional development of chemistry teacher students by bringing them in contact with today's chemistry research. The main question of our empirical study is: In which way does the professionalism of students studying chemistry education change if they are confronted with today's research?

The dimensions of Subject Matter Content Knowledge, Pedagogical Content Knowledge and the students´ Nature of Science view are investigated and evaluated. Therefore, a learning environment was developed which combines contemporary chemical lab research with educational aspects. Also, a theoretical model combining chemical, philosophical and educational aspects was evolved.
The study follows a mixed methods approach of quantitative methods (questionnaires) and qualitative methods (interviews, discussions, videography) which are combined to create a wider foundation.
First results show interesting changes in the students´ professionalism like an increase in Pedagogical Content Knowledge. Concerning the students' Nature of Science view, we found a more evolutionary thinking of the formation of theories in science.

Lab Work as an Everyday Assessment Tool

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The teaching methods used in school chemistry education increasingly aim at developing high-order cognitive skills rather than memorizing chemical facts. Despite this, assessment tools remain mostly the same: paper and pencil tests often focussing on encyclopaedic chemical knowledge. Thus, there is a gap between the quality of teaching and the ways of testing. It therefore seems feasible to develop new assessment tools that focus on broader fields of competence. Lab activities offer possibilities for learning in important fields of competence and are of great importance in school chemistry teaching. The integration of typical, complex procedures of science within an experiment is the reason for promotion inquiry-based learning and should be an argument for using lab-work as assessment-instrument, too. Therefore, we investigated how lab activities can be used as assessment-instrument in everyday chemistry lessons and which effects such a use has.
To answer these questions different ways to use students' lab work as assessment-instrument were developed and tested in a participatory action research setting. Several useful approaches arose, that can easily be created based on existing teaching material. Experiences with such assessment-instruments show that they provide teacher with important additional information and change the attitude of students and teachers towards experimenting.

Impacts of NAPLAN Preparation Impacting on the Teaching of Science to Stage 3 Students in New South Wales Schools?

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The study reports on data drawn from a larger study researching into New South Wales (NSW) Stage 3 primary teachers' use of Information and Communication Technologies to enhance their own science content knowledge. Principals from 31 schools and 47 of their teaching staff were surveyed to establish background information on their schools' culture followed by interviews with 10 teachers. The initial surveys were designed, in part, to establish the participant's perceptions of whether or not some subjects were prioritised in their schools. A very close correlation between the perceptions of the principals and their participating staff was noted for the highly prioritised subjects of English and Mathematics.

Throughout the research, teachers made frequent reference to the impact of the National Assessment Programme - Literacy and Numeracy (NAPLAN) on the teaching of science and the possible negative impacts could deepen concerns - long-held in many sectors - about the teaching of science in Australian primary schools.

Developing a Model to Analyse Secondary Students' Perceptions of Nature in Relation to a Biodiversity Rescue

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New Zealand has a unique biodiversity, which includes large number of endemic species which have become threatened since human occupation. One significant threat to these endemic species is the introduction of mammalian predators. Eradication of these introduced pests to rescue the diminishing

biodiversity is a contentious issue amongst New Zealanders. This study aims to investigate New Zealand secondary school students' views of nature in relation to a biodiversity rescue. Open-ended questions in response to photographs about the use of sodium fluoroacetate (1080) were used to collect data about these students' views. A model initially developed by Steg and Sievers (2000) has been adapted to analyse these data. Initial testing of the adapted model, using a polythetic approach has shown that students seem to hold one of the following different worldviews: *Nature Tolerant, Nature Ephemeral, Nature Benign or Nature Capricious*. Furthermore, it seems that the students' views about nature do not alter when given more information but they do become more informed about the issue. The adapted model and initial data analysis will be presented for critique and discussion.

STEM Education Curricular Models

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This paper presents a description of various case studies of education systems around the world that have implemented science, technology, engineering and mathematics (STEM) education. Firstly, the role of STEM and its educational importance is discussed in light of educational and economic developments in Australia and overseas. This is followed by a presentation of examples from around the world where STEM practices have been implemented. These examples are explored in terms of their schooling level and type of curricular integration. In presenting the case studies, this review conceptualises STEM pedagogy and provides recommendations for STEM related endeavours.

Teacher's Perspectives on the Role of Collaborative Partnerships in Secondary Science Education

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Collaborations between schools and external organisations to teach science are increasingly common. These collaborative learning experiences utilise the expertise and resources of the external partner and can offer students engaging and accessible ways of learning science. However there is limited understanding of the role that collaborative partnerships can play in students' science education, particularly regarding long term collaborations. The research presented here draws from a larger case study of a collaborative partnership between a specialised science centre and two Australian secondary schools. Specifically this paper aims to investigate teachers' experiences within a collaborative partnership and their perceptions of the role it plays in their students' science education. A series of qualitative interviews were carried out with teachers over the 2016 school year. Preliminary findings show that teachers were primarily concerned that the programs for junior students (7 and 8) did not effectively use the centre's resources and were not well integrated into their school curriculum. However despite this and other issues occurring in program organization and attendance, teachers saw the partnership as developing positively and valued it as a way to extend students' learning and promote awareness of STEM tertiary courses and careers.

Proportional Reasoning for Science Understanding: A Science Curriculum Audit

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Students' understanding of many scientific concepts relies heavily on proportional reasoning (PR), a crucial component of numeracy. PR involves understanding multiplicative and relative thinking, ratio, proportion, rate, and scale. Despite their central importance, research on PR concepts in science is limited. Two key issues are: PR is pervasive and not explicit in science curricula and teachers have difficulties recognising and teaching PR concepts. This paper focuses on the first of these: the lack of an explicit focus in the science curriculum.

A literature review identified six elements of PR. The Australian science curriculum to Year 10 was audited to identify concepts strongly associated with each of these identified elements. Findings were compared and discussed to ensure the alignment of interpretations.

The audit revealed significant findings: aspects of PR underlying science concepts were identified across all strands in all year levels and yet, no curriculum examples explicitly identified PR; students' understanding of some elements is assumed; and as students progress, the level of complexity increases and reasoning changes from qualitative to quantitative. The findings suggest the need to support teachers to identify PR requirements in the science curriculum and to improve their knowledge and practices to better support students.

Learning to teach out-of-field: Positioning, Agency, Continuity and Expertise

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The challenges of being a new teacher are compounded when expected to teach content or a subject for which they have little background, that is, teach out-of-field. This paper presents a theoretical model derived from research to capture the transitional experiences of out-of-field early career teachers. The PACE model draws on various theories to examines a number of components in relation to teacher 'role': positioning and identity (P), agency and autonomy (A), continuity (C), and expertise (E). While the four components of the model are interrelated in practice, the model helps to understand how each component has its own trajectory as a new teacher gains experience and greater clarity and understanding of their teacher roles.

This is the first model of its kind to examine the transition of early career out-of-field teachers. While the boundary crossing model is a change model also, the power of which signals the potential for the boundary to promote learning, it assumes that the fields are more or less stable, cohesive, and identifiable. The PACE model is informed by transition theories and recognises that change over time is to some extent incremental. The next stage of theory development will be to examine how the elements of the PACE model are influenced by context, both proximal (school) and distal (systemic).

Sustaining STEM-Based Reforms in Secondary Schools: Insights into Successful Implementation

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STEM initiatives and curriculum are becoming widespread in schools in response to government and industry pressure to deliver quality STEM outcomes. But how sustainable and embedded are these changes likely to be? Without critical analysis of the enablers of and challenges to sustaining the

incorporation of STEM practices, pedagogy and curriculum, this move towards STEM is likely to encounter the same fate as other efforts to integrate, innovate and contemporize schooling. This paper will examine the enablers and challenges facing the teachers of ten secondary schools involved in a STEM professional development program as they attempted to embed new STEM teaching and learning within their schools. The teachers used a 'STEM vision' framework to structure teachers' learning, planning and collaboration with others. A case study is used to illustrate the journey of how one of the schools developed a STE(A)M vision and how it has become embedded. This school's journey was presented to the other schools at one of the PD sessions; ensuing observations highlighted that the schools have taken different approaches to developing, embedding and sustaining their STEM visions. From these observations, and drawing on the insights from the case study school's 'successful' implementation plan, a framework has been developed that identifies the key enablers, challenges and trajectories of change associated with STEM–based reforms.

Investigating Representational Pedagogies for Learning Electricity in Year 6

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The research described in this paper is designed around the notion that learning involves the recognition and development of students' representational resources. This paper describes a Year 6 classroom sequence in Electricity that focuses on representations and their negotiation, and reports on preliminary findings on the effectiveness of this perspective in guiding teaching, and in providing further insight into student learning. The classroom sequence involving a science specialist was videotaped using a combined focus on the teacher and a group of students. The paper reports on the effect of this approach on teacher pedagogy and on student learning of Electricity. The paper will present data from video of classroom activities, students' work samples, student and teacher interviews and pre and post-unit testing, to explore what a representational focus might entail in teaching Electricity, and the role of representations in learning and reasoning and exploring complex scientific ideas.

Principals Leading the STEM Agenda in Australian Primary School Education: Influence, Tone and Responsibility

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Australia's Chief Scientist, Dr Alan Finkel in an interview in late 2016 recognized the influence of school leaders in Australia's education results in international tests like the Program for International Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMMS). He posited that it was principals 'who set the tone in their schools and, with the right strategies and focus they could drive a culture of constant improvement'. This factor is also acknowledged by the Commonwealth Science Council, whose members provide strategic advice to the Australian government on science and technology issues, and who work to build collaboration between scientists, researchers and industry. This paper does not debate the merits or otherwise of international testing in schools, but instead takes up what mattered to a group of principals in recent Science, Technology, Engineering and Mathematics (STEM) research conducted in NSW primary schools.

Using data gathered through interviews, and examined through the lens of sociocultural theory, interactions suggest the lack of deep teacher knowledge in the STEM disciplines is an outcome of education policy that has privileged literacy and numeracy at the expense of the STEM disciplines.

Recommendations centers upon prioritizing pedagogy, increasing STEM resources in schools, alongside changes to pre-service teacher education.

The Development of Grade 10 Students' Critical Thinking and Conceptions on Nucleic Acid and Protein by Using Project-based Learning

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There is the relationship between nucleic acid and protein concepts. The problem for Thai curriculum is these two concepts are separated. This makes it is difficult and complicate for students to find out their relationship. This research aimed to explore how project-based learning (PBL) could develop grade 10th students' critical thinking and conceptions on nucleic acid and protein. The activity in this topic was a gallery walk, which each group of students need to present their project, simple protein translation models. The data were collected by using open-ended questionnaires namely critical thinking test and concept test. Moreover, the qualitative data were collected from students' exit slips and their peer projects assessment. The data were interpreted and categorized into groups based on scientific conceptions. The result showed that the students' critical thinking was increased, especially for making decision based on scientific conceptions. Most students also showed their systematic thinking during the collaborative works. Another result showed that most students held scientific conceptions. The finding of this study revealed that PBL was an effective instructional strategy to develop both students' thinking and scientific conceptions by making project. The teacher role was facilitator who prepared materials, asked questions and gave suggestions.

STEM Subject Choice in Year 12: The Influence of Demographic Characteristics, Attitudes Towards Science and Achievement

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Research, internationally, has highlighted an increasing need for a workforce skilled in science, technology, engineering and mathematics (STEM) for the technologically advancing global economy. Declining enrolments in STEM subjects and a perceived STEM skills shortage have brought the issue of enrolment in STEM subjects at school to the forefront of governments and of educational institutions. Although some researchers have questioned the data being used to warrant these assertions, the importance of a society equipped with adequate STEM related skills is clear. This paper examines factors that influence the Year 12 STEM subject enrolment decisions of students in Australian schools. Multinomial logistic regression and multilevel modelling are used to identify influential factors and to gain a deeper understanding of the STEM enrolment decision making process. Items from the 2006 cohort of the Programme for International Student Assessment and the Longitudinal Surveys of Australian Youth are used with variables measuring students' backgrounds, their attitudes towards science, and achievement as predictors of STEM subject intentions and subsequent enrolment. The Theory of Planned Behaviour, a behavioural prediction model, will be used as the guiding conceptual framework.

