ASERA Conference
2022 Handbook
28 June – 1 July
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Full abstracts
For more information regarding postgraduate degrees, click the following links:

https://study.curtin.edu.au/
https://research.curtin.edu.au/higher-degree-by-research/

Email: HUM-ED-HDR@curtin.edu.au
Welcome from the Conference Committee

Welcome to the West, and to the 2022 Conference of the Australasian Science Education Research Association (ASERA). We are delighted that you can join us, we are all super excited to get together to see old and new friends in person and enjoy not just the presentations but the fellowship at the dinner and the ability to luxuriate in the warmth of friends and acquaintances.

Curtin University is the host for the conference, and we are taking advantage of the new buildings including the new on-campus hotel. The Early Career Researcher Workshop will be provided by Associate Professor Kok-Sing Tang and Associate Professor Karen Murcia, who will share their vast experience and provide colleagues with advice and support around publishing, book proposals and paper acceptance. We are also fortunate to be further supported by University of Western Australia colleagues, Professor Vaille Dawson and Associate Professor Christine Howitt who will present the fireside conversations. Professor David Treagust was also a wealth of knowledge and we called on his sage wisdom frequently.

Jane Sutherland, Aoife McCarthy, Kate Mattes and Natalie Pretorius from the Curtin Professional Learning Hub for Educators, who will be around and helping to make everything run smoothly during the Conference, have been invaluable in supporting every detail of the planning and organisation of the Conference. The Committee wants to thank them very much.

We hope that you will enjoy the surroundings here at Curtin. Fingers crossed that the weather will be lovely, and you can take advantage of the beautiful campus and the facilities. We hope you can spend time in Perth and surrounds more broadly, and we also hope that you will go home from ASERA 2022 feeling informed, engaged, and energised.

On behalf of the Conference Organising Committee, welcome!

Conference Organising Committee

*Associate Professors Rekha Koul and Rachel Sheffield*

The Conference Organising Committee gratefully acknowledge the time, energy and enthusiasm of the following volunteers who are post-graduate students in the School of Education:

- Michael Graffin
- Michael Calarese
- Nicole Fairhurst
- Michele De Kok
ASERA CONFERENCE 2022

TRIBUTES

David Symington
29 December 1935 - 4 August 2021

David was one of the very early active researchers in ASERA, in the days when research on student conceptions was picking up steam. He did beautiful studies on children’s explanations of natural phenomena. He wrote about museum field trips and drawing as a learning strategy. In the last couple of decades his research has centred on partnerships between schools and the science community, reflective of his work in the 1990s with CSIRO in education and communication. He was involved in some significant projects at Deakin on rural and regional education, STEM education pathways, school-community links including evaluation of the STEM professionals in Schools program, school reform, and community views of science education. David’s research was notable for its incisiveness and its ‘big picture’ thinking aimed at policy influence. There he was well connected. He brought to his research an innovative, free-ranging spirit and a political acuity that served to frame research designs to raise significant questions. At Deakin University, through the 90s he was Dean of Primary education and was known for his gentle humour and wise counsel.

Peter Fensham founder of ASERA
AM FASSA FRACI 1927-26 Aug 2021

In 1967 Peter joined Monash as the first Professor of Science Education in Australia (and likely the first outside USA). Much of his research and development was about curriculum and policy. His core values - equity and social justice, humanity and compassion - indicate why he was so committed to “Science for All”, his name for the socially responsible science with much greater focus on public understanding, gender equity and the environment that he advocated for decades. He was especially widely recognised around the globe for his involvement with, and his generosity to, countries whose economic and social struggles remain profoundly more difficult than is true across the industrialised world. Peter lived his core values in every way. In 1970, Peter initiated ASERA, the second oldest professional body of science education researchers in the world (after NARST). He deliberately created an organisation and conference structure that was egalitarian and collaborative --- for example, ASERA had no constitution (or need for one) until the mid-1990s, in its now 53 years the conference has never had an invited or keynote speaker.
Emeritus Professor Richard (Dick) Tisher
1930 - 16 November 2021

Dick was at the initial meeting at Monash University that became ASERA, in 1970. He organised the first conference at the University of Queensland in 1971 and was the first editor of the journal (called RISE from 1974 onwards). He was editor of RISE 1971-1973, 1983-88 and co-editor 1974, 1989.

Dick was a lecturer/senior lecturer at the University of Queensland for many years, before moving to Monash University as a professor of education in 1974. He left Monash in 1990 to become Executive Chairman of the Victorian Curriculum and Assessment Board (VCAA).

Professor Darrell Layel Fisher
4 July 1940 – 12 December 2021

As a long time ASERA member, Darrell started his career in north-west Tasmania as a secondary school science teacher and later moved to academia.

Darrell was a very effective and efficient researcher and supervisor who has 105 publications in ResearchGate, primarily on learning environment research, and has successfully supervised over 120 doctoral students in Australia, Thailand, South Africa and many countries in Southeast Asia. He initiated the International Conference on Science, Mathematics and Technology Education and organised many of its successful conferences in numerous countries. Darrell was a Fellow of the Australian College of Educators (ACE) and national President of the National Council of Independent Schools (NCIS).

In 2014, Darrell was awarded an honorary doctorate from the World Maritime University in Malmo, Sweden, based on his collaboration during 21 years as a Visiting Professor.
Business Events Perth

https://www.businesseventsperth.com/

Established in 1972, Business Events Perth (formerly known as Perth Convention Bureau) is responsible for attracting international and interstate business events to Western Australia.

Curtin University

https://www.curtin.edu.au/

Curtin is an innovative, global university known for its high impact research, strong industry partnerships and commitment to preparing students for the jobs of the future.

Nesuto Hotel

https://www.nesuto.com/curtin

Nesuto redefines hotel living, and the new look Nesuto Curtin offers the benefits and convenience of either a hotel room or a two-bedroom suite for more space and to suit
Professional Learning Hub for Educators

(PLHub) offers evidence-based programs and professional networking for teachers and educators in Australia and overseas. Our team includes internationally renowned educators, researchers, and speakers whose research focuses on improving the quality of current and established teaching practices.

For more information on the Professional Learning Hub for Educators and what we can do you contact us via

Email: learninghub@curtin.edu.au

Web: https://study.curtin.edu.au/professional-development/professional-learning-hub-for-educators/

Or sign up to our mailing list to be kept informed on our latest offerings.
Perth, Western Australia

**Airport**
Perth airport is approximately 20 minutes from the Perth CBD.
A taxi from the airport to Curtin University (Nesuto Hotel) will cost around $45.
See links to taxi services in the "How to get around Perth" section.

**How to get around Perth**
Bus terminal at Curtin University – Hayman stand 7 – bus number 960 – 30-minute ride to Perth City.
Uber, Didi, Ola – ride share companies operating in Perth.
Taxi service –

**Places of interest in Perth City**
Kings Park, Elizabeth Quay, Yagan Square, Perth Mint.
See link below for details on events and places to visit in the city.
Fremantle or “Freo” is Perth’s Old Town. It’s a maritime city with spirit and soul, full of vibrancy, colour and culture.

**Getting there**

Train to Fremantle – train from Perth Station platform 7 – catch Fremantle line train approx. 30 minutes to Fremantle. Fremantle is bursting with things to do, click the link below for what’s on in Freo.


Rottnest Island sits just offshore from the city of Fremantle. A protected nature reserve, it's home to the quokka, a small wallaby-like marsupial. No trip to Perth is complete without a “selfie” with a quokka.

Ferry to Rottnest Island departs from the B-Shed in Fremantle – quick walk from the Fremantle train station.