The Effect of Introducing Socioscientific Issues in a College Biology Course for Pre-service Science Teachers

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The students have to have decision-making ability on socioscientific issues, which is a component of scientific literacy. In this respect, pre-service science teachers have to prepare to deal with these issues. In this study, the effect of introduction of socioscientific issues on pre-service science teachers' character and values in college biology course was investigated. In the first semester of 2016, 75 pre-service science teachers who registered biology course were divided into 20 groups. Each group selected the social issue related biology such as embryonic stem cell, doping test, and designed baby, they collected the related materials, made a presentation and a report on the issue. As a result of administration of questionnaire of character and values, the total score of pretest was 3.78, that of post-test was 3.80, and this difference was not statistically significant. But the difference of the scores in the statement "I can predict the social, ethical, and moral results from the advance of biotechnology" was statistically significant. And 80% of participants answered that it is needed to deal with socioscientific issues in secondary school science class. It would be helpful to develop teaching profession for pre-service science teachers to make group presentation on socioscientific issues.

Determining the Most Appropriate Model to Guide Policy Development for Gifted and Talented Science Students in New South Wales

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Gagné's model for gifted & talented (G&T) students is prevalent in Australia with all states using his model to form their policies for the past 10 -15 years. No policy presents a rationale for using this model or for the selection of this model over others. Additionally, students in NSW who have outstanding potential to contribute to Australia's intellectual capital have been left behind in terms of policy with no updates since 2004. This proposed research will gather first hand data on the current status of gifted & talented education in NSW schools to assess whether this is in keeping with the model in the current policy i.e. Gagné's model. The research will explore and examine facts regarding current school policy, provisions (resources) and practice utilised in science classrooms for gifted and talented students and the perceptions of educators on educational policies. From the findings, theoretical and practical consideration will be given as to whether it is the most appropriate model for 21st Century students, or whether other published models could be justified as being more appropriate. There is potential for a new model to emerge from this study thus contributing to the theoretical aspects of educational research and reform.

The Parallel Vision and Creativity Between Science and Art in the 20th Century: A Case Study of Paintings of Rene Magritte from the Copenhagen Interpretation

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The relationship between science and art has been a prolonged issue in science and science education research. It is interesting to note that science and art encountered a similar shift in the twentieth

century; from deterministic view to undetermined and probabilistic view in science, and from representation to expression in art. This study aimed at interpreting the paintings of Rene Magritte as a representative of pioneer artists from the Copenhagen interpretation prevailed at that time. The Copenhagen interpretation was composed of five key ideas by Heisenberg: probabilistic wave function (Born rule), indeterminacy principle (or uncertainty principle), correspondence principle (wave-particle duality), ontological meaning of quantum phenomena (superposition of probabilistic wave functions), and non-instantaneous change in quantum phenomena (quantum jump). The paintings of Rene Magritte were accorded with the aforementioned features of the Copenhagen interpretation. The results showed that there are similarities between the two in terms of ontological stance about the reality and many of the paintings were viewed as inclusion of concepts related to quantum mechanics. Thus, this study tried to give some implications about how to combine science and art as an interdisciplinary education.

Professional Noticing of Student Science and Mathematics Reasoning by Primary School Teachers

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The construct of teacher professional noticing as a distinctive mark for teaching expertise has gained increasing attention over the last decade (Mason, 2002; Russ & Luna, 2013; Scheiner, 2016; Sherin & Russ, 2014). In a classroom, multiple and unpredictable events often occur simultaneously that require teachers to selectively attend to, interpret, and make decisions about how to respond to student thinking in the moment as the lesson unfolds (Jacobs, Lamb, Phillip, & Schappelle, 2011). However, accessing in-the-moment noticing of teachers is quite complex because the dynamic relationships between various activities involved in teacher noticing are not obvious (Scheiner, 2016). This paper discusses some of the theoretical and methodological challenges in studies of teacher professional noticing in classrooms using video-based approaches. Drawing upon data from a project that investigated primary school teachers' professional noticing of student science and mathematics reasoning, this paper interrogates the dynamic and complex intersections of perception, situated knowledge, awareness, beliefs and practices and how understandings of these dynamics might contribute to theorizing of teacher professional noticing.

A Teacher's Perspective on the Good Practice of Promoting Moral Reasoning in a Biology Classroom

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This classroom action research aims to examine good practices in promoting moral reasoning in High School Biology from a teacher. The teacher implemented socioscientific issue-based approach in the unit of Genetics and DNA Technology for a classroom of grade 12 students (N = 41) in an enriched-science high school in Bangkok Metropolitan Region. The data were collected by Moral Reasoning in Bioethics Test (MRBT), students' artifacts, students' reflective journals, semi-structured interview, and a teacher's reflective journals. Content and inductive analyses were employed to analyze the data. The research findings revealed that SSI-based approach could enhance students' moral reasoning. There is an increase in the percentage students who examined effect of choices (Consequentialist) and those who applied ethical principles in their judgment (Virtue Ethicist). The emerging practical knowledge of SSI based instruction from multiple iterations of the PDCA cycle, include selecting an updated,

impactful and controversial issue related in DNA technology, using though provoking multimedia, equipping students with adequate scientific understanding of the issue and argumentative skills, and creating safe and respectful space for in-depth, evidence based and open discussion in a classroom.

Optimising Mobile Learning in Science Education – Part 1

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This session presents selected findings from a current ARC Discovery project: *Optimising teaching and learning with mobile intensive pedagogies.* Mobile technologies are ubiquitous in Australia but knowledge about their widespread effective application for school education is patchy. The project investigates the complex factors that promote or inhibit quality teaching and learning with mobile technologies in secondary school mathematics and science education. This session presents *qualitative and quantitative results* of our recent national survey of secondary school teachers. The survey elicited participants' *patterns of use* of mobile devices in their teaching. This session particularly focuses on findings from the 115 teachers from around Australia who identified as science teachers in the survey. The results offer a snapshot of current mobile learning practices amongst Australian secondary science teachers, contributing to an understanding of the factors that promote and inhibit effective mobile pedagogies in science education.

Collaborative Partnerships between Specialist Science and Technology Centres and Universities

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The Reconceptualising Maths and Science Teacher Education Programs (ReMSTEP) project is a collaboration between four Victorian universities that responds to the need for improved competence and confidence in the teaching of science and maths, as a pre-service focus, across the Australian Curriculum. ReMSTEP's activities are centered on developing new teacher education practices that align contemporary approaches to STEM with engaging teaching and learning. This project directly promotes collaboration between researchers and educators in science, mathematics and education in order to reconceptualise the education of teachers of STEM through active partnership between educators, mathematicians, scientists and engineers.

This session describes initiatives in which pre-service teachers (PSTs) from the ReMSTEP universities have worked with Specialist Science and Technology Centres and scientists to explore contemporary science perspectives. As an exemplar, 'Reconceptualising Rocks' involved PSTs working with Melbourne Museum scientists and teacher educators to explore the science of geology and the role of the museum in conservation and communication. The session will present two different models whereby PSTs developed multimedia resources for schools through their interactions with the museum. In doing so, the affordances and challenges of such partnerships will be discussed.

Grade 11th Gifted Students' Scientific Reasoning Ability

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This study aims to examine grade 11th gifted students' scientific reasoning ability. The data were collected from a situation-based scientific reasoning test, adapted from Lawson (1982, 2005). The test was designed for probing the students' reasoning skills on probabilistic thinking, control of variables, proportional thinking, and correlational thinking. The participants were 36 grade 11th gifted students of a girl school in Bangkok. Data were analyzed by classifying it into three skill levels – low, intermediate, and advance. Surprisingly, the findings show that majority of the students were fallen into low skill level. Most students cannot identify hypotheses and variables in agreement with the experiments given on the test. Many students had difficulty to reason how data on the given situations related to their conclusions. In addition, a number of students struggled to net relationships among variables. These findings provoke science teachers to rethink whether we have done a well-preparation for the gifted children on this fundamental ability – scientific reasoning skills – before moving into advanced inquiry skills, or even STEM education.

Frameworks Guiding the Teachers' Work in Scientific Inquiry

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Engaging students in the thinking processes and activities has become a fundamental approach for teaching and learning of the Sciences. A rich vocabulary is already documented to describe these thinking processes and activities, often grouped under inquiry-related approaches; for example: scientific inquiry; inquiry-based teaching and learning. This plethora of terms indicates that scientific inquiry is a multifaceted concept; is conceptualised from both the teaching and learning perspectives and is difficult to define, making the outcomes in a classroom setting problematic to compare among all the different versions that are being practised. This paper is the result of extensive classroom observations of scientific inquiry in action. The result is a theorising of the frameworks guiding a teacher's work with inquiry: (a) classroom goals; (b) instructional approach used to engage the student; and (c), the degree of direction from the teacher. This paper will explore these frameworks, and in doing so conceptualise the nexus between teachers' scientific inquiry literacy and their locus of control.

Affordances and Constraints of Pre-service Teachers' Design of STEM Resources on Demand (STEMROD)

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Connecting schools and teachers with industry and community partners is essential for improving STEM outcomes for students. Two pilot STEM Hubs were created across schools in Brisbane and Townsville that connected secondary STEM teachers with local industry and community partners. The collaboration afforded innovative STEM units to be conceptualized by teachers and partners. This study reports on the role of pre-service teachers who collaborated with STEM Hub participants to

write the units of work known as "STEMROD" (STEM Resources on Demand). Data from student and partner interviews were used to ascertain the affordances and constraints of the STEMROD initiative. The analysis revealed two affordances: firstly, the creation of the resources provided a valuable experience for pre-service teachers and secondly, STEM Hub teachers appreciated the importance of tangible outcomes like the STEMROD for classroom innovations. Furthermore, constraints such as time to write the resources and the availability of the pre-service teachers are highlighted.

A Study of Science Reading Scaffolding Effects for High School Students Toward Science News Texts in Taiwan

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Based on the premise that language plays an important role in the attainment of a scientific literate society, the purpose of this study is to explore the effects of science reading scaffolding instructions for high school students within the context of science information appeared in media environment. Seventy-two 10th graders in central Taiwan were invited to participate in this study and a quasi-experiment approach was designed. During two months of data collections and analysis, two local science news texts were selected and modified as the research tools and the science reading scaffolding was intervened for comparisons. The qualitative and quantitative results reveals that the experiment group outperformed their counterpart with respect to their scientific literacy performances in different dimensions. It is implied that appropriate science reading strategy instructions can be positively supportive for students' literacy performances within science education and science communication context and some reflections and recommendations will be discussed during the conference.

The Explorations of Frames and Framing within Science News Regarding Genetically-modified Organism in Taiwan

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Since socio-scientific issues (SSIs) are one of the appropriate contexts for scientific literacy and informal reasoning performances and news framing affects the science information perceived by general public, the purpose of this study is to explore the frames and frame packages appeared in science news regarding genetically-modified organism (GMO) information. The popular local news text in Taiwan were selected for investigation and the total number of articles collected was 107. A qualitative approach was adopted and the literature established frames were theoretically used for content and framing analysis and some new sub-frames were inductively constructed. The results reveals that "problem solving" was the new frame package found in these articles in which a sophisticated argumentation pattern was also observed compared to other frame packages of "progress" and "harm". It is implied that SSIs within science news can be potential resources of science education or science communication for the attainment of a scientific literate society and some reflections and recommendations will be discussed during the conference.
Keyword: science news, socio-scientific issues, news frames

Developing and Validating a Constructed-Response Assessment of Scientific Abilities: A Case of the Optics Unit

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This study aimed at validating a constructed-response assessment of scientific abilities and developing its rubric. The assessment included 32 open-ended test items and categorized into 4 subscales: Understanding scientific knowledge, Applying scientific procedures, Explaining phenomena and concepts, and Generating questions, hypotheses, and solutions. 1530 eighth and ninth graders from Taipei city participated in this study. The statistical results showed that the intrarater and interrater consistencies were acceptable. Additionally, the analysis of many-facet Rasch measurement showed no significant difference in rater severity and both severe and lenient raters could distinguish high-ability students from low-ability students effectively. After the deviances estimated by the rating scale model and the partial credit model were converted to the values of Bayesian information criterion, the results showed that the former model fitted the empirical data better than latter, and that the severity threshold of raters was same. Thirdly, the confirmatory factor analysis revealed an acceptable goodness-of-fit among the assessment items. Finally, the Cronbach's α coefficients of the four sub scales and the full assessment was above .85, indicating a high internal-consistency reliability of the assessment. Together these results suggest that the assessment was a valid and reliable instrument for accurately measuring scientific abilities.

Exploring the Nature of Challenges to Science Teachers' Pedagogical Equilibrium when Organsing for Teaching

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Teaching is a complex and sophisticated business, yet the tacit knowledge teachers develop is intuitively constructed and therefore difficult to appreciate. To better understand the conditions that enhance teachers' professional knowledge (PK) development, to benefit student learning in science, greater awareness about the nature and development of teachers' PK is essential. Opportunity for exploring this development exists when the limits of knowledge are reached and can be identified via feelings of uncertainty, surprise and confusion. The human tendency is to hurry through these experiences, however findings from this study suggest that these moments offer the opportunity for learning.