Hotel Information – NESUTO Curtin

Nesuto Curtin is located in the suburb of Bentley, a bustling commercial and educational hub just 8km South of Perth CBD. Nesuto Curtin Perth Hotel is situated in a great location, a new build right in the heart of Curtin University, opposite Curtin Stadium and Curtin Central Bus Station with a direct bus to Optus Stadium on special event days.

Our facilities include 24-hour Reception and a friendly team always on hand to assist, housekeeping service, on campus parking (subject to availability), free WiFi, Karla Mia Lounge, meeting and conference facilities and dry-cleaning services.

For the ASERA Conference the hotel is offering a special rate, please use special Discount Code is **ASERA21** to receive 10% off the best available rate. [https://reservations.nesuto.com/113917?discount=ASERA21](https://reservations.nesuto.com/113917?discount=ASERA21)

Places to eat!

A short 5-minute walk from the hotel will take you to Waterford Plaza Shopping Mall where you will find a number of restaurants and bars along with supermarkets, chemists and various speciality shops.

- Yang’s Dumplings
- Varsity Bar and Grill
- Subway
- Domino’s Pizza
- Phoeever Waterford
- Mikasa – Asian fusion
- Old Chang Kee – Singaporean
- Zambrero – Mexican
- Seoul Delish - Korean
ASERA CONFERENCE 2022
PERTH AND SURROUNDS

High Street Fremantle, photo courtesy of Unsplash.com

Little Armstrong Bay, Rottnest Island, photo courtesy of WA Tourism

Aboriginal cultural tours of Kings Park, photo courtesy of WA Tourism

World famous wildflowers of Western Australia, photos courtesy of WA Tourism
## Conference Overview

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>Details</th>
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<tr>
<td><strong>Tuesday 28th June</strong></td>
<td>11.00am-4.00pm</td>
<td>Building 418</td>
<td>ECR HDR Workshop room 418.204</td>
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<td></td>
<td>5.00pm-7.00pm</td>
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<td>Conference welcome reception building 418</td>
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<tr>
<td><strong>Wednesday 29th June</strong></td>
<td>8.30am-4.45pm</td>
<td>Building 418</td>
<td>Presentations rooms 418.203, 204, 205, 206</td>
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<td></td>
<td>5.00pm-7.00pm</td>
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<td>Fireside chat session 418.207</td>
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<td></td>
<td>5.30pm-7.00pm</td>
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<td>Board meeting 418.204</td>
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<tr>
<td><strong>Thursday 30th June</strong></td>
<td>8.30am-3.00pm</td>
<td>Building 418</td>
<td>Presentations rooms 418.203, 204, 205, 206</td>
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<td></td>
<td>3.45pm-5.00pm</td>
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<td>ASERA AGM in Medical Building 410</td>
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<td></td>
<td>6.00pm-10.00pm</td>
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<td>Conference dinner – The Raffles Hotel</td>
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<tr>
<td><strong>Friday 1st July</strong></td>
<td>9.00am-12.30pm</td>
<td>Building 418</td>
<td>Presentations rooms 418.203, 204, 205, 206</td>
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**Bathurst Lighthouse, Pinky’s Beach Rottnest Island**  
Photo courtesy of WA Tourism
### TUESDAY 28TH JUNE 2022

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>9.30 - 11.00</td>
<td>Conference registration opens&lt;br&gt;Registration tables setup in hotel foyer and on level one in 418</td>
</tr>
<tr>
<td>11.00 – 12.30</td>
<td>ECR/HDR Workshop&lt;br&gt;A/Professor Kok-Sing Tang and A/Professor Karen Murcia&lt;br&gt;Room 418.204</td>
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<tr>
<td>12.30 – 1.15</td>
<td>LUNCH for workshop attendees in 418.102 Collaboration Hub – open area on ground floor of building 418</td>
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<tr>
<td>1.15 – 4.15</td>
<td>ECR/HDR Workshop&lt;br&gt;A/Professor Kok-Sing Tang and A/Professor Karen Murcia&lt;br&gt;Room 418.204</td>
</tr>
<tr>
<td>1.15 – 5.00pm</td>
<td>Conference registration opens&lt;br&gt;Registration tables setup in hotel foyer and on level one in building 418</td>
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<tr>
<td>5.00 – 7.00pm</td>
<td>Conference Welcome&lt;br&gt;418.102 Collaboration Hub – open area for welcome reception</td>
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Fishing boat harbour Fremantle.<br>Photo courtesy of Chris King - Unsplash.com
<table>
<thead>
<tr>
<th>Time</th>
<th>Room 418.203 Mod: Michael Graffin</th>
<th>Room 418.204 Mod: Michelle de Kok</th>
<th>Room 418.205 Mod: Nicole Fairhurst</th>
<th>Room 418.206 Mod: Michael Calarese</th>
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<tbody>
<tr>
<td>8.30 – 9.10</td>
<td>Development of Chemical Experiments to support the understanding of Nature of Science Janne-Marie Bothor (HDR), David-Samuel Di Fuccia (Supervisor)</td>
<td>Enacting the NT Preschool Science Games: Supporting teacher practice in early childhood science education Cristina Guarrella (HDR), Jan van Driel (Supervisor), Caroline Cohrssen</td>
<td>Using learner-centered approaches to enhance science communication skills among pre-university STEM students Jejomar Bongat (HDR Student) ONLINE</td>
<td>Impact of Adaptive Expertise in Science Teaching on Preservice Teachers’ Attitudes toward Integrated STEM Education Mounir Saleh, Bashirah Ibrahim, Ernest Afari ONLINE</td>
</tr>
<tr>
<td>9.10 – 9.50</td>
<td>Adolescents’ Use of Social Networking Sites (SNS): Links to Science Achievement and Collaborative Problem Solving Skills in Advanced and Developing Economies Shaljan Areepattamannil</td>
<td>Use of XR (extended reality) technologies to promote scientific literacy in a year 5 science class Christine Howitt, Vaille Dawson, Grace Oakley, Mark Pegrum</td>
<td>An exploratory study on how the STEAM approach influences students’ engagement in science learning Hye-Eun Chu, Ei Seul Kim, Hyeong Moon Lee, Sonya Martin</td>
<td>Effects of contemporary chemical research on chemistry education students Mareike Frevert, David-Samuel Di Fuccia (Supervisor)</td>
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<tr>
<td>10.30 – 11.00</td>
<td>Morning Tea</td>
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<td>11.00 – 11.40</td>
<td>Science teacher perspectives and practices of supporting EAL students’ word knowledge, and alignment with the new Victorian EAL curriculum Amanda Berry, Anna Fillipi, Minh Hue Nguyen</td>
<td>Introducing Quantum Physics in Year 5 - A trial summary Kyla Adams (HDR), David Blair (Supervisor), Tejinder, Kaur (Supervisor), David Treagust (Supervisor)</td>
<td>Teaching student graphing in Mathematics and Science: The utility of Peirce’s Semiotics John Cripps Clark, Joseph Paul Ferguson, Catherine Legg</td>
<td>How the experience of a STEM industry engagement can promote deep learning and understanding of Science and STEM among preservice teachers Carol Aldous, Alice Dunlop</td>
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<tr>
<td>Time</td>
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<td>11.40 – 12.20</td>
<td>Implementing Guided Inquiry in Senior Biology Settings: A Design Based Research</td>
<td>Amrita Kamath, Peta White (Supervisor)</td>
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<td></td>
<td>Adaptive Expertise in primary science and mathematics education: Findings from a scoping review</td>
<td>Lihua Xu, Amanda Berry, Jan van Driel, Kennedy Chan and Jinny Kim ONLINE</td>
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<td>Collaborative science learning in immersive virtual reality: It takes more than a couple of VR headsets</td>
<td>Mihye Won, Dewi Ungu, Henry Matovu (HDR), David Treagust, Mauro Mocerino, Roy Tasker, Chin-Chung, Tsai</td>
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<td></td>
<td>Pre-service teacher experiences in a Makerspace</td>
<td>Helen Georgiou, Wendy Nielsen, Peta Halliburton (HDR) ONLINE</td>
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<td>12.20 – 1.45</td>
<td>Lunch including demonstration from Mihye</td>
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<td>1.45 – 2.25</td>
<td>Understanding the nature of integrated STEM in K-12 classrooms</td>
<td>Gillian Roehrig, Emily Dare, Joshua Ellis, Elizabeth Ring-Whalen ONLINE</td>
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<td></td>
<td>Primary teachers’ conceptualisations of disciplinary-specific creativity in science</td>
<td>Joseph Paul Ferguson, Melinda Kirk (HDR) ONLINE</td>
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<td>Citizen Science: What’s in It for the Citizen?</td>
<td>Léonie Rennie</td>
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<td>Role-playing design and Critical Thinking in Secondary Science Pre-Service Teacher Education</td>
<td>Jose Manuel Hierrezuelo-Osorio, Antonio Joaquin Franco-Mariscal ONLINE</td>
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<td>2.25 – 3.05</td>
<td>More storytelling: chemists, crime, fraud and scandal</td>
<td>William Palmer ONLINE</td>
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<td>Jurassic World as an educational resource encouraging science education</td>
<td>María del Mar López-Fernández (HDR), Antonio Joaquin Franco-Mariscal ONLINE</td>
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<td>What can schools learn from STEM Centres?: STEM skills and practices through Victorian Tech Schools</td>
<td>Linda Hobbs, John Cripps Clark, George Aranda, Peta White, Seamus Delaney, Chris Speldewinde ONLINE</td>
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<td>Theoretical developments in social semiotics and multimodalities research in science</td>
<td>Wendy Nielsen, Jennifer Yeo, Kok-Sing Tang ONLINE</td>
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<td>3.05 – 3.25</td>
<td>Afternoon Tea</td>
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<td>3.25 – 4.05</td>
<td>What do integrated STEM projects look like in classrooms? A systematic literature review of empirical studies of ISTEM projects</td>
<td>Felicity McLure, Kok-Sing Tang, John Williams ONLINE</td>
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<td>Intentional teaching and STEM learning in a play-based setting</td>
<td>Shukla Sikder ONLINE</td>
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<td>Professional actors’ difficulties and educational effects who participated in the production of Science Play</td>
<td>Shincheol Kang (HDR), Jinwoong Song (Supervisor)</td>
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<td>Upcycling systems thinking oriented education research into science teaching practice</td>
<td>Seamus Delaney, Madeleine Schultz ONLINE</td>
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<td>Time</td>
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<td>4.05 – 4.45</td>
<td>Early learning of powers of ten for understanding concepts of modern Physics. Anastasia Popkova (HDR), David Blair (Supervisor)</td>
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<td>Analysing students’ collaborative drawings using discourse maps</td>
<td>Jina Chang, Joonhyeong Park, Kok-Sing Tang, David F, Treagust, Mihye Won</td>
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<td>ONLINE</td>
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<td>Leadership perspectives on mutually beneficial relationships between school and local STEM centres</td>
<td>George Aranda ONLINE</td>
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<td>Development of a project-based early STEM module and a teacher workshop integrating biomedical engineering and medical care</td>
<td>Ching-Ting Hsin, Chun-Yu Chuang, Hsin-Kai Wu ONLINE</td>
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5.00 – 7.00 pm  Fireside chat with registered participants Room 418.207