As part of a larger study, semi-structured interviews were conducted with fifteen practicing teachers (six of which were science specialists) to better understand teachers' PK development. The new construct of Pedagogical Equilibrium was suggested as a means of disseminating situations were equilibrium was challenged and learning ensued.

This paper focuses on the challenges to equilibrium that arise when teachers organise for teaching, of which four broad themes emerged: developing teaching and learning approaches; balancing teacher versus learner centered teaching; balancing depth and breadth; and planning for assessment and testing. Science teachers in particular experienced discipline specific challenges related to preparing and undertaking practical work.

Victorian Teachers of Psychology survey: Psychology is a Science? Most definitely!

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Psychology is one of the most popular Victorian Certificate of Education (VCE) studies studied by approximately 70% of females and a science subject. Despite this, psychology is not recognised within the Victorian F-10 and Australian (F-10 and Senior) science curricula. Do teachers of psychology view psychology as a science? In what ways do they view science? Do they think they are teaching psychology in 'science' ways? This paper discusses results from an online 'teaching of psychology' survey. A total of 87 VCE Psychology teachers responded representing a range years in teaching of psychology along with other learning areas. Psychology is placed in the science department in all of the teachers' schools, and over half of the sample of teachers had taught psychology at Years 7 to 10. All but 2 teachers viewed psychology as a science, and reported that they often/ always teach psychology as a science. Interestingly, responses suggested that psychology teachers hold a range of views of science and ways of teaching psychology as a science. Implications for the teaching of psychology and psychology's place in the curriculum are also discussed.

Integration with Arts: Can STEAM Education be Used to Attract and Retain Young Women in STEM?

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Encouraging greater student interest and participation in STEM subjects is a prominent focus in curriculum design across education sectors. Student entry into STEM subjects and courses is declining in Australia and many countries across the globe. Researchers are investigating the potential for more cross-disciplinary approaches to helping students develop STEM skillsets and the STEAM approach to education has emerged from this. The incorporation of arts within STEM education has the potential to encourage young women to develop STEM skills and pursue relevant study and career pathways. STEAMpunk Girls aims to investigate this potential and identify how STEAM education can be used to effectively increase the number of young women interested in STEM, and help them to develop 21st century fluencies to prepare them for the future workforce. This paper describes the first stage of STEAMpunk Girls. Data was collected through focus groups with teachers and pre and post-surveys with students. Findings present a female high school student perspective on STEAM education and engagement. This provides educators with insights to help them design engaging educational experiences. Key ideas, themes and findings from the co-design process are being used to design the STEAMpunk Girls pilot.

What Influence do Science Teachers have in Creating Positive Learning Experiences for Learners of Science?

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What influence do science teachers have in creating positive learning experiences for learners measuring the impact of their decisions on self-efficacy and improved classroom environments.

Through classroom observations and interviews evidence implicates the impact schools have upon science teachers through models of coaching, support, mentoring and the introduction of programs that are intended to improve adolescent student experiences impact on teachers' self-efficacy. Linking to teacher attrition rates from the profession.

The strategies teachers used to manage student behaviours were observed through philosophical assumptions of constructivism based on a phenomenological inquiry. The research provides empirical evidence on how we support science teachers to retain their passion for teaching and how they regain confidence to own the narrative around positive learning environments with adolescent learners.
Key insights from the research show that:

1. Science teachers need to be confident in creating positive classroom environments
2. Current training of skills comes mainly from within the organisation through a social learning model based on outdated strategies
3. A top down model applies in areas of coaching intended as support systems. Leading to beliefs that result in outcomes completely opposed to their intended use.
4. Science teachers changed their teaching practice immediately based on the program
5. Implications for schools around what happens to our teachers while we are busy ensuring our students are set up for their best learning experiences.

Who is Teaching Science in Our High Schools? Exploring Factors Influencing Pre-service Secondary Science Teachers' Decisions to Pursue Teaching as a Career

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A central objective of recent government reports focuses on the important role of education in preparing a skilled and dynamic science, technology, engineering and mathematics (STEM) workforce, with effective teaching in secondary STEM classrooms reliant on the engagement and retention of high-quality STEM teachers. This study sought to explore the factors influencing pre-service secondary science teachers' decisions to pursue teaching as a career. Participants in this study were enrolled in undergraduate and postgraduate teacher education programs at a large, urban Australian university. A total of 12 pre-service teachers enrolled in a science curriculum course participated in the study. Analysis of interview data identified two key factors influencing their decisions, including their perceptions and experiences in high school, and a lack of opportunities in STEM-related fields. Other findings indicated participants expressed positive outlooks regarding their decisions to pursue teaching as a career, and articulated views of science and science teaching aligned with contemporary perspectives in science education. Implications from this study suggest that although these participants are likely to encourage students to consider teaching as a profession, they may not promote STEM-related professions as possible career paths, due to their previous career experiences.

Using Student-Constructed Animation to Facilitate Middle School Students' Conceptual Change in Earth Science

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A number of challenges impacting the quality of Earth science education in Australia and internationally call for research into instructional approaches that best support students' conceptual

understanding. To this end, this study investigated the effectiveness of using a type of student-constructed animation, 'slowmation', to facilitate students' conceptual change. The research questions were: (1) Does the process of constructing a slowmation have a significant effect on students' conceptual change? and (2) How does the process of constructing a slowmation influence students' conceptual change? This study was conducted with ninth grade students (N=95) and was quasi-experimental in design. While two classes constructed a slowmation to represent the geological processes that occur at tectonic plate boundaries (N=52), two classes experienced teaching as usual (N=43). Data were generated using a two-tiered multiple-choice test instrument, the GeoQuiz, which was designed and validated by the researchers, and audio-recordings of students verbalising their thinking during the construction process. A significant improvement was found in the GeoQuiz scores of students who constructed a slowmation, which indicates that conceptual change occurred. Analysis of the qualitative data found that the construction process afforded 'teachable moments' as students recursively checked the accuracy of their representations with their teacher. A range of implications for science education theory and practice, including a tentative framework for learning with slowmation, are also discussed.

A Study on Creating a Picture-story Animation to Communicate an Environmental Problem

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Zoos are informal public institutions in which both children and adults can gain science literacy. The author and students developed a picture-story of 'Ranny Hiroko: An Asian elephant at Tennoji Zoo' to communicate elephants' habitat loss through deforestation. When zoo visitors heard the story while observing the animal, they sympathized with the character of Ranny Hiroko and were interested in learning about the problem. In this research, the picture-story (the picture and story are separate) was altered to a three-minute animation (the picture and story are combined) evaluating how it promoted awareness among non-zoo visitors. Altogether, 36 candidates viewed this animation and described their impressions by a word association. Results revealed that 32 candidates were unaware elephants faced environmental problems. The most frequent impression words among 318 were: sad (27), pitiful (22), cruel (22), lovely pictures (12), painful (11), intelligible contents (10), dark (9), selfish people (8), coexistence (7), affectionate (6), painful (6), environment (6), and importance of knowing (6). These terms indicate that the candidates felt guilty about elephants and faced the dilemma of discovering human being's rich culture was created by victimizing the animal. This animation effectively communicated an environmental problem between humans and wildlife with the public.

Toward a Culturally Contextualised Australian Science Classroom: Addressing Post-colonial Tensions About Scientific Views

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Constructivist science educators support students to favour scientific explanations for their observations of the world in preference to alternative conceptions that are not based in science. These alternative conceptions encompass a continuum from misrepresentations of scientific theory, through socially and culturally contextualised world views, to views based in myth and legend. Given the diversity of school communities, teachers must accommodate socio-cultural ways of knowing as a

component of their practice. In the classroom this may not form a structured part of the program, more typically the discussion arises in response to a question or action. The way that the teacher navigates this discussion is influenced by their own efficacy with respect to the nature of science, and knowledge of cultural perspectives. Discussions need not detract from the teaching of science, rather provide valid context for science understanding. The intention is not to compromise the validity of alternative knowledge systems, but to forefront evidence based scientific practice. The teacher must judge whether this enriches the discussion or confuses students with respect to understanding a scientific concept. To manage these spontaneous interactions we propose a four-part framework based on teacher empathy, self-knowledge, openness, and self-efficacy with respect to the nature of science.

Essential Features of Inquiry in the American Biology Teacher and Journal of Chemical Education Journals

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Research on inquiry has mostly focused on teachers' conceptions of inquiry, implementation of inquiry instruction in science classrooms, student learning, and inquiry coverage in science textbooks. Little is known about inquiry coverage in science practitioner journals that are accessible to teachers and college instructors. This study examined inquiry representation in the *American Biology Teacher* (ABT)and *Journal of Chemical Education* (JCE) journals by analyzing articles that were published from 2000-2015. Results show that over the 16- year period the articles analyzed in ABT and JCE contained at least one feature of inquiry. However, most articles in both journals contained five of the six essential features of inquiry prescribed in the US National Science Education Standards (NRC, 1996), suggesting more partial inquiry than full inquiry activities in both practitioner journals. Very few articles gave priority to engaging learners in scientifically oriented questions. More priority was on collecting evidence, analysis, formulating explanations, connecting explanations to scientific knowledge, and communicating explanations. The degree of variation of essential features of inquiry in the articles was more teacher-centered than student-centered. In general, the representation of inquiry in both practitioner journals was partial inquiry and teacher-centered. Results have implications on inquiry instruction, teacher education, and student learning.

Youth STEM Career Choices

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There is increasing concern that the future demand for STEM graduates will exceed supply (Hackling, Murcia, West & Anderson, 2013). There is a crucial role for school Career Counsellors to assist students in developing their interests and awareness of the current (and future) workforce demands (Falco, 2016). Studies have also shown that parents have by far the greatest influence on youth's career choices (Council of Canadian Academies, 2014).

In this presentation, we will discuss the case study research that explored the influence of parent's attitudes to STEM on students' career interest and self-efficacy and how Career Counsellor's awareness and engagement with STEM impacts on students' career interests. Three schools participated in the research. Semi-structured interviews were held at each school with the career guidance officer, focus groups of students and their parents.

Through thematic analysis, it was evident that students don't make connections between school science and future employment. Students lack knowledge of career options related to STEM and that they don't take science because they don't want to "go into science". Parents and Career Counsellors felt under prepared and resourced to provide youth with up to date insights or advice regarding STEM careers.

Designing a Science Education Lesson: Changing Pre-service Teachers' Views on Science Lessons in Undergraduate School

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We conducted a case study to design a series of science education lessons for the primary school teacher course of undergraduate school. The lessons were aimed at enhancing pre-service teachers' views on science lessons The following design principles were set for the teacher training class dealing with 'science education': (1) Indicate the policy of designing the primary science lesson involving an everyday context. (2) Let students engage in mutual evaluation of the trial lessons repeatedly using a series of components that are essential for the lesson. (3) Let students perform short trial lessons again to overcome the shortcomings found from the trial lesson. At the first and the last session of a series of classes, students were asked to respond to 22 items of a questionnaire to provide their views on science lessons. Each item referred to the desired view of the primary school science lesson that we expected. In the pre-test, over 70% of students chose 'strongly agree' only for six items. However, in the post-test, over 70% of the students chose 'strongly agree' for every single item on the questionnaire. Consequently, it was concluded that the design principles were effective in changing students' views on science lessons.

The South African Science Schooling Curriculum on Issues of Scientific Literacy in addressing Climate Change – a Policy Critique

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Collectively as societies we are not only operating in a knowledge based world, but we are also faced with serious global environmental issues which dictate a relook at the role of science education in preparing students for citizenry and work. In South Africa, the challenge we face is that schooling curriculum policy has been changing sporadically over the last 15 years, resulting in confusing messages being send regarding the goals of learning and teaching of science. Several studies (Nakedi et al. 2012; Lubben & Bennett, 2008) reported a retreat of the South African Physical Sciences curriculum on issues of scientific literacy and societal relevance. This study used comparative document analysis to explore the implications of this retreat by contrasting the current and preceding physical science curriculum policies on issues of scientific literacy, with a focus on the standing of global climate change in these two policy frameworks. Besides the marked diminished potential in promoting procedural knowledge, the study reports a drawback where focus on critical topics relating to global climate change were diminished in the current physical science schooling curriculum. The paper highlights the implications of this withdrawal on the socio-economic stability of our society and offers well considered practical policy measures which could be taken without throwing the system into further chaos.