5.30 – 7.30 pm  ASERA Board meeting – building 418.204
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<tr>
<th>Time</th>
<th>Room 418.203</th>
<th>Room 418.204</th>
<th>Room 418.205</th>
<th>Room 418.206</th>
<th>Room 418.207</th>
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</thead>
<tbody>
<tr>
<td>8.30</td>
<td>Dialogic Teaching in Secondary School Science – A Case Study in a High Performing All-Girls School in Singapore Han Pin Goh (HDR), Yann Shiou Ong (Supervisor), Yew Jin Lee (Supervisor) ONLINE</td>
<td>Digital play and young children’s creative science inquiry Katie Fielding (HDR), Emma Cross, Karen Murcia (supervisor) ONLINE</td>
<td>On Four Different Senses of Embodiment in Science Education Magdalena Kersting, Jesper Haglund, Rolf Steier</td>
<td>Positioning teachers as active co-researchers examining problem-based learning in school-based STEM education Jennifer Mansfield, Kathy Smith, Peter Ellerton, Amanda Berry, Nicoleta Maynard, Deb Corrigan</td>
<td>Changes in pre-service teacher understanding of the STEAM inquiry model Harry Kanasa, Ben Barlow, Kate Thompson, Susan Chapman</td>
</tr>
<tr>
<td>9.10</td>
<td>Investigating the use of engineering notebooks in scaffolding school students’ communication and collaboration skills. Michael Graffin, (HDR Student), Rachel Sheffield (Supervisor), Rekha Koul (Supervisor)</td>
<td>The Aspects of Elementary Students’ Productive Disciplinary Engagement from the Perspective of Practical Epistemology Seungho Maeng (Supervisor), Arim Kim (HDR) Phil Seok Oh</td>
<td>The role of community connections in STEM teacher education Emma Stevenson, Jan van Driel (Supervisor), Victoria Millar (supervisor) ONLINE</td>
<td>A reading group for science educators: An approach for developing personal and collective pedagogical content knowledge in science education Jared Carpendale, Ange Fitzgerald, Rebecca Cooper</td>
<td>NO SESSION</td>
</tr>
<tr>
<td>9.50</td>
<td>Science and Digital Technology - An evidence-based integration Brigitte Glasson, Ben Egerton ONLINE</td>
<td>From generalist primary teacher to specialist STEM teacher: Opportunities and challenges encountered by an educator making the shift Frances O’Brien, Kimberley Pressick-Kilborn</td>
<td>Co-constructing an interdisciplinary framework in context: connecting science and sustainability education through environmental learning David Zandvliet, Connie Cirkony ONLINE</td>
<td>Science Head Teachers’ Perspectives on Writing in the Discipline Wendy Nielsen, Honglin Chen, Helen Georgiou</td>
<td>Balancing teaching scientific practice and addressing content knowledge: A case of two science classrooms in Singapore Jing Da Tan (HDR), Wan Hsuan Shermayne Soh, Micchie Soh</td>
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<tr>
<td>10.30</td>
<td>Morning Tea</td>
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<td>11.00</td>
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<td>11.00 –</td>
<td>Exploratory discussions in immersive virtual reality to learn hydrogen bonding within snowflakes</td>
<td>Dewi Ungu, Henry Matovu, Mihee Won (Supervisor), David Treagust (Supervisor), Mauro, Mocerin (Supervisor), Roy Tasker-Chin-Chung, Tsai</td>
<td>ONLINE</td>
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<td>11.40 –</td>
<td>Analysing representational strategies in instructional videos for teaching science inquiry</td>
<td>Joonhyeong Park, Jina Chang, Jisun Park, Hye-Gyoung Yoon</td>
<td>ONLINE</td>
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<td>11.00 –</td>
<td>An investigation of indigenous Tao students’ learning about biological taxonomy</td>
<td>Yun-Ping Ge</td>
<td>ONLINE</td>
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<td>11.40 –</td>
<td>Science for the Community: Pre-Service Teachers’ Developing Understandings</td>
<td>Tristan Orbeta (HDR), Frederick T. Talaue, Alex L. Torres, Hanny Pearl S. Camerino, Heidi Gibson, Logan Schmidt, Sheryl Lyn C, Monterola</td>
<td>ONLINE</td>
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<td>11.40 –</td>
<td>Influencing high school students to continue with science at school</td>
<td>Tracey-Ann Palmer</td>
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<td>12.20 –</td>
<td>Conceptual PlayWorlds: An educational experiment into the place of Imagination in STEM in K-6 classrooms</td>
<td>Marilyn Fleer</td>
<td>ONLINE</td>
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<td>12.00 –</td>
<td>Rethinking passivity as the essence of agency in STEM learning contexts.</td>
<td>James Davis</td>
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<td>1.15 –</td>
<td>Mobile Learning in University Science Education: A Systematic Literature Review</td>
<td>Le Quan Ly (HDR), Matthew Kearney (Supervisor)</td>
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<td>2.00 –</td>
<td>Inquiry-Based Learning in Senior Secondary Science: ‘What are Expert Teacher Practices?’</td>
<td>Deborah de Ridder (HDR)</td>
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<td>2.00 –</td>
<td>Symposium: Investigating an interdisciplinary mathematics and science approach in primary schools</td>
<td>Peta White (organiser &amp; author), Melinda Kirk, Russell Tytler, Chris Nielsen (authors)</td>
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<td>2.00 –</td>
<td>Thinking When Problem-solving: How Students Think in an Integrated STEM Curriculum</td>
<td>Tang Wee Teo</td>
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<td>2.40 –</td>
<td>Evaluating the accuracy and coherence of scientific explanations constructed by lower secondary students in Singapore</td>
<td>Wei Jian Chua (Undergrad. Student), Miechie Leo, Wan Hsuan Shermayne Soh</td>
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<td>2.40 –</td>
<td>The Effect of Community-based SSI Instruction on Risk Perception and Perceived Risk of Chemicals in Cosmetics of High School Students in South Korea</td>
<td>Gahyoung Kim, Hyunyoung Na</td>
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<td>2.40 –</td>
<td>Research on the effects of online versus lab collaborative problem solving and students’ achievement levels</td>
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<td>2.40 –</td>
<td>Exploring relationships between novice teachers’ science backgrounds, science identities, and NOS pedagogies</td>
<td>Kathy Paige, Lisa O’Keefe</td>
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<td>2.40 –</td>
<td>Culturally responsive pedagogy for transdisciplinary STEM</td>
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<td>3.20</td>
<td>Empowering Thai Teacher Candidates Transform their Pedagogical Beliefs for Effective Inquiry-based Science Teaching through Virtual Lesson Study</td>
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<td>3.20-3.40</td>
<td><strong>Afternoon Tea</strong></td>
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<td>3.45-5.00</td>
<td>AGM in medical building</td>
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<td>6.00-10.00</td>
<td>Dinner at Riverside Room Raffles Hotel</td>
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Cottesloe Beach
Photo courtesy of Tourism Western Australia
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<td>Mod: Michael Graffin</td>
<td>Mod: Michelle de Kok</td>
<td>Mod: Nicole Fairhurst</td>
<td>Mod: Michael Calarese</td>
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<td>Henry Matovu, Dewi Ungu, Mihye Won (Supervisor), David Treagust(^1) (Supervisor), Mauro, Mocerino (Supervisor), Roy Tasker, Chin-Chung, Tsai</td>
<td>Timna Garnett (HDR Student), Yvonne Zeegers (Supervisor) ONLINE</td>
<td>Connie Cirkony, David Zandvliet ONLINE</td>
<td>Ching-Sui, Hung (HDR), Hsin-Kai, Wu (Supervisor) ONLINE</td>
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<td>9.50 – 10.30</td>
<td>The ‘Sonaphor’ as tool for secondary science education using sound</td>
<td>Co-designing an interdisciplinary climate science course: Hearing the educators’ voices</td>
<td>STEM Career Readiness of Senior High School Students</td>
<td>The Effects of College Students’ PM2.5 Environmental Literacy, Critical Thinking and Project Citizen Performance through Project-based Reflective Journal Teaching</td>
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<td>Alice Motion, Alexis Weaver, Genevieve Firmer, Chiara O’Reilly, Daniel Yeadon, Jadey O’Regan</td>
<td>Chris Eames, Cathy Bunting, Marcus Wilson, Martina Pietsch-Brown ONLINE</td>
<td>Edwehna Elinore Paderna, Alvin Barnachea</td>
<td>Teng-Shun Yang, Chung-Fen Yen, Tsai-Liang Hsu ONLINE</td>
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<td>10.30 –</td>
<td>Morning Tea</td>
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<td>11.00 – 11.40</td>
<td>Raising a scientifically literate and culturally competent population: are senior chemistry courses in Australia up the task?</td>
<td>An Integrative Review of STEM Integration in Early Childhood Education</td>
<td>‘Researcher’, ‘teacher’, ‘other’? Considering a non-scientist’s role in a science-focused research project</td>
<td>Drawing explanatory diagrams to understand balanced and unbalanced forces</td>
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<td>Genevieve Firmer (HDR), Alice Motion (Supervisor), Siegbert Schmid (Supervisor)</td>
<td>Andrea Ng (HDR), Sarika Kewalramani, Gillian Kidman ONLINE</td>
<td>Ben Egerton ONLINE</td>
<td>Sherab Tenzin (HDR), Mihye Won (Supervisor) David Treagust (Supervisor)</td>
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<td>11.40 – 12.20</td>
<td>NO SESSION</td>
<td>Far-reaching Ripple Effects for primary and secondary students – Learning By Doing the Citizen Science Way</td>
<td>Thant Sin Phway, (HDR), Chris Preston, Alice Motion (Supervisor), Yaela Golumbic, John Martin, Peter Rutledge, Ciara Keneally</td>
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<td>Student’s perceptions of their STEM Learning Environment</td>
<td>Nicole Fairhurst (HDR), Rekha Koul (Supervisor), Rachel Sheffield (supervisor)</td>
<td>No session</td>
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Abstracts

Wednesday 29th June

8.30 – 9.10

Room 418.203

Development of Chemical Experiments to support the understanding of Nature of Science

Janne-Marie Bothor (HDR), David-Samuel Di Fuccia (Supervisor)

University of Kassel, Germany

Chemical experiments are used in the classroom to reproduce existing scientific knowledge or the process of Scientific Inquiry. These experimental settings support an understanding of Nature of Science (NoS) only implicitly and - for the development of scientific literacy - often not sufficiently. Therefore, our project follows these research questions: What beliefs do students have about the goals of using chemical experiments in the classroom? How do students develop experiments in which the support of NoS should be explicitly addressed? Two learning environments have been developed in which the students develop experiments that explicitly support NoS. The beliefs on the goals and the use of experiments in the classroom were collected in a first learning environment from interviews with 7 participants. In a second learning environment with 20 participants an open questionnaire in pre-post design was used. The results of the interview and the pre-questionnaire showed that the participants' beliefs on the use of experiments mainly regard experiments as an instrument for knowledge reproduction and only rarely as an instrument for supporting NoS. The developed experiments showed that the students often explicitly reflect the process of Scientific Inquiry instead of NoS and also the design historical-problem-oriented settings.

Room 418.204

Enacting the NT Preschool Science Games: Supporting teacher practice in early childhood science education

Cristina Guarrella¹ (HDR), Jan van Driel¹ (Supervisor), Caroline Cohrssen²

¹ The University of Melbourne, Victoria
² The University of Hong Kong

Australian policy documents emphasise the importance of young children’s learning process skills typically associated with science; however existing frameworks do not explicitly refer to science. To bridge this gap, the Northern Territory (NT) Government commissioned the development of the NT Preschool Science Games. This research aimed to understand how these playful science games may support high quality teacher practice. Drawing on bioecological theory, this timely study used classroom observations and semi-structured interviews to measure classroom interactions and identify teachers’ assessment practices and influences during game implementation. Findings demonstrate that the games provide a supportive structure for teachers to transform pedagogical prompts into teaching practice, yet despite having specific tools to support assessment for learning, the assessment of science process skills was inconsistent. These findings have implications for the design of future curriculum resources, teacher professional learning and national, state and territory learning frameworks. When teachers are clear about what science learning is possible within playful experiences, they are better equipped to observe and assess children demonstrating what they know. This can then inform authentic scaffolding and contingent planning for playful science teaching and learning.
Using learner-centered approaches to enhance science communication skills among pre-university STEM students

Jejomar Bongat (HDR Student)
De La Salle University, Manila, Philippines; Philippine Science High School - Main Campus, Quezon City, Philippines

Experts and students in science, technology, engineering, and mathematics are increasingly expected to be proficient in communicating scientific expertise to diverse audiences. This expectation has led to the integration of science communication courses in science programs internationally. Related research in the Philippines echo science communication issues explored in Western work, but with amplified challenges of accessibility and local attitudes to science. This study investigates the enhancement of science communication skills among pre-university students in a secondary STEM school in the Philippines who were enrolled in an introductory engineering elective. This research will be done through evaluating baseline skills, implementing learner-centered interventions, and measuring learning outcomes. Initial student output will be evaluated using a modified tool based on the work of Mercer-Mapstone and Kuchel (2016) to determine baseline skills. Learning interventions will then be designed based on the results of the evaluation, which will be integrated in the science communication learning unit. Students will produce communication plans and products within the unit as their learning evidence. These products will be assessed using the same evaluation tool to determine achievement of improved learning outcomes. Qualitative analysis will also be conducted to determine action steps for succeeding implementations.

Impact of Adaptive Expertise in Science Teaching on Preservice Teachers’ Attitudes toward Integrated STEM Education

Mounir Saleh, Bashirah Ibrahim, Ernest Afari
University of Bahrain, Bahrain

Integrated Science, Technology, Engineering, and Mathematics (iSTEM) teaching equips students with competencies needed to address 21st century challenges. Nevertheless, teachers’ attitudes toward iSTEM teaching influence implementation of this teaching approach. Hence, studying factors that impact these attitudes is useful. Prior research focused on teachers’ background characteristics and teaching context as potential factors. Predisposing and enabling factors are yet to be examined. Adaptive expertise is a construct that incorporates both types of factors. Adaptive experts tend to demonstrate positive attitudes toward unfamiliar tasks, such as iSTEM teaching. In this study, we used a cross-sectional survey method to study the relationship between adaptive expertise in science teaching and iSTEM attitudes on fourth-year primary preservice teachers (PSTs) (n=93). Regression analysis revealed positive impact of PSTs’ adaptive expertise in science teaching on their attitudes toward iSTEM teaching. The findings of this study have promising implications on the design of teacher preparation/professional development programs.
Adolescents’ Use of Social Networking Sites (SNS): Links to Science Achievement and Collaborative Problem-solving Skills in Advanced and Developing Economies

Shaljan Areepattamannil
Emirates College for Advanced Education, United Arab Emirates

In this era of ICT-rich environments, the number of students using social networking sites (SNS) for educational and non-educational purposes has increased manifold. However, there is a scarcity of research examining the links between the frequency of use of SNS outside of school for educational as well as non-educational purposes and performance on standardized science assessments among adolescents employing nationally representative samples of adolescent students. This study, therefore, examined the relations of social networking sites (SNS) usage to science achievement and collaborative problem-solving skills among nationally representative samples of adolescent students drawn from 29 advanced economies and 15 developing economies across the globe. Results of multigroup multilevel path analyses, after accounting for student- and school-level demographic and socio-economic factors, indicated that adolescent students’ use of SNS for communication with other students about schoolwork was significantly negatively related to their science achievement and collaborative problem-solving skills in most of the advanced and developing economies. In contrast, adolescent students’ general SNS usage was significantly positively associated with their science achievement and collaborative problem-solving skills in developing economies. General SNS usage was significantly positively linked to science achievement and collaborative problem-solving skills in nearly half of the advanced economies and either significantly negatively related or not significantly related to the rest of the advanced economies.

Use of XR (extended reality) technologies to promote scientific literacy in a year 5 science class

Christine Howitt, Vaille Dawson, Grace Oakley, Mark Pegrum
University of Western Australia

Emerging XR technologies using augmented reality and virtual reality are increasingly available for use in schools. These technologies have the potential to, (1) motivate and engage students, (2) improve students’ understandings of abstract concepts and, (3) improve students’ science communication skills. Using a case study approach this study focussed on an exemplary teacher and her year 5 class in a Western Australian independent boys school. After UWA and school ethics approval, the teacher participated in a brief professional development on MergeCube before introducing her students to the chemistry concepts of states of matter, atomic structure, and changes of state over a six-week period of 2-3 science lessons per week. Using co-design research, the teacher and one researcher worked collaboratively to design activities using 360-degree videos, MergeCube and Metaverse. Data analysis of classroom observations, teacher lesson plans, and multiple teacher interviews demonstrated that: extensive teacher preparation and trialling is essential, students of all ability levels were thoroughly engaged, and students had multiple opportunities to communicate scientifically in multimodal forms. It is recommended that school sectors consider provision of teacher professional development to both share expertise and tinker with XR technologies.
**Room 418.205**

An exploratory study on how the STEAM approach influences students’ engagement in science learning

Hye-Eun Chu¹, Ei Seul Kim², Hyeong Moon Lee², Sonya Martin²

¹ Macquarie University, New South Wales
² Seoul National University, Republic of Korea

The integration of the arts in STEM, known as STEAM, involves students engaging with science concepts in the context of social-cultural phenomena. A problem in implementing STEAM is how to integrate the arts/culture element into classroom activities so as to situate science learning in real world contexts. The research questions were: 1. What ways of integrating the arts in science learning influence student engagement? and 2. What features should arts-related activities have to raise engagement? To select arts-related activities the researchers first explored the target science concepts to identify social-cultural contexts in which the concept would account for an event or be a solution to a problem. Evidence of student engagement was collected by means of pre- and post-project student interviews. Student engagement was found to be enhanced by arts-/culture-related problem-solving activities requiring the application of science concepts in a cultural context. Additionally, arts or culture-related products or events that raised student engagement in STEAM lessons were characterised by accessibility to students and innovativeness. These results make a significant contribution to addressing a challenge in the successful implementation of STEAM: how to integrate the arts in science teaching such that it promotes the learning of science concepts.

**Room 418.206**

Effects of contemporary chemical research on chemistry education students

Mareike Frevert, David-Samuel Di Fuccia (Supervisor)

Universität Kassel, Germany

Chemistry education students rarely have contact with contemporary chemical research, but knowledge in this area is beneficial for finding modern, scientific, everyday-life examples for use in their teaching and imparting an adequate understanding of chemistry to their students (Demuth et al., 2008). This project focused on confronting chemistry education students with contemporary chemical research in theory and practice. The main question was: ‘What are the effects if students at university are confronted with modern chemical research?’ Therefore, a theory was developed to combine knowledge types of teacher professionalism (Content Knowledge, Pedagogical Content Knowledge, Nature of Science) with chemical research (Bachelard, 1987; Shulman, 1986). A learning environment was created, where students have contact with chemists in authentic research situations (Fölling-Albers et al., 2004). To investigate the effects of this involvement in research, a companion study was implemented and evaluated, which used above all the method of qualitative content analysis (Mayring, 2002). Results of the study showed different effects on chemistry education students’ knowledge types and their view on chemistry. The theory, learning environment, study and its results will be presented and critically reflected.