State of Years 9 and 10 Students' Views of Science and Science Education

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As part of a larger partnership project funded by the *Australian Mathematics and Science Partnerships Program* initiative, this research sought to investigate the state of years 9 and 10 students' perceptions across a range of themes related to science learning. The aim of the partnership project was to address the issue of student disengagement in school science that continues to pose a threat to lifting the participation rates of students undertaking STEM courses and careers. Survey responses obtained from over 1,300 students and focus-group interview data from 162 students in schools in New South Wales, Western Australia and South Australia will be presented. The research themes explored were (i) students' views about science in general (e.g. contribution of science to society, science outside school); (ii) self-conceptions in science (iii) teaching and learning science (iv) how scientists work (v) areas/topics of interest in science (vi) use of digital technology in science learning and (vii) future participation in science that includes intended science subject choices for year 11 and science career decisions. The presentation will discuss similar research conducted in recent years. The research is significant in informing curriculum development and pedagogy.

Multimodal Resources in Generating a Digital Explanation: Mapping the Variety Created by Tertiary Science Students

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In this paper, we consider two research questions: *What kinds of multimodal resources do students use to create blended media? How do they account for their choices?* We present a 'mapping' of the modal variety that students use to create a 'blended media' text, which is a 3-5 minute digital media mash-up that explains an aspect of science to a particular audience. We also present our analysis of student pre- and post-interviews to consider their design choices as they assembled multiple semiotic resources into single texts. We will present clips from several student texts drawn from a data set of over 50 examples from a range of university science learning contexts across Australia. In these texts, tertiary science students may explain a pharmacological process to first-year university students or pre-service teachers may explain a science concept to children. Importantly, these texts use a combination of modal forms to represent scientific meaning.

Results suggest that students' design choices are shaped by both their conceptual understandings and their understandings of multimodal communication. Our work has implications for the role of multimodality in learning and the use of multimodal texts as assessment in contemporary science classrooms.

Fresh Water Literacies: An Interdisciplinary Study with Primary Teachers and Researchers

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An interdisciplinary project based on Fresh Water literacies has involved three case studies in primary schools, two classes on the River Murray and one class in the city near a wetland. The first phase of the project involved provocations around developing a Curriculum for the Anthropocene. The teachers participated in three day workshops where topics such as critical praxis, place based

literacies, citizen science, transdisciplinary approaches to STEM and arts education have been explored. The research team involved, experienced Literacy, and Science Academics and early career Mathematics, English and Indigenous perspectives. The Research model is one of action research, where teachers have one term provocation, one term preparation, then a term implementation and finally a term evaluation. This presentation will discuss innovative approaches, initial outcomes and planning frameworks that have evolved.

Physical and Chemical Change in Textbooks: Twenty Years On!

William P. Palmer, David Treagust

The aim of this study is to revisit the topic of physical and chemical change about which a paper 'Physical and chemical change in textbooks: an initial view' by David Treagust and Bill Palmer was published in *Research in Science Education* (RISE) in 1996. Bill published a number of papers in this area and successfully presented a thesis entitled 'A study of teaching and learning about the paradoxical concept of physical and chemical change' in 2003. The thesis has remained largely unnoticed, but the 1996 paper has attracted a little attention (21 citations). This study will discuss what new ideas have been put forward by the papers citing the 1996 paper and survey the literature since 1996 on physical and chemical change. The question being asked is 'Should physical and chemical change still be taught in schools? The answer would still appear indefinite with the age of the students and their country of origin being major considerations.

Enhancing of Grade 10th Students' Environmental Action Using Socioscientific Issues-Based Teaching

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This research aimed to enhance10th grade students' environmental action using socioscientific issue-based teaching. To evaluate the enhancement, data were collected from twenty-nine students from a high school situated in Bangkok through environmental action questionnaire included open-ended questions, students' artefacts, students' reflective journal and semi-structured interview. Both descriptive statistics and content analysis were used to analyze the data consistent with the purpose of this study. The results indicated that both active and passive students' environmental actions were about 8% increased after teaching the topic of ecology with socioscientific issue. Findings also revealed that students mostly involved in passive environmental action. This study hopes to shed light on environmental education on the importance of environmental action and promoting the ways for teachers to teach in order to enhance students to act on environmental problems with socioscientific issue.

The Development of an Activity for Promoting Pre-service Teacher Technological Pedagogical Content Knowledge (TPCK)

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The purpose of this study was to develop an activity for promoting pre-service teachers to integrate technology in teaching. The participants were thirteen pre-service teachers. The preliminary study showed that all pre-service teachers had limited experiences and did not recognized Law and Act

related to technology. An activity was developed for introducing variety of technologies and how to integrate technology in teaching. The first activity, each group of pre-service teachers designed a learning activity by selecting a concept in their field and integrating appropriate technologies. The pre-service teachers were asked to explain why, when and how to integrate technology into their teaching. The second activity, a pre-service teacher designed their own lesson plan. All pre-service teachers discuss about their lesson plan. At the end of activity, the questionnaire about pre-service teachers' TPCK was implemented. All pre-service teachers respond that they developed their ability to integrate technology in teaching. Most pre-service teachers perceived that their lesson plan promote the students to use technology as tools for learning to reflect student's understanding via artefacts. They also perceived that their lesson plan encouraged the students to aware of Law and Act related to technology. All pre-service teachers' responses were consistent with researcher's assessment.

Case Studies of the Development of Pre-service Science Teachers' Understandings and Practices of Socioscientific Issues (SSIs)-Based Teaching Through an Online Mentoring Program

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Under educational reform, teaching through socioscientific issues (SSIs) is considered to be the way to promote scientific literacy for citizenship as the goal of science teaching and learning. To achieve this goal, Thai pre-service science teachers (PSTs) are expected to be the effective educators. This study was to develop three case studies' understandings and practices of SSIs-based teaching using online mentoring (OM) program. Throughout the OM program, data were collected from online observations, semi-structure interviews, online discussions, and online document reviews, and were analyzed using within-case and cross-case analysis methods. The findings showed that the OM program had positive impacts on their understandings and practices of SSIs-based teaching. The findings showed in term of the changes of case studies' understandings and practices to be in line of SSIs-based teaching as a result of the OM program. For understanding of SSIs-based teaching, they could identify which issues are SSIs more than before. In addition, they knew more about the important of SSIs-based teaching, characteristics of teaching, teaching models, learning assessment of SSIs-based teaching. For teaching practices, they provided more opportunity for their students' sharing ideas, doing higher-order practices in classroom. Moreover, they linked ethics and morals as well as various social dimensions to their teaching content. Therefore, this study can yield practical guidelines which enhance PSTs' understandings and practices about SSIs-based teaching. Hopefully, the OM program could be a guideline for further professional development in the remote learning area.

The Development of Students' Mental Models of Chemical Equilibrium through Argumentation within Model-based Learning

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Previous research on topics such as chemical equilibrium indicates that students' mental models are often inconsistent with the scientific models. The purpose of this study was to investigate how eleventh grade students develop their mental models of chemical equilibrium through Argumentation within Model-based Learning (AMBL). A qualitative research approach was employed as a research methodology, drawing upon classroom observation, student reflective journals and pre-post chemical equilibrium mental models questionnaire (CEMMQ). The CEMMQ consisted of five items covering five

main topics of chemical equilibrium; reversible reaction, dynamic equilibrium, factors affecting equilibrium, equilibrium constant and Le Chatelier's principle. Data were analyzed inductively to identify patterns and categories. The research findings revealed that AMBL could develop students' tentative mental models to scientific models particularly in the topics of reversible reactions and dynamic equilibrium. It was also found that AMBL could provide students with opportunities to use evidence and justification for their arguments and link their understandings at the macroscopic and microscopic levels. The results highlight the need for greater emphasis on the teaching of the role of argumentation in model-based learning.

Which Way Forward for Teaching Primary Science and Technology? Cases of Generalist and Specialist Teachers in NSW Schools

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Concern for the effective design and delivery of high quality Science and Technology for primary school students is at the heart of questions about whether classroom programs are best taught by specialist or generalist teachers. This contentious issue has implications for pre-service teacher education, and raises questions about the broader purpose and nature of primary schooling. In this paper, findings from participatory case study research conducted in six NSW primary schools – 3 with specialist Science and Technology teachers, 3 with Science and Technology taught by generalist classroom teachers – are reported. Participant teachers were nominated by School Principals as 'good' teachers of Science and Technology. Case study data were derived from interviews, lesson observations, teacher reflections, and document analysis. This paper focuses on evidence for the benefits and disadvantages of specialist and generalist models of program planning, design and implementation, including resourcing and professional learning provisions. Strengths and limitations of different models of specialist teaching also are considered. We argue that the complexities in delivering effective, high quality primary Science and Technology extend beyond the specialist or generalist teacher debate. Each case study teacher demonstrated strong pedagogical content knowledge, along with personal enthusiasm for Science and Technology learning; how we promote these characteristics more widely amongst primary teachers seems our professional challenge.

Pre-service Primary Teachers' Voices – reflections of their Experiences in Learning to Teach Science and Technology

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This paper presents perceptions from Master of Teaching students on the impact of a methods unit on their developing knowledge and skills for teaching science and technology. The study was designed to explore the use of toys, diagrams and digital technologies in assisting preservice teachers to overcome learning barriers including low self-efficacy and perceived lack of background knowledge for teaching science. Data collected using Photovoice provides insights into students' reaction to and thinking about their learning experiences. Students critically reflected on the significance of selected images that captured influential aspects of their university classes. Findings indicate factors that lead to the development of positive dispositions towards science and technology. The study revealed that students were conscious of the purposeful strategies used by their lecturer and could relate them to their future practice. An implication of the study is the usefulness of this method in establishing a community of learners through monitoring students' development and evaluating university teaching practice.

Values Relating to the Certainty/Uncertainty of Scientific Knowledge

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How are values relating to the certainty/uncertainty of scientific knowledge presented in public communications? The paper draws upon four studies, carried out over several years, exploring people's perceptions about the nature of scientific knowledge. The studies focused on (1) attendance at a lecture about human genetics, (2) a visit by adults to a science centre, (3) a visit by a different group of adults to a natural history museum, and (4) seven teenagers who experienced a mentoring program in biotechnology. All four studies collected data both before and after participation in the experience, and all had similar findings: Participants enjoyed their experience, believed that they had learned something about science, and became more positive in their perceptions of the value of science, the work done by scientists, and their ability to communicate their research findings to the public. However, participants also tended to become less "scientific" in their thinking about science, particularly in terms of the cumulative nature of scientific knowledge and its inherent uncertainty. Possible explanations are suggested relating to the nature of participants' engagement in their experiences and the ways in which science was communicated in the various presentations.

Mapping Controversies: A Pedagogical Approach for Communicating about Socioscientific Issues

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The aim of this study was to investigate how a pedagogical approach designed to promote productive discourse and undistorted communication (Habermas, 1984) can enable secondary school students to communicate about socioscientific issues (SSIs). A small-scale qualitative study design was employed to explore how a group of 13 Biology students communicated about the badger – cattle controversy in the UK and which types of knowledge they use in this process. A pedagogical approach based on students mapping controversies in combination with asynchronous online communication was designed and implemented across 3 lessons to facilitate their communication process. The approach followed a familiarisation (mapping), exploration (discussing) and consolidation (mapping) stage. Our findings suggest that the approach was effective. Students' controversy maps during the consolidation phase were conceptually different from those in the familiarisation phase, showing that they had a more developed understanding of the complexity of the SSI. The themes found during the consolidation phase were extensively discussed during the exploration phase. The online exchange allowed them to elaborate on their views and thinking, question each other, and draw on a range of knowledge types in deciding what should be done about the controversy. Implications for classroom practice and teacher education are discussed.

Making Reliable Judgments of Quality in Senior Science Assessments

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The redevelopment of senior science syllabuses in Queensland to support the introduction of the new senior assessment system has required the design of new assessment processes. During this

redevelopment process, officers from the Queensland Curriculum and Assessment Authority engaged with education research literature to find information that could be used to inform the design of assessment processes related to making reliable judgments. The research was used to answer the broad question:
How can a central curriculum and assessment authority support teachers to make reliable judgments of the quality of higher-order thinking used by students to complete senior science assessment tasks?
Three minor questions guided engagement with the literature. These were:
1. What linguistic construction of written standards can support teacher-assessors to have a common understanding of 'quality'?
2. What procedural and cognitive processes are employed by people when making judgments?
3. What advice based on the research findings, should be provided to teacher-assessors to support them in making reliable judgments of quality?
This paper presents the relevant findings from the research literature and concludes by identifying six challenges and six recommendations, to improving the ability of teachers across Queensland to make reliable judgments of quality in senior science assessments.