**References**

Can Year 7 students construct quality arguments about water SSI after instruction?

Vaille Dawson
University of Western Australia

Internationally, there are calls to improve young people’s scientific literacy, particularly their skills in being able to use their scientific understandings to make informed decisions about the world in which they live. Students need multiple opportunities throughout their formal schooling to develop and practice these skills. Using a mixed methods case study design, this study investigated the impact of teaching behaviours and strategies used by two early career science teachers who taught argumentation about a water-based socioscientific issue (SSI) during a chemistry unit with their year 7 (11-12 years old) students. The 57 students spent three lessons learning how to construct and critique the arguments of themselves and their peers. Students’ argument quality measured using Toulmin’s structure, and the number of categories improved significantly from pre- to post-instruction (p=0.006). Key teacher behaviours and teaching strategies observed were: developing a safe classroom environment; providing opportunities for all students to contribute; practicing argument construction; providing clear instructions about the structure of an argument; and gradually removing scaffolds that support argument construction. It is recommended that preservice teacher education and teacher professional development explicitly emphasise effective teacher behaviours and strategies that lead to successful use of SSI to promote argumentation.

Characterising and supporting student transduction of meanings across modes

Russell Tytler, Vaughan Prain
Deakin University, Victoria

While researchers now broadly agree that students need to identify, link, co-ordinate and expand meanings across modes to understand and make scientific claims, how teachers support this student multi-modal reasoning, or ‘transduction’ (Kress & van Leeuwen, 2006, p. 39), has been less explored. Researchers have variously focused on sign system grammars (Svensson & Eriksson, 2020), sign functions (Prain & Tytler 2021), and variation theory (Volkwyn 2019) to explain what enables and supports this process. In this paper, drawing
on Peirce’s (1955) theory of meaning-making through sign functions, we use a recent analysis of classroom transduction processes to stimulate discussion about the nature of transduction in meaning-making and learning. We focus on a learning sequence in primary school astronomy designed around representational work to explore the teacher’s key role in supporting student transduction. In the Interdisciplinary Mathematics and Science (IMS) project we developed a four-stage pedagogy of orienting, posing representational challenges, evaluating and building consensus, and applying and extending conceptual understanding to support transduction. We use micro-ethnographic analysis of the teacher’s strategic framing and interactions with students and their artefacts to: 1) explore the nature of transduction as students engage with material and representational work, and 2) the role of the teacher in anticipating challenges for students in integrating meanings across multiple, multimodal representations of astronomy phenomena. We build on this analysis to raise the questions: What enables students to achieve cohesive meaning-making across representational modes to understand and apply science concepts? What part is played by students’ relevant conceptual knowledge, understanding of sign functions and affordances, and reasoning? How should we think of science ‘concepts’ in relation to this process? How should we support teachers in this student learning?

**Room 418.205**

**Development and conceptions of STEM teacher identity**

Tabetha Spiteri, Tanya Stephenson

Monash University

In recent years, there has been an increased emphasis on integrated science, technology, engineering, and mathematics (iSTEM) education, with teachers encouraged to adopt an integrated approach towards STEM. To increase teacher capacity in developing and implementing iSTEM education, an alignment between teachers’ identities and their understanding of iSTEM is vital. However, our current understanding of STEM teacher identity is limited. This study explores how STEM teacher identity has been conceptualised in existing literature, and identifies current gaps regarding its development and conceptualisation. A rapid literature review was conducted for peer-reviewed journal articles examining K-12 STEM teacher identity in English until 1 January 2022. Three emerging themes and their implications regarding the conceptualisation of STEM teacher identity were uncovered: (a) teachers’ personal beliefs, (b) teachers’ professional characteristics, and (c) the characteristics of a distinct STEM teacher identity. Findings highlight that research regarding STEM teacher identity tends to carry the more traditional ‘siloed’ approach, with a larger focus on science and mathematics teacher identities, making it important to examine the unique nature of STEM teacher identity. The significance of teacher education and professional development programs that emphasise an integrated approach to STEM education is also highlighted.

**Room 418.206**

**Science outreach in Australian universities**

Victoria Millar, Maurice Toscano, Jan van Driel

University of Melbourne, Victoria

Science outreach is a model of informal education that is typically run by universities, industry, science museums or other public and private science institutions. Outreach programs have historically been put together in an
effort to promote science to school students and the general public in order to enhance science literacy, attitudes, engagement and retention. The majority of Australian universities now undertake some form of science outreach program, although the types and scales of these programs vary considerably. The growth of such programs can be seen in many universities in recent decades as outreach becomes increasingly incentivised both by expectations that universities engage more actively with communities and as a result of outreach being linked to competitive research funding. This paper considers how the emphasis on outreach in Australian universities and the range of purposes that such outreach programs seek to achieve has changed over time. It will do so through an historical analysis of policies and outreach programs in Australia, shedding light on the rise of outreach in Australian universities and the benefits and tensions that are created as a result.

11.00 – 11.40

Room 418.203

Science teacher perspectives and practices of supporting English as Additional Language (EAL) students’ word knowledge, and alignment with the new Victorian EAL curriculum

Amanda Berry, Anna Fillipi, Minh Hue Nguyen
Monash University, Victoria

The recent implementation of the Victorian Curriculum F-10: EAL requires all teachers who teach EAL students to be familiar with the revised EAL curriculum for the purposes of planning and developing approaches to assist learners’ English language development. Word knowledge is considered an important aspect of EAL students’ English language learning. Science education uses a specialised language and language patterns which can act as a barrier to student learning. Acquiring and being able to use these language features is therefore an important enabler of student learning and academic success. However, science teachers, typically, have little if any background in language development nor how to integrate language and content matter instruction. This research investigated the perceptions and practices of one science teacher working in collaboration with an EAL teacher, to teach vocabulary in a Year 7 science class; and to examine how these practices align with the Victorian Curriculum F-10: EAL. Analysis of interview and classroom data revealed that the science teacher understood and practised some of the principles of language learning to inform vocabulary teaching, even if she expressed a lack of confidence in using particular strategies and a lack of familiarity with the EAL Curriculum. Implications will be discussed.

Room 418.204

Introducing Quantum Physics in Year 5 - A trial summary

Kyla Adams¹ (HDR), David Blair¹ (Supervisor), Tejinder, Kaur¹ (Supervisor), David Treagust² (Supervisor)

¹ The University of Western Australia
² Curtin University, Western Australia

Concepts that form the basis of the technology behind solar panels and smart phones are typically relegated to university courses. We know that primary and secondary students are interested in these technologies and there is increasing evidence that the underlying concepts can be understood by students at these levels. Einstein-First has been developing curriculum materials for primary and secondary schools (Years 3-10) that present these
concepts using toys, models and analogies that are conceptually accessible and fun for the students. Modern physics concepts, specifically those relating to quantum physics, need to be first introduced in the primary years and can be vital to changing student attitudes to science. I report on a trial of a Year 5 quantum physics-based module that was conducted in a Perth primary school and presented by a single teacher who participated in an Einstein-First professional development session. The results consist of student knowledge on pre- and post-tests, teacher interview data and feedback. We found that student understanding of quantum concepts improved as a result of the trial. However, this improvement was limited by the teacher's confidence and background knowledge. This trial has provided the motivation to further develop teacher training resources.

**Room 418.205**

**Teaching student graphing in Mathematics and Science: The utility of Peirce’s Semiotics**

John Cripps Clark, Joseph Paul Ferguson, Catherine Legg
Deakin University, Victoria

Teachers of Mathematics and Science strive to better support their students to interpret, create and critique their own graphs and those of others. Researchers have struggled to develop a framework to critically analyse the effectiveness of these student-generated graphs as part of classroom teaching practice, effectively falling back on contingent embedded cultural norms, rather than principled theoretical insight. Building on previous work by Legg on “diagrammatic teaching” (2017), we extend Peirce’s semiotics – in particular, his icon/index/symbol distinction, as a means to deconstruct student-generated graphs considered as diagrams. We demonstrate the nature and potential of this framework by applying it to examples of student graphs generated from practical physics activities which model motion. We suggest that students are likely to execute graphing more confidently and competently if they understand and appreciate all three sign aspects of graphs as diagrams, that is iconic (‘pictures’), indexical (‘pointers’) and symbolic (‘predicates), and their teachers are able to elucidate the semiotic elements of their students’ graphs. By learning how to subject such graphs to semiotic analysis, we can better support teachers to teach graphing in ways that can scaffold powerful induction into the meaning-making practices of Mathematics and Science.

**Room 418.206**

**How the experience of a STEM industry engagement can promote deep learning and understanding of Science and STEM among preservice teachers.**

Carol Aldous, Alice Dunlop
Deakin University, South Australia

This study sought to understand the impact of a first-hand experience of the practical application of STEM skills within industry upon pre-service secondary science teachers. This was done with respect to preservice teachers’ view of STEM, their self-perceptions of their ability to teach STEM as well as their confidence and creativity in STEM. The research used a mixed method design applying surveys and focus group interviews. Quantitative data collection (N=86 pre-service secondary science teachers) involved pre and post industry placement surveys, to assess the impact of the industry experience upon their confidence and view of STEM, on their understanding of the value of creativity in STEM and creative problem solving. Qualitative information involved focus group interviews pre industry visit and post industry visit (N=28). Findings highlighted that industry engagement helped pre-service teachers to build confidence in teaching STEM and to develop a deeper appreciation of the
importance of science and STEM to society and of how creativity is important to these fields. Pre-service teachers felt more confident in their level of science knowledge and understanding following their post-industry engagement. Further, the preservice teachers felt that they were better able to make science an engaging and meaningful subject for their students.

11.40 – 12.20

Room 418.203

Implementing Guided Inquiry in Senior Biology Settings: A Design Based Research

Amrita Kamath, Peta White (Supervisor)
Deakin University, Victoria

Research continues to endorse Guided Inquiry Based Learning, but senior science (year 11 and 12) settings in Australia still appear to predominantly adopt transmissive teaching pedagogies. Based in Victoria, this Design Based Research (DBR) seeks to explore this pedagogical misalignment through two main research questions; How can guided inquiry be effectively enacted to enhance student learning and engagement? What cultural, technical, and political influences shape effective enactment of guided inquiry in senior biology settings? To undergird the intervention steps of DBR, which are set to commence this year, a phenomenological exploration of teachers’ perceptions and practices of inquiry was undertaken in 2020. Findings indicated three major sets of concerns: ambiguity in teachers’ interpretation of inquiry; lack of readiness for inquiry; and pressures/school culture expectations at senior secondary level. Furthering these pilot findings, the soon to be enacted DBR will employ collaboration, field observations, teacher/student interviews, documentation of artefacts, and classroom recordings; to promote teacher introspection and gain insights into perspectives. There is potential for significantly improved outcomes and transformative teaching and learning agendas to be developed in conjunction with key teachers, to provide evidence-based advice concerning possible modifications to pedagogical practice to focus on guided inquiry.

Room 418.204

Adaptive Expertise in primary science and mathematics education: Findings from a scoping review

Lihua Xu$^1$, Amanda Berry$^2$, Jan van Driel$^3$, Kennedy Chan$^4$ and Jinny Kim$^2$

$^1$ Deakin University, Victoria
$^2$ Monash University, Victoria
$^3$ The University of Melbourne, Victoria
$^4$ University of Hong Kong

Australian primary teachers are usually trained as generalists who often lack understanding of how to connect mathematics and science in meaningful ways to promote students’ interdisciplinary learning. Research shows that teaching mathematics and science in interdisciplinary ways is challenging for teachers. Traditional professional learning programs tend to focus on the development of teachers’ routine expertise, that is, the ability to effectively and efficiently apply routines to typical classroom situations. Therefore, to design and implement professional learning initiatives that effectively support primary teachers, a better understanding of the development of adaptive expertise for interdisciplinary mathematics and science teaching is needed. The notion of adaptive expertise is not new, but its characteristics and development remain under-researched. In this presentation, we share the outcomes of a scoping review of literature on adaptive expertise and discuss
their relevance to science and mathematics education, in our Australian Research Council funded project, Primary teachers’ adaptive expertise in interdisciplinary mathematics and science (2021-2024). We will discuss key concepts and characteristics associated with adaptive expertise and identify research gaps in the existing literature, for the purpose of providing a strong theoretical basis for our own project and future studies on teacher adaptive expertise.

Room 418.205

Collaborative science learning in immersive virtual reality: It takes more than a couple of VR headsets

Mihye Won¹, Dewi Ungu¹ (HDR), Henry Matovu¹ (HDR), David Treagust¹, Mauro Mocerino¹, Roy Tasker², Chin-Chung, Tsai³

¹ Curtin University, Western Australia
² Western Sydney University, New South Wales
³ National Taiwan Normal University

Correcting students’ naïve misunderstandings of scientific theories is crucial for effective scientific learning and is seen as a central goal in primary science education, but amending such thinking is not easy. Even adults are prone to making basic scientific mistakes, as naïve thinking is not simply replaced by scientific thinking but is suppressed upon encountering counter-intuitive conflicts. Previous studies suggest that executive functions such as inhibition, cognitive flexibility and working memory play important roles in this suppression process among children and adolescents, but it remains understudied among adults. This small-scale experiment included 22 adults using seven computerised cognitive tasks, four measuring executive functions and three measuring suppression of naïve thinking. Results indicated that executive functions, especially cognitive flexibility and inhibition, are positively correlated with the ability to suppress naïve thinking in both physics and biology. This finding suggests that the suppression of naïve thinking and activation of scientific thinking occurs simultaneously when solving counterintuitive scientific questions. These results indicate the importance of executive functions for scientific learning, and hold promise for improving science pedagogy from a cognitive psychology perspective.

Room 418.206

(ONLINE)

Pre-service teacher experiences in a Makerspace

Helen Georgiou, Wendy Nielsen, Peta Halliburton (HDR)

University of Wollongong

The idea of ‘STEM’ has had significant reach in education, particularly at the primary level, where it is often considered a standalone key learning area and ‘STEM’ or ‘STEAM’ classrooms and Makerspaces are increasingly common. However, preservice teachers (PST) have very little experience with Makerspaces and STEM and are known to lack confidence in this area. In this research, we explore how Makerspaces enable and constrain understanding of and confidence in STEM. This is a multiple-case-study design, with four cases representing four participant groups. The participating groups designed a product in a community Makerspace as part of a formal university assessment in a Science subject as part of their primary education degree. Data for each of the four cases include: observations of the entire process of designing the product in the Makerspace over a period of 5 weeks (approximately 7-15 hours), artefacts such as pictures and course material, ‘heat maps’ of where in the space they worked in, the group’s final assessment, and interviews with at least one member of the group.
Results show how STEM knowledge and confidence develops and the enablers and constraints of this confidence and knowledge in terms of working in the Makerspace.