Pre-service Teachers' Knowledge and Understanding Gained about the Environment from Their Participation in Clean Up Australia

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Seldom do days pass without the Australian media making mention of environmental and sustainability issues, and the need for industries and the community to take responsibility for actions that impact on the Australian landscape. Clean Up Australia is the nation's largest, community event where teams of citizens remove trash for their local parks and nature reserves. This study reports on the experiences of 40 pre-service elementary teachers who participated in the 2015-2017 Clean Up Australia event, their developing knowledge and understanding about the environment and sustainability issues gained from that event, and the ability of a university assessment task to identify and challenge these pre-service teachers' views as consumers of manufactured goods. Pre-service teachers submitted written work as part of the assessment and then analysed from an interpretive lens. Findings of the analysis indicated that in general these pre-service teachers found involvement with Clean Up Australia to be a worthwhile part of their learning about the impact of rubbish on the environment and the power of community involvement as a force for good.

Inquiry- based Instruction in Science Classrooms in Qatar: Findings from TIMSS 2015

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The purpose of this study was to explore the status of Inquiry-based instruction in Grade 8 science classrooms in Qatar as perceived by science teachers. The data of 334 science teachers in Qatar who participated in TIMSS 2015 were used to answer the research questions. The teachers were asked to select one of the following responses for each item: Every or almost every lesson (3), about half the lessons(2), some lessons(1), or never (0). The mean of implementation of Inquiry feature represented by the items ranged from 1.01 to 2.49 out of 3 such as :Asking students to explain new content had the highest mean (M= 2.49); Asking students to observe phenomena (M= 2.04); asking students demonstrate experiment (M = 1.97); Asking students to interpret data (1.82) ; Asking students to use

evidence to support science (M = 1.81); Asking students to conduct experiments (M = 1.80); Asking students to plan experiment (M = 1.74); Asking students to present data (M = 1.73); and asking students to do field work was least frequent (M = 1.01). The means for most of the items were less than 2 indicating that the students were moderately offered opportunities to practice inquiry. On the other hand, most of the teachers reported that they had relatively high confidence in teaching science using inquiry. The Professional development programs should more pay attention to inquiry-based instruction and its dimensions. Teachers should be provided with training and working ideas in the context of Qatar on how to promote the participation of students in planning investigations, deciding what data to collect, suggesting procedures for data analyses, interpreting the results, sharing the findings and exchanging ideas with other groups.

Assessing the Impact of Formative Practices on Science Learning Outcomes: A Mixed Methods Study

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This presentation will outline a mixed methods transformative research design to assess the impact of formative practices on science learning outcomes. The design informed the collection of data subsequently used to construct answers to three research questions about the impact of two assessment-related interventions on the nature of and effectiveness of assessment work in junior secondary science. The first intervention took the form of advice to teachers about formative assessment. The second took the form of a low stakes, large scale, test based diagnostic assessment program enhanced by the inclusion of Structure of the Observed Learning Outcome (SOLO). The quantitative data were derived from descriptive and inferential statistics which was applied to the analysis of teacher provided data about their practices and school level test results. The qualitative data were derived from audio recorded interviews and artefacts of assessment practice provided by researcher-selected volunteer science teachers using an interpretive approach. The findings provide good news for students in regional schools and a sound basis for policy advice to the Department. The policy advice to be provided is in keeping with the transformative intention of the research.

Engagement in STEM: "Stuff that Works"

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In this presentation, I will discuss ideas and strategies that promote learning and STEM implementation that can be used directly in the classroom. I will provide arguments for why we need STEM. I will also share my personal history that led to me receiving the Prime Minister's Award for Secondary Science Teaching (2015) and being recognised as a finalist in The Global Teacher Prize (2017).

Ken's commitment to increasing the educational outcomes of science students across NSW has been demonstrated as the founder and coordinator of the iSTEM (invigorating Science, Technology, Engineering and Mathematics) program. This program was personally designed and gives talented science students from a range of schools across his region the opportunity to participate in science enrichment activities on weekends and school holidays.

Understanding the Role of Student Questioning in Their Argumentation: Moving beyond Toulmin's Models

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There has not been sufficient research on the role of student questioning in argumentation, especially outside of formal classroom discourse. This paper presents an analysis of middle school students' talk as they come across an unusual tree with variegated leaves. We found that students used questions to make claims, to disagree and to justify their views. However, they also used questions to become cognizant of what they do not know, to get others to consider contradictions, and to become meaningfully involved in the discourse.

We found that spontaneous discourse that happens in naturalistic settings is complex and requires an analysis that addresses functional, social, and affective aspects. Reducing naturalistic discourse to just claims, evidences, justification, etc., as is done in Toulmin-type analyses, does not exhaust the potential understanding of the discourse. Also, Toulmin's model borrows heavily from ideas of formal logic and hence fails to address issues of gender, class and authority present in most everyday discourse. We found that we need to explicitly study questioning in understanding argumentation. Going further, we have highlighted salient features of our data in which girls argue with boys, a parameter present, not because it's the need of the content, but rather as an underlying familiar cultural practice.

Developing Grade 10th Students' Scientific Explanation in the Topics of Forces, Mass and Laws of Motion through an Argument-driven Inquiry Approach

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This research aimed to investigate grade 10th students' ability in making scientific explanation through Argument-driven inquiry. The given situations were used to elicit the students' ability in making scientific explanations which comprised of claim, evidence, and reasoning. Data were analyzed inductively to categorise the students' answer and calculate the average scores in each component of scientific explanation. The results revealed that the students' ability in making scientific explanation were high in the component of claim, evidence, and reasoning respectively. It was also found that the good characteristic of situation for promoting student's ability in making scientific explanation should relate to the students' interest, prior knowledge, and prior experiences. The teacher should provide enough time for the students to think and make the scientific explanation.

Teaching Primary Science Constructively: Editor's Reflections on Changes Over 20 years of this Research-based University Text

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This is not a standard research presentation. Its content, though, is grounded in science education research. The aim, and hence significance, was to identify, and reflect upon, how research advances

have impacted the content of the successful text, *Teaching primary science constructively (TPSC)* (6th edition available August/September 2017), over the last 20 years. This book has been a long-standing university text for Australian, and more recently New Zealand, pre-service teacher education candidates. The 'methodology' involved a 'first level' content analysis and interpretation by the editor over the six editions.

Constructivist learning theory – in its various forms – underpins *TPSC's* pedagogy and guides the selection of teaching-learning models/sequences and strategies. *TPSC* is an unashamedly research-based book that draws upon, and cites, the most current research and professional literature because, as professionals, teachers need to recognise their inherent beliefs about science, learning science and teaching science and hence make research-based pedagogical decisions. The pedagogical research and curriculum scene has changed over 20 years and altered the 'evidence' and other factors teachers must consider. 'Findings', in this presentation, identify how *TPSC* has addressed these changes (e.g., constructing representations to learn in science is now a major focus). Other changes, and their content implications, are discussed.

Quality Learning~ Teachers Changing Their Practice

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This presentation reports on findings from a whole school approach to teacher professional learning which placed self-improvement directly in the hands of teachers themselves. Set in a primary school, the approach initially aimed to support primary teachers to build their confidence and personal capacity in science education. Actions and support explicitly aimed to effectively nurture teacher interest and capacity to work as self- directed learners, making decisions about what mattered for their own learning and that of their students. A culture of trust and valued collaboration allowed participant teachers to engage in regular, thought provoking and interactive professional dialogue: exposing and challenging each other's thinking and beliefs; capturing data about student learning; and, articulating and extending their professional knowledge. In this presentation, a data set comprising a collection of teachers' professional writing, demonstrates how teachers began to individually interrogate their professional practice to understand more about the relationship between quality learning and teaching. Three themes emerged about the nature of teacher learning: developing purposeful and contextually relevant pedagogical practice; understanding the complex knowledge of professional expertise as seen through the eyes of the teacher-researcher; and, redefining educational leadership to focus on working with teachers rather than directing teaching.

What Teachers Should Know About Contemporary Australian Scientists, and Why

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We report further outcomes of a research project that discovered and documented the variety of ways in which contemporary Australian research scientists interacted with their communities. Data for the study were generated by semi-structured one-on-one interviews that lasted from 90-120 minutes, and interrogated using interpretive phenomenological analysis.

In this paper we focus specifically on data generated from 18 scientists who, as part of their day-to-day work, interact with more or less specific groups with fairly well-defined interests and purposes. We

report on: the range of groups, both 'scientific' and 'non-scientific', with which those scientists interact; what these scientists reported discussing with those groups; and the ways in which they reported approaching their interactions. The scientists described their motivations as including a desire to facilitate productive conversations with the public. The extent to which the work of these contemporary scientists requires interacting with sectors of the general public makes it clear that a student who will become a scientist cannot correctly assume she/he will not work with people. Rather, these findings provide a further warrant for a new look at science in schools.

Partnering with Pre-service Teachers for a School Science Extension Program

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Involving students as partners in learning and teaching opens the door to transformative learning experiences. This study reports on a group of secondary science pre-service teachers who joined with their course coordinator as a teaching team. The team planned and delivered a science extension program at a local primary school. The initiative incorporated partnerships at three levels: between tertiary students and their teacher, between an initial teacher education program and a school, and between primary and secondary science teachers. Pre-service science teachers' planning documents, peer reviews, reflections and conversations combined to tell stories of engagement and learning. Students reported benefits of authentic application of course learning as a collaborative endeavour with teacher and peers. Additionally, the initiative traversed the virtual barrier between secondary and primary science education, promising immediate and projected benefits. This study is part of a growing body of research on partnerships in higher education that has implications for initial teacher education and school science.

Development and Implementation of Socio-scientific Issues-based Learning in Indonesian Secondary School Biology: Students' Experience and Perceptions on the Issue of Breastfeeding

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Socio-scientific issues (SSI) is a topic of great interest in science education research. While much research has argued that SSI learning can improve scientific literacy among secondary school students, SSI-based learning has not been well-developed in science education practice in many countries, particularly in Indonesia. Thus, this study was conducted to understand how students in Indonesia perceived their experience in SSI-based learning in their biology lessons. Involving a class of 11th grade students, this case study developed and implemented a SSI-based learning on the issue of breastfeeding. Data about the students' experience of and perceptions about the lessons were collected through a Likert-type questionnaire, observations, and interviews. The research findings showed a multifaceted dimensions of students' perceptions of SSI-learning, including contextualisation of SSI, attitude toward SSI learning, student involvement, and SSI-learning objectives. These four dimensions of students' perceptions will be further discussed in the presentation.

Grade 10th Students' Scientific Argumentation Skills on Micro-plastic Waste

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This study aims to investigate a class of grade 10th students' scientific argumentation skills on a micro-plastic waste issue. Data were obtained from a situational-oriented test. The test has two sections. The first section provides a rich information regarding to the micro-plastic issue, both pros and cons. Another section is designed to probe students' scientific argumentation skills. In this part, the students are requested to response to three questions: 1) what is your claim on this issue? 2) What are evidences utilized for supporting your claim? And 3) what is your explanation for linking between claim and evidences? Students' answers to these questions were analyzed by critically examine structure of argumentation (claim, evidence, and justification) as well as argumentation quality. Findings show that, most students are able to make claims and choose specific information to support their claims. However, they lack of skills to analyze and elicit significance evidences from the data set to support their claims. The children tend to select only data that support what they value, instead of considering other alternative explanations. Some students struggle to construct sound reasoning for backing up their claims. Implications on these findings for environmental education will be discussed in our presentation.

Japanese Pre-service Science and Technology Teachers' Views on Science and Technology: Why are They Different from Those of Typical Definitions Found in the International Literature?

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The purpose of the study was to investigate Japanese pre-service science and technology teachers' views on science and technology using a text mining method (Higuchi, 2014). A questionnaire consisting of five general questions was administered to 62 initial-year pre-service teachers (38 science and 24 technology majors). While the first two questions asked their interests in science (Question 1) and technology (Question 2) by a 5 point Likert scale, the remaining three requested them to describe freely images of science (Question 3), technology (Question 4) and their mutual relationship (Question 5). The responses to Question 3 and 4 were analyzed by KH Coder. The responses to Question 5 were categorized according to the expressed relationships between science and technology. The results indicated that some of the pre-service teachers' views of certain aspects of science and technology were very different from those of typical definitions found in international literature (e.g., NGSS Lead States, 2013). Ogawa (1995) pointed out that culture and society affect the existence of science. The authors attempt to decipher the Japanese pre-service teachers' views from Japanese historical and educational perspective.

Scaffolding Grade 10th Students' Scientific Conceptions on Digestive System through the Lens of Epistemological and Affective Perspectives

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This study aims to elicit appropriate teaching strategies, under the lens of epistemological and affective perspectives, for scaffolding students' pre-instructional concepts on digestive system to

science concepts. The participants were 29 tenth graders in a Biology class of a magnet school in Bangkok. Data were obtained from biology teacher's journal, video-records of the lessons, student artifacts, and student comments on the classroom instructions. The appropriate teaching strategies were found through an inductive data analysis. Findings reveal that proper ways for helping student to restructure his/her conceptual framework on science concepts could be an activity that allow the leaners to: 1) physically engage (see, touch, smell, dissect) with real objects; 2) evaluate their peers' pre-instructional concepts; 3) debate on difference and similarity between their concepts and other possible explanations; and finally 4) edit their works after experienced some learning activities. These findings help to fulfil a gap on what science teachers should do to facilitate students' reconstruction of conceptual schemes to meet with intended science concepts. We are looking for further discussion on other appropriate methods that support conceptual change in real classroom settings.

Enhancing Grade 11 Students' Views of Nature of Science through Explicit Nature of Science Approach with Argumentation

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The purpose of this study was to investigate students' views of NOS during engaging explicit nature of science (NOS) approach with argumentation integrated in the topic of photosynthesis. The participants were forty-seven grade 11 students. A qualitative research approach was employed as a research methodology, drawing upon teacher reflective journals, student reflective journals and pre-post open-ended NOS questionnaire. The questionnaire consisted of 11 items covering 9 aspects: scientific definition; scientific experiment; subjectivity in science (theory-ladenness); empirical evidence; differences between science and technology; the creative and imaginative nature of scientific knowledge; observations and inference; social and cultural influences on science; and scientific theories and laws. Data were analyzed by inductive process; interpreting and inferring data. The research findings indicated that at the end of the intervention, students' views of NOS had improved from naïve to transitional views and to informed views in all the aspects. However, some aspects such as scientific experimentation and scientific theories and laws were slightly developed. It was also found that argumentation was a key role in engaging discussion about NOS and enhancing students' views of NOS.

Development of Critical Thinking for Grade 11 Students Using Problem-based Learning with Forensic Science Activities

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This study aims to 1) Develop problem-based learning using forensic science activities, and 2) compare critical thinking (CT) before and after the implementation of teaching and learning activities. Thirty two of 11th graders who were studying in the second semester of 2016 academic year of Khon Kaen University Demonstration School were the target group. Pre-experimental design with one group pre-test post-test design was deployed in order to collect data. A designed forensics activities and lesson plan incorporated the forensics activities were used as tools for teaching and learning activities, while the standard CT, The Cornell Critical Thinking Test Level X, was used to collect CT ability. Results show that 1) the quality of Forensic science activities evaluated by experts were at very good level, and 2) statistical analysis of CT before and after the implementation of teaching and learning activities indicates that CT is significant improved in all aspect of CT ($\alpha < .05$). This can be concluded that the problem-based learning using forensic science activities can improve CT.

Exploring a Culture of Co-operation and Co-construction in Year 9 Science New Opportunities for Science Teachers and Students Working in Flexible Learning Spaces

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This study explored the opportunities in Year 9 science classes where teaching strategies of student co-operation and co-construction were considered. The term co-operation describes students sharing a task together, students having the opportunity to work and interact with their teacher and their peers. By contrast the essence of the term co-construction is to create knowledge with others- a kind of knowledge building. With these approaches in mind, the New Zealand Ministry of Education is encouraging schools to update to more flexible learning spaces (FLS) and activate teaching strategies that augment such environments. This yearlong exploration was with five secondary science teachers at different schools in the central North Island region who have initiated science programmes where students have increased opportunity to be co-operative and co-constructive. The science faculties in this study have had changes to their physical settings creating large open rooms where 60 or more students can work, adjoining rooms with practical science workbenches and smaller break out rooms. Data to inform the case study came from audiotaped teacher workshops, teacher interviews, a student questionnaire and classroom observations. It is titled "The Sprout" to symbolise a rising opportunity to further understand the complexities of adopting this trend.

Thai Science Students' Conceptions of Stoichiometry

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The objectives of this study were to explore Thai tenth grade science students' conceptions of stoichiometry and to categorize those conceptions with respect to scientific conceptions. The participants included thirty students in tenth grade level from a school, run and administered by one large university situated in Bangkok, Thailand. The students were asked to complete a chemistry concept test in the topic of stoichiometry. The test examined the conceptions of atomic mass, molecular mass, relationship between a mole and Avogadro's number, relationship between the number of moles and the mass, relationship between moles and volume of a gas, percent concentration, molar concentration, molal concentration, chemical equation, law of conservation of mass and law of constant proportion. Moreover, they were interviewed according to the results of the test. The results showed that the students' conceptions varied from scientific conceptions to alternative conceptions. They had mostly scientific conceptions. While some of them had alternative conception in the topic of chemical equation.

The Study of Tenth Grade Students' Conceptions in Forming of Ionic Bonding and Motivational Beliefs Through Conceptual Change Approach: Analogy and Application Software (4D Elements©)

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This qualitative research was to study students' conceptions in forming of ionic bonding and motivational beliefs through conceptual change approach. The participants were 27 students in

science enrichment classroom. The preliminary study showed that most students said forming of ionic bonding was boring, abstract and difficult to understand. The analogy and application software (4D Elements©) were used because this application helped students saw the chemical phenomena of forming ionic bonding more obviously and analogy could promote students to be interested in chemistry. The students' conceptions were collected by Ionic Bonding concept test and worksheet, while students' motivational beliefs were elicited by motivational beliefs questionnaire, exit slip and interview. Data were analyzed by categorizing into groups based on scientific conceptions. Findings revealed that application software (4D Elements©) encouraged students' conceptions in forming of ionic especially in an issue of explanation in macroscopic level of chemical reaction in forming ionic bonding. Analogy facilitated students' understanding about how electrons transfer between metal and non-metal. Moreover, this lesson showed the usefulness for promoting motivational belief. Most students increased their interests and self-efficacy because they had opportunities to discuss and present their ideas.

Enhancing 10th Grade Students' Scientific Explanation of Ecosystems Using Socioscientific Issue-Based Teaching

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The objective of this classroom action research was to enhance students' scientific explanation of ecosystems through socioscientific issue-based teaching. The participants of this study comprised 28 students in 10th grade from a laboratory school in Bangkok. The data were obtained by administering the scientific explanation test, student worksheets and semi-structured interview. The quantitative data were analyzed using means, frequencies and percentages, while the qualitative data were analyzed by content analysis. The findings demonstrated that students improved their scientific explanation scores from 38.84% to 59.67%. Moreover, they also developed in all scientific explanation components, which includes claim, evidence and reasoning. The biggest improvement was in reasoning, followed by evidence and claim, respectively. This research indicated that socioscientific issue-based teaching can enhance the students' scientific explanation ability especially in reasoning.

Evaluating the Aboriginal Summer School for Excellence in Technology and Science (ASSETS)

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Context: CSIRO, supported by BHP Billiton Foundation, are half-way through their five-year $28m Indigenous STEM Education Project aimed at increasing participation and achievement of Indigenous students in STEM subjects and careers.

Significance: The project is currently reaching over 5,800 Indigenous students a year. Each of the project's six program elements enact one or more of the core project methodologies of academic excellence in curriculum development, cultural relevant pedagogies and content, high expectations extra-curricula engagement, and personalised support.

Aim: To present initial quantitative and qualitative student and parent data relating to the ASSETS program element. This data will be contextualised with the broader project research strategy.

Methods: Students (n=100) attended one of three summer schools in December 2016 or January 2017. They were invited to complete a pre and post questionnaire. Parents were also invited to

complete a questionnaire during Term 1 2017. Data was analysed with SPSS software to determine changes in key indicators relating to the project's impact pathways.

Results: Students showed increased awareness of STEM careers, an increased appreciation of the link between their cultural identity and STEM careers and increased likelihood of choosing STEM subjects in Years 11 and 12. These results are analysed in respect to family and peer support structures and other social and demographic characteristics.

Investigating a Flipped Classroom Approach to Foster Learning and Engagement in Science and Technology Education at the Undergraduate Level

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One of the challenges for science educators in undergraduate primary teacher education is to improve student knowledge and understanding of scientific concepts. This paper outlines how the two authors evaluated a flipped classroom approach in the delivery of content in an undergraduate unit titled, 'Scientific Discovery and Inventions' at Western Sydney University. For the first half of the unit, the first author focused on the nature of scientific discovery while the second author focused on inventions in the second half of the unit. Most of the content was delivered through on-line lectures and tutorials with four face-to-face tutorials. As an example, the second face-to-face tutorial explored how life may be detected on Mars and drew on the scientific discovery of extremophiles on Earth and what conditions can life exist and what makes a planet Earth-like and thus could harbour life. A series of inquiry activities helped students engage, explore, explain, elaborate and evaluate key ideas or concepts. The authors will discuss how they evaluated student feedback to using a flipped classroom approach to learning about scientific discovery and inventions and discuss some of the implications on curriculum design and the assessment of student learning.

Fourth Year Teacher Education Students Who perceive They Can Teach Primary Science are Motivated and Know the Science

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In this paper, we investigated fourth year primary education students' achievement motivation, interest and efficacy in teaching primary science. One hundred and nine final year primary education students completed an online survey after finishing a required primary science teaching methods unit. Linear regression analysis was conducted to develop a model to predict achievement motivation. The results showed that interest in science predicts achievement motivation. Further linear regression analysis was conducted to identify the underlying variables and results indicated that interest is predicted by enjoyment of science. Science content knowledge had no significant effect on the prediction of these two constructs. However, to become a teacher it is expected that students will be able to teach science. Efficacy was included in further analyses to investigate students' perception of their capability to teach primary science. Teacher efficacy was found to be predicted by science content knowledge, enjoyment of science, and the absence of anxiety. Therefore, our results indicate that students with a higher knowledge of science, who enjoy studying science, and who are not anxious about studying science, showed a high level of science teacher efficacy.

Embodied Experience of Balance in Solving Problems with Levers

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There is increasing recognition that human cognition is necessarily and fundamentally embodied (Hall & Nemirovsky, 2012; Lakoff & Johnson, 2008; Lakoff & Núñez, 2000; Núñez, Edwards & Matos, 1999). A central thesis in theories of embodied cognition is that cognitive processes are deeply rooted in the body's interactions with the world (Barsalou, 2008; Wilson, 2002). This paper investigates the role of the body in student sense-making of a series of lever problems in the Science of Learning Research Centre (SLRC) Classroom which were designed specifically to explore inquiry-based science learning involving representation construction in a collaborative learning environment. The sessions were documented using multiple video and audio recording facilities, allowing for close scrutiny of speech, gestures and actions by each individual student. The analysis of the SLRC data demonstrates how students' bodily experience of balance is manifested and translated into other forms of representations as they attempted to understand, represent and solve the lever problems. This paper argues that science learning is embodied in three key senses: based in perception and action; grounded in the physical environment; and rooted in everyday bodily experiences. Abstract concepts such as equilibrium can be regarded as conceptual extensions of the embodied experiences of balance.

Science and Mathematics Teachers' Perceptions of Students' Collaborative Problem Solving Skills

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This study investigated teachers' perceptions of students' collaborative problem solving (i.e. CPS) skills in Taiwan. A survey method by snowball sampling was adopted in the study. There are totally 234 teachers (107 science teachers, 50 mathematics teachers, and 77 multiple subject teachers) responded to the survey. The survey questionnaire (Teacher's Perceptions of Students' Collaborative Problem Solving Skills, TPOS-CPS) consists of 24 items, which is based on PISA 2015 CPS framework, allow teachers to check their expectations to students and students actual performance in classroom on CPS skills. The reliability for teacher expectation scale is 0.970 and for actual scale is 0.962. Descriptive statistics, paired sample *t* test and ANOVA with SPSS 20 were used for data analysis. The results indicated that: 1. Teachers agreed that their students are able to show two core CPS skills in classroom, which include "establishing and maintaining shared understanding", and "planning and executing." 2. A significant differences exist between teachers' expectations and their perceptions of students' actual performances on CPS skills. 3. Teaching subjects is a factor influence teachers' expectations of students' CPS skills. Level of teaching and gender influences teachers' perceptions of students' actual performance in classroom. Teaching experience has no effect.

Using Representational Challenge for Productive Scientific Discussions in Year 11 Science Classes

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This study explored a representation-creation pedagogy intervention based on an active process involving students collaborating to construct and critique of their own animations and those of others. The teaching sequence for the investigation consisted of interdependent elements including pairs of students creating their own animations, teacher guidance and discussions to critique the animations.

Students created and analysed multiple representations in reaching conceptual consensus. They identified strengths and weakness of the conceptions and the ways in which they represented these views. The representational construction approach underpinned the learning experience with students creating animations and negotiating meaning in extended small group collaboration and through whole class discussions. They also watched expert animations and critiqued them, highlighting the similarities and differences between the 'expert' animations and their own. The results showed that discussions about students own animations allowed students' ideas to be made explicit and created a learning environment in which students not only asked questions and clarified their own ideas but also compared and contrasted their ideas with those of other students. Students gained confidence during the process and learned how to critique even the expert animations.

Patterns of Students' Diagram Construction: A Case of Species Extinction

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The ability to comprehend and construct graphical representations is important to science literacy, since it facilitates communication in science. However, diagrammatical literacy is not innate. Diagrams carry messages of how multiple variables interact, so readers must be able to recognize graphical features and interpret the messages being implied. Effective strategies for developing students' diagrammatical literacy include interpreting variable relationships and diagram construction. This study presents a 3-hour course for developing high school students' graphical literacy in science. A total of 60 students were asked to play a card game that simulates phenomena related to species extinction. The game also involved activities such as collecting animal data and making corresponding diagrams. The results illustrate patterns in the students' organization of variables and their ability to plot results in diagrams. Additionally, suggestions regarding courses to enhance students' diagrammatic literacy are offered.

Identifying and Comparing Representational Schemes for Producing Interpretive Explanations in Dynamics, Thermal Physics and Electromagnetic Induction

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Producing a scientific explanation entails the competency to orchestrate a set of unified representations (e.g., textual, diagram, gesture), to generate and advance meanings. This study aims to identify and compare the representational schemes (RS) for producing law-based explanations in Dynamics, Thermal Physics and Electromagnetic Induction (EMI). We analysed students' explanations produced during think-aloud interviews using Lemke's multimodal framework. We found that while mathematical representation was a key resource, their RSs were topic-dependent. Dynamics entails the transformation of textual description of phenomenon to vector diagram to identify the presence and attributes of forces, and to vector equation to relate force and motion. For thermal physics, textual representations were transformed to mathematical symbols and equation. For EMI, diagrams and gestures became prominent to think about the spatio-temporal elements when deducing the changes in magnetic fields and current in a conductor over time. We attribute the differences to their ontological nature – vectors are useful devices to reason about the magnitude and direction of forces; arithmetic for increase/decrease in energy, and gestures and images for rate of change in EMI. Findings imply that teaching physics and teachers' knowledge should include understanding the relationship of representations to content and with one another, besides content knowledge.

PROGRAM

WEDNESDAY, 28 JUNE 2017

8.30am — **OFFICIAL WELCOME TO ASERA 2017**
Aerial Function Centre, Building 10, Level 7

	WATTLE Room	THOMAS Room	BROADWAY Room	JONES Room	HARRIS Room
9am – 9.40am SESSION 1	**Vaille Dawson, Katherine Carson** Teaching of argumentation and socio-scientific issues in three diverse schools **Chair: Simon Taylor**	**Lihua Xu, Russell Tytler, Joseph Ferguson** Embodied experience of balance in solving problems with levers **Chair: George Aranda**	**Gurinder Singh, Karen Haydock** Understanding the role of student questioning in their argumentation: Moving beyond Toulmin's models **Chair: Nuttawan Sirithon**	**Les Vozzo, Jessy Abraham** Investigating a flipped classroom approach to foster learning and engagement in science and technology education at the undergraduate level **Chair: Wendy Nielsen**	**Dorothy V Smith, Pamela J Mulhall, Richard F Gunstone, Christina E Hart** What Teachers Should Know About Contemporary Aust Scientists, and Why? **Chair: Teerana Chumsaeng**
9.45am – 10.25am SESSION 2	**Simon Taylor** Exploring a culture of co-operation and co-construction in year 9 science: New opportunities for science teachers and students working in flexible learning spaces **Chair: Vaille Dawson**	**George Aranda, Joseph Ferguson** Metarepresentational practices in an inquiry science classroom **Chair: Lihua Xu**	**Nuttawan Sirithon, Ekgapoom Jantarakantee** Developing grade 10 students' scientific explanations in the topics of forces, mass and laws of motion through an argument-driven inquiry approach **Chair: Gurinder Singh Homi**	**Wendy Nielsen, Helen Georgiou, Pauline Jones, Annette Turney** Multimodal resources in generating a digital explanation: Mapping the variety created by tertiary science students **Chair: Les Vozzo**	**Teerana Chumsaeng, Ekgapoom Jantarakantee** Using a context-based approach to develop grade 10 students' scientific explanation ability in an equilibrium unit **Chair: Dorothy V Smith**

MORNING TEA 10.25am to 10.45am - Breakout areas & Balcony

POSTER PRESENTATION - SESSION 1 - Aerial Function Centre, Lobby Area

10.25am – 11.30am	**Yi-Fen Yeh** Patterns of students' diagram construction: A case of species extinction	**Thepsathit Taruwan, Parichat Saenna** Development of critical thinking for grade 11 students using problem-based learning with forensic science activities	**Eunyoung Jeong** The effect of introducing socio-scientific issues in a college biology course for pre-service science teachers	**Shiho Miyake** A study on creating a picture-story animation to communicate an environmental problem	**Panisara Supanya, Jeerawan Ketsing, Ratcha Chaichana** Grade 10 students' scientific argumentation skills on micro-plastic waste

WEDNESDAY, 28 JUNE 2017			WATTLE Room	THOMAS Room	BROADWAY Room	JONES Room
	10.50-11.30am	SESSION 3	**William. P. Palmer, David Treagust** Physical and chemical change in textbooks: twenty years on! **Chair: Linda Hobbs**	**Boris Handal, Kate Winchester, Kevin Watson, Marguerite Maher** STEM education curricular models **Chair: Carol R Aldous**	**Ko-Hui Lu , Pei-Yu Yao, Kuo-Hua Wang** High school teachers' perceptions of teaching collaborative problem solving skills in science and mathematics **Chair: Kazumasa Takahashi**	**Jessy Abraham, Lynde Tan** "It was interesting, but some of it almost killed my brain": Student responses to senior secondary physics curriculum in NSW **Chair: Jennifer Yeo**
	11.35am – 12.15pm	SESSION 4	**Hunkoog Jho** The parallel vision and creativity between science and art in the 20th century: A case study of paintings of Rene Magritte from the Copenhagen interpretation **Chair: William P. Palmer**	**Carol R Aldous** Boundary crossing, STEM industry engagement and communities of practice: Bridging the gap between theoretical science knowledge and its application in society. Preliminary findings **Chair: Frackson Mumba**	**Kazumasa Takahashi, Tadahiro Koizumi** Japanese pre-service science and technology teachers' views on science and technology: Why are they different from those of typical definitions found in the international literature? **Chair: Ko-Hui Lu**	**Jennifer Yeo, John Kenward Gilbert** Identifying and comparing representational schemes for producing interpretive explanations in dynamics, thermal physics and electromagnetic induction **Chair: Lihua Xu**
	12.20pm – 1pm	SESSION 5	**Linda Hobbs, Chris Speldewinde, Coral Campbell** Learning to teach out-of-field: Positioning, agency, continuity and expertise **Chair: Hunkoog Jho**	**Frackson Mumba, Laura Ochs, Sara Blankenship, Vivien Mweene Chadalengula** Essential features of inquiry in the *American Biology Teacher* and *Journal of Chemical Education* journals **Chair: Boris Handal**	**Pei-Yu Yao, Ko-Hui Lu, Kuo-Hua Wang** Science and mathematics teachers' perceptions of students' collaborative problem solving skills **Chair: Kazumasa Takahashi**	**Wendy Jobling, Lihua Xu, Wanty Widjaja** Professional noticing of student science and mathematics reasoning by primary school teachers **Chair: Jessy Abraham**
	LUNCH 1pm to 1.45pm - Breakout areas & Balcony					
	1.50pm – 2.30pm	SESSION 6	**Léonie Rennie** Values relating to the certainty/uncertainty of scientific knowledge **Chair: Deya Chakraborty**	**Anupong Praisri, Chatree Faikhamta, Vittaya Punsuvon** The development of students' mental models of chemical equilibrium through argumentation within model-based learning **Chair: Karen Murcia**	**Christine Preston** Pre-service primary teachers' voices: Reflections of their experiences in learning to teach science and technology **Chair: Ange Fitzgerald**	**Jutamas Kanwong, Pongprapan Pongsophon, Teerasak E-kobon** A teacher's perspective on the good practice of promoting moral reasoning in a biology classroom **Chair: Jennifer Mansfield**
	10.25am –	SESSION 7	**Deya Chakraborty** Science practical work of IER: nature, impact and improvement **Chair: Léonie Rennie**	**Karen Murcia, John Williams** Youth STEM career choices **Chair: Anupong Praisri**	**Ange Fitzgerald** Inspiring primary science pre-service teachers as researchers **Chair: Christine Preston**	**Jennifer Mansfield** Exploring the nature of challenges to science teachers' pedagogical equilibrium when organising for teaching **Chair: Jutamas Kanwong**

WEDNESDAY, 28 JUNE 2017						
AFTERNOON TEA 3.15pm to 3.30pm - Breakout areas & Balcony						
		WATTLE Room	**THOMAS Room**	**BROADWAY Room**	**JONES Room**	**HARRIS Room**
3.35pm – 4.15pm	SESSION 8	**Natchiya Tananuson, Jeerawan Ketsing, Wirasak Fungfuang** Scaffolding grade 10 students' scientific conceptions on digestive system through the lens of epistemological and affective perspectives **Chair: Nattakid Thongnoy**	**Maya Marcus, Sonia Saddiqui** Integration with arts: Can STEAM education be used to attract and retain young women in STEM? **Chair: David F. Treagust**	**Kelly-Anne Jawerth, Jennifer Donovan** Determining the most appropriate model to guide policy development for gifted and talented science students in NSW **Chair: Sirinoot Khemkong**	**Nouf Mohammed Albadi, Jean Harkins, John Mitchell O'Toole** Saudi Year 10 Physics teacher and student perceptions of recent reforms in Secondary Science education **Chair: Reece Mills**	**Leah Moor, B.Pearce** Toward a Culturally Contextualised Australian Science Classroom: Addressing Post-colonial Tensions about Scientific Views **Chair: Megan Ennes**
4.20pm – 5pm	SESSION 9	**Nattakid Thongnoy, Sasithep Pitiporntapin, Pramote Chumnanpuen, Partorn Phongpaijit** Enhancing 10th Grade students' scientific explanation of ecosystems using socio-scientific issue-based teaching **Chair: Natchiya Tananuson**	**Agung W. Subiantoro, David F. Treagust, Kok-Sing Tang** Development and implementation of socio-scientific issues-based learning in Indonesian secondary school biology: Students' experience and perceptions on the issue of breastfeeding **Chair: Maya Marcus**	**Sirinoot Khemkong, Jeerawan Ketsing and Teerasak E-gobon** Grade 11 gifted students' scientific reasoning ability **Chair: Kelly-Anne Jawerth**	**Reece Mills, Louisa Tomas, Brian Lewthwaite** Using student-constructed animation to facilitate middle school students' conceptual change in earth science **Chair: Nouf Mohammed Albadi**	**Megan Ennes, M.Gail Jones, Emily Cayton, Katherine Chesnutt, Pamela Huff** Educator self-efficacy in informal science centers **Chair: Leah Moore**
FIRESIDE CHAT 5.30pm to 7pm – Building 10, Level 4 – School of Education (use lifts to Level 4)						

THURSDAY, 29 JUNE 2017		WATTLE Room	THOMAS Room	BROADWAY Room	JONES Room	HARRIS Room
8.30am – 9.10am	SESSION 1	**Deepa Dewali Chand, John Kenny, Sharon Fraser** Drawings as a vehicle for student generated representations to learning of sciences in Fijian primary schools **Chair: Stephen Fogwill**	**Amanda Woods-McConney, Marold Wosnitza, Cheryl Jones** Fourth-year teacher education students who perceive they can teach primary science are motivated and know the science **Chair: Keith Skamp**	**Sung-Tao Lee, Ke-Hsuan Zeng** A study of science reading scaffolding effects for high school students toward science news texts in Taiwan **Chair: Mpunki Nakedi**	**Rebecca Cooper, Karen Marangio** Establishing a school and science education partnership: A science teacher education perspective **Chair: Joanne Burke**	**Pattamporn Pimthong** The development of an activity for promoting pre-service teacher technological pedagogical content knowledge (TPCK) **Chair: Tim Strohfeldt**
9.15am – 9.55am	SESSION 2	**Zeynep Yaseen** Using representational challenge for productive scientific discussions in Year 11 science classes **Chair: Stephen Fogwill**	**Keith Skamp** Teaching primary science constructively: Editor's reflections on changes over 20 years of this research-based university text **Chair: Amanda Woods-McConney**	**Saed Sabah** Inquiry-based instruction in science classrooms in Qatar: findings from TIMSS 2015 **Chair: Sung-Tao Lee**	**Joanne Burke,** Case studies of excellent science teachers' beliefs and practice **Chair: Rebecca Cooper**	**Davis Baptiste Jn, David Palmer, Jennifer Archer** Preservice teachers' conceptions of how to increase students' interest in science **Chair: Wilhelmina van Rooy**
10am – 10.40am	SESSION 3	**Stephen Fogwill** Student-generated analogies: Windows towards canonical understandings of science **Chair: Zeynep Yaseen**	**Jennifer Donovan, Carole Haeusler** Should primary children be taught the atomic-molecular theory of matter? **Chair: Amanda Woods-McConney**	**Mpunki Nakedi** The South African science schooling curriculum on issues of scientific literacy in addressing climate change – a policy critique **Chair: Sung-Tao Lee**	**Christine V. McDonald** Who is teaching science in our high schools? Exploring factors influencing pre-service secondary science teachers' decisions to pursue teaching as a career **Chair: Joanne Burke**	**Wilhelmina van Rooy** Pre-service primary teachers' knowledge and understanding gained about the environment from their participation in Clean Up Australia **Chair: Pattamporn Pimthong**
MORNING TEA 10.40am to 11am - Breakout areas & Balcony						
POSTER PRESENTATION - SESSION 2 - Aerial Function Centre, Lobby Area						
8.30am – 9.10am		**Hsiao-Hui Lin, Sieh-Hwa Lin, Hsin-Kai Wu** Developing and Validating a Constructed-Response Assessment of Scientific Abilities: A Case of the Optics Unit	**Sung-Pei Chien, Hsiao-Hui Lin, Hsin-Kai Wu, Pai-Hsing Wu** Examining the impacts of science teachers' practice and beliefs about technology-based assessments on students' performances: A hierarchical linear modelling approach	**Sung-Tao Lee, Ying-Chun Chen** The explorations of frames and framing within science news regarding genetically modified organisms in Taiwan	**Kudanaree Tanwannarak, Chatree Faikhamta, Wachiryah Thong-asa** Enhancing Grade 11 Students' Views of Nature of Science through Explicit Nature of Science Approach with Argumentation	**Hayashi Nakayama, Tomokazu Yamamoto** Designing a science education lesson: changing preservice teachers' views on science lessons in undergraduate school	**Kanyarat Thanaphatwetphisit, Chittamas Suksawang, Boontana Wannalerse** Thai science students' conceptions of stoichiometry

THURSDAY, 29 JUNE 2017			WATTLE Room	THOMAS Room	BROADWAY Room	JONES Room	HARRIS Room
	11.05am – 11.45am	SESSION 4	**Karen Marangio** Victorian teachers of psychology survey: Psychology is a science? Most definitely! **Chair: Tracey-Ann Palmer**	**David-Samuel Di Fuccia** Lab work as an everyday assessment tool **Chair: Jim Scott**	**Coral Campbell, Chris Speldewinde, Christine Howitt, Amy MacDonald** Early childhood teachers' STEM pedagogy and practices: A snapshot **Chair: Kimberley Pressick-Kilborn**	**Dean Cairns, Shaljan Areepattamannil** Exploring the relations of teacher-directed instruction, adaptive instruction and enquiry-based instruction to science achievement and dispositions in 68 countries **Chair: Wan Ng**	**Joseph Ferguson, George Aranda, Radhika Gorur** Studying teacher intervention through example: Purposeful selection from rich video data sets **Chair: Ruth Fentie**
			ASERA AGM 11.50am to 12.45pm ~ THOMAS Room				
			LUNCH 12.50pm to 1.45pm - Breakout areas & Balcony				
	1.50pm – 2.30pm	SESSION 5	**Mareike Frevert, David-Samuel Di Fuccia** Contemporary science in chemistry teacher education **Chair: Tim Strohfeldt**	**Joseph Ferguson** Exploring the nature of science students' computer-mediated abductive reasoning **Chair: Siriya Thongloleart**	**Worawan Phanpreeda, Sasithep Pitiporntapin, Pramote Chumnanpuen, Suradet Sritha** Enhancing of Grade 10 students' environmental action using socio-scientific issues-based teaching. **Chair: Willeke Rietdijk**	**Brendan Cooney, Azra Moeed** Making Connections **Chair: James P. Davis**	**Michael Tynan, Tom Keenan** Evaluating the Aboriginal summer school for excellence in technology and science (assets) **Chair: Debra Panizzon**
	2.35pm – 3.16pm	SESSION 6	**Sasithep Pitiporntapin, N. Yutakom, T. D. Sadler** Case studies of the development of pre-service science teachers' understandings and practices of socio-scientific issues (ssis)-based teaching through an online mentoring program **Chair: Mareike Frevert**	**Bette Davidowitz, Marissa Rollnick, Marietjie Potgieter** A comparison between the knowledge bases of chemists and teachers for teaching organic chemistry **Chair: Joseph Ferguson**	**Willeke Rietdijk, Andri Christodoulou, Marcus Grace, Ralph Levinson** Mapping controversies: a pedagogical approach for communicating about socio-scientific issues **Chair: Worawan Phanpreeda**	**James P. Davis, Alberto Bellocchi** Using a sketch map as a conceptual metaphor: A micro-sociological perspective **Chair: Kathryn Garthwaite**	**Anne T Galvin, Rekha B Koul** Impacts of NAPLAN preparation impacting on the teaching of science to Stage 3 students in New South Wales schools? **Chair: Michael Tynan**

			WATTLE Room	THOMAS Room	BROADWAY Room	JONES Room	HARRIS Room
THURSDAY, 29 JUNE 2017	3.20pm – 4pm	SESSION 7	**Tim Strohfeldt, Margaret Marshman** Partnering with preservice teachers for a school science extension program **Chair: Mareike Frevert**	**Siriya Thongloleart, Pattamaporn Pimthong, Aphisit Songsasen** The study of 10th Grade students' conceptions in forming of ionic bonding and motivational beliefs through conceptual change approach: analogy and application software (4d elements©) **Chair: Joseph Ferguson**	**Kian Keong Aloysius, Ong Ai Choo Jennifer, Yeo Kim Chwee Daniel, Tan Poh Hiang** Investigating experienced teachers' pedagogical content knowledge (PCK) in representation-based instruction: A sociocultural perspective **Chair: Worawan Phanpreeda**	**Kathryn Garthwaite** Developing a model to analyse secondary students' perceptions of nature in relation to a biodiversity rescue **Chair: James P. Davis**	**Deborah Corrigan, Debra Panizzon** Exploring the role of STEM education in relation to innovation and entrepreneurship as economic change agents **Chair: Anne T Galvin**
	AFTERNOON TEA 4pm to 4.20pm - Breakout areas & Balcony						
	CONFERENCE DINNER 7pm to 10pm ~ Dockside, Cockle Bay						

FRIDAY, 30 JUNE 2017			WATTLE Room	THOMAS Room	BROADWAY Room	JONES Room	HARRIS Room
	9.15am – 9.55am	SESSION 1	**Jim Scott** Assessing the impact of formative practices on science learning outcomes: A mixed methods study **Chair: Ken Silburn**	**Caroline McCarty** What influence do science teachers have in creating positive learning experiences for learners of science? **Chair: Dylan Roche**	**Donna King, Terry Lyons, Les Dawes, Tanya Doyle, Megan O'Loughlin** Affordances and constraints of pre-service teachers' design of STEM Resources on Demand (STEMROD) **Chair: David Jeffries**	**Jan van Driel, Rebecca Cooper** Analysing science teachers' pedagogical content knowledge: the second PCK summit **Chair: Kathleen Hayes**	**Matthew Kearney, Tracey-Ann Palmer, Sandy Schuck** Optimising mobile learning in Science Education Part 1 **Chair: Peter Aubusson**
	10am – 10.40am	SESSION 2	**Ken Silburn** Engagement of STEM: "Stuff that works" **Chair: Jim Scott**	**Dylan Roche** Making reliable judgments of quality in senior science assessments **Chair: Caroline McCarty**	**David Jeffries, David Curtis** STEM subject choice in Year 12: the influence of demographic characteristics, attitudes towards science and achievement **Chair: Donna King**	**Kathleen Hayes, Merryn McKinnon John Cripps Clark** Teacher's perspectives on the role of collaborative partnerships in secondary science education **Chair: Jan van Driel**	**Muneera Bano, Sandy Schuck, Didar Zowghi, Peter Aubusson, Meera Varadharajan** Optimising mobile learning in Science Education Part 2 **Chair: Matthew Kearney**
	MORNING TEA 10.45am to 11.05am - Breakout areas & Balcony						
	11.10am – 11.50am	SESSION 3	**George Aranda, Joseph Ferguson, Russell Tytler and Radhika Gorur** The roles of drawing in reasoning and learning in the science classroom **Chair: Peter Hubber**	**Gillian Kidman, Niranjan Casinader** Frameworks guiding the teacher's work in scientific inquiry **Chair: Ewa Biviano**	**Sally Birdsall Bev France** Students' beliefs about pest animals: An international comparative study **Chair: Susanne Digel**	**Linda Hobbs, Scott Mcleod, Barry Plant** Sustaining STEM-based reforms in secondary schools: Insights into successful implementation **Chair: Wan Ng**	**Jane Hunter** Principals leading the STEM agenda in Australian primary school education: Influence, tone and responsibility **Chair: Kathryn Paige**
	11.55am – 12.35pm	SESSION 4	**Peter Hubber, Christine Preston** Investigating representational pedagogies for learning electricity in Year 6 **Chair: George Aranda**	**Ewa Biviano, Gillian Kidman** When is a chemistry experiment an investigation? **Chair: Niranjan Casinader**	**Susanne Digel, David Treagust, Alexander Kauertz, Patrick Löffler, Jochen Scheid** Beyond content knowledge - how modelling skills and student concepts interrelate in context-based tasks **Chair: Sally Birdsall**	**Wan Ng, Jennifer Fergusson** State of Years 9 and 10 students' views of science and science education **Chair: Linda Hobbs**	**Kathryn Paige, David Lloyd** Fresh water literacies: an interdisciplinary study with primary teachers and researchers **Chair: Jane Hunter**

FRIDAY, 30 JUNE 2017	**LUNCH 12.40pm to 1.30pm - Breakout areas & Balcony**					
			WATTLE Room	**THOMAS Room**	**BROADWAY Room**	**JONES Room**
	1.35pm – 2.15pm	SESSION 5	**Kathy Smith** Quality learning- teachers changing their practice **Chair: Hye-Eun Chu**	**Annette Hilton, Geoff Hilton** Proportional reasoning for science understanding: A science curriculum audit **Chair: Onanong Inta**	**Peter Aubusson, P.F. Burke, Kimberley Pressik-Kilborn** Barriers to teaching of primary science and technology **Chair: Tracey-Ann Palmer**	**Leissa Kelly, Mary Gibson, Merryn Dawborn-Gundlach** Collaborative partnerships between Specialist Science and Technology Centres and Universities **Chair: Zeynep Yaseen**
	2.20pm – 2.55pm	SESSION 6	**Hye-Eun Chu, Kok Siang Tan, Daniel Kimchwee Tan** Investigating factors for implementing assessment innovation in science classrooms **Chair: Kathy Smith**	**Onanong Inta, Pattamaporn Pimthong, Teerasak E-kobon** The development of Grade 10th students' critical thinking and conceptions on nucleic acid and protein by using project-based learning **Chair: Annette Hilton**	**Kimberley Pressick-Kilborn, Tracey-Ann Palmer** Which way forward for teaching primary science and technology? Cases of generalist and specialist teachers in NSW schools **Chair: Peter Aubusson**	