1.45 – 2.25

Room 418.203

Understanding the nature of integrated STEM in K-12 classrooms

Gillian Roehrig¹, Emily Dare², Joshua Ellis², Elizabeth Ring-Whalen³

¹ University of Minnesota, USA
² Florida International University, USA
³ St Catherine University, USA

This study shares research from a new K-12 STEM (science-technology-engineering-mathematics) observation protocol. The protocol was developed using 2030 elementary, middle, and high school classroom videos collected in the United States. Each of the ten items assesses the degree to which characteristics of integrated STEM are evident in the lesson. This study reports the results of principal component analysis which revealed two core dimensions of integrated STEM education. Real-world Problem-solving includes 21st century skills and STEM practices necessary for developing solutions to real-world problems. The nature of Integrated STEM includes items that promote integration between the real-world context, students’ personal experiences, STEM careers, and STEM content. PCA also suggested the possibility of an additional dimension of integrated STEM involving technology practices in STEM. Further analysis revealed statistical differences across science-centric vs. engineering-centric STEM lessons within the video repository. The mean for all items within the Real-world Problem-solving dimension, as well as most items within the Nature of Integrated STEM dimension (items related to contextualizing learning, content integration, and STEM career awareness), were statistically higher for engineering-centric lessons. Whereas scores for relating content to students’ lives and technology practices were significantly higher for science-centric lessons.

Room 418.204

(ONLINE)

Primary teachers’ conceptualisations of disciplinary-specific creativity in science

Joseph Paul Ferguson, Melinda Kirk (HDR)

Deakin University, Victoria

Primary teachers as generalists need to competently switch between the disciplinary-specific practices of various subject areas. Creativity is a key competency that is increasingly recognised as manifesting in different forms in different disciplines. In this paper, we use a pragmatist semiotic lens to analyse interview data to explore primary teachers’ conceptualisations of creativity as it specifically plays out in science for them and their students. The two participating teachers were part of a longitudinal design-based study to develop with researchers a pedagogy that enables them to induct their students into the disciplinary-specific practices of science, including creativity. In undertaking this journey with researchers, these teachers have developed a comprehensive and increasingly precise notion of what it is for their students to be creative in science and what it means for them as teachers to notice and support this process. This involves teachers working with their
students to undertake science inquiry in collaborative ways that open up possible avenues to express and realise new ideas. However, more work needs to be done to support teachers to more sharply differentiate the form which creativity ought to take in science and the forms it takes in closely related disciplines, in particular mathematics.

Room 418.205

Citizen Science: What’s in It for the Citizen?

Léonie Rennie
Curtin University, Western Australia

Over the last two decades, citizen science projects have become a major means of involving people, both students in schools and adults beyond schooling, in community-related scientific issues. In 2015, the Australian Citizen Science Association held its first conference in Canberra and has endorsed the “Ten Principles of Citizen Science” developed by the European Citizen Science Association. This presentation addresses the third and fifth of these principles which are, respectively, “Both the professional scientists and the citizen scientists benefit from taking part” and “Citizen scientists receive feedback from the project”. These principles are explored in the context of a citizen science project named Australasian Fishes, based around a website hosted by iNaturalist, a joint initiative of the California Academy of Sciences and the National Geographic Society. iNaturalist asks citizens to “record your observations, share with fellow naturalists, and discuss your findings”. For the Australasian Fishes project, citizen participation begins with posting an observation (usually a photo accompanied by what, where, and when information) on the website, but then what happens? How do the scientists benefit? How does the citizen benefit? These questions are answered in terms of the personal experience of the presenter.

Room 418.206

(ONLINE)

Role-playing design and Critical Thinking in Secondary Science Pre-Service Teacher Education

Jose Manuel Hierrezuelo-Orsorio, Antonio Joaquín Franco-Mariscal
Faculty of Science Education. University of Málaga (Spain)

Role-playing is an educational strategy that simulates a current, controversial, unsolved problem about which information is available and accessible. This work, within the framework of the R&D project PID2019-105765GA-I00, presents an activity for pre-service science teachers focused on developing critical thinking skills such as argumentation and decision-making. This programme has been implemented with 107 Master in Secondary Education Teaching students at the University of Málaga (Spain) in the specialisations of Physics and Chemistry, and Biology and Geology during 2020-21 and 2021-22. The participants, acting as professors, and working in small groups, had to design a role-playing game for students in their educational stage, indicating the contributions of the activity to the development of critical thinking skills. The analysis of the productions showed that the most recurrent themes of the designs were health (42.9 %) and environmental education (28.6 %). Other themes used were scientific research, genetics and energy consumption, with 9.5% of all designs. In addition, the students highlighted that the role-playing game allowed them to develop various skills related to critical thinking, with information analysis (24.7%), argumentation (18.5%) and decision-making (17.3%) standing out.
More storytelling: Chemists, crime, fraud and scandal

William Palmer
Curtin University, Western Australia

The purpose of this study is to extend the research that I presented at ASERA 2021, where I attempted to connect chemists and crime by finding the stories of some villainous and scandalous chemists. I have avoided connecting chemists to criminality using the connection with forensic science, where the chemist’s evidence in court leads to the conviction of a criminal. This study will provide examples of chemists, or persons with an extensive chemical knowledge, using that knowledge to commit a crime or committing a crime in the course of their chemical career. It will include some more recent instances, though this opens up very large numbers of cases due to the huge expansion of the chemical enterprise. The examples chosen will provide instances to discuss the legal moral and chemical aspects of the cases. This could provide a useful starting point for courses involving a discussion of ethical issues in science.

Features of and Representational Strategies in Instructional Videos for Primary Science Classes

Joonhyeong Park¹, Jina Chang², Jisun Park³, Hye-Gyoung Yoon⁴

¹ National Institute of Education, Nanyang Technological University, Singapore
² Seoul Seongil Elementary School, Seoul, South Korea
³ Ewha Womans University, Seoul, South Korea
⁴ Chuncheon National University of Education, Chuncheon, South Korea

The utilisation of instructional videos for science teaching has become more widespread due to the expansion of the online teaching and learning environment and the well-known awareness of the benefits of videos, such as enabling the use of effective multiple representations. With this in mind, this study aims to examine the features of instructional videos for teaching scientific practices, a key element of science education, and learners’ engagement, a crucial issue in instruction in terms of representational strategies used. For this, we analysed 16 instructional videos for science teaching generated by pre-service teachers. We found that the instructional videos focused on posing a question related to the scientific phenomenon and its explanation conceptually, as opposed to conducting experiments and interpreting the results. It was also found that there were alternations between providing relevant and conceptual resources and affording learners opportunities to answer questions verbally and visually to prompt their engagement. Various representational strategies, such as summarising, comparing, highlighting, sequencing, and presenting vivid phenomena, were also employed for better teaching scientific practices as a part of learners’ ongoing cognitive activities. Based on the findings, we argue that the potential for using instructional videos for teaching science, considering the representational strategies in terms of scientific practices and learners’ engagement.
What can schools learn from STEM Centres?: STEM skills and practices through Victorian Tech Schools

Linda Hobbs, John Cripps Clark, George Aranda, Peta White, Seamus Delaney, Chris Speldewinde

Deakin University, Victoria

STEM-related skills, capabilities and practices have been positioned as critical to the broader STEM agenda. The Tech Schools Initiative in Victoria aims to equip young people with STEM skills for future employment in industry growth sectors. Drawing on findings from our evaluation of this Initiative, this paper explores the question: What can schools learn from Tech Schools about how to address STEM practices when teaching STEM? Interview data with students and teachers who have used Tech School facilities, programs and outreach support was analysed. Thematic analysis identified four design features that underpin the Tech School’s innovative approach to teaching the STEM skills and practices: links with industry providing contexts for learning; technology as the vehicle for learning; design thinking and problem solving as the pedagogical approach; and the 21st century skills as the focus of learning. The values that are placed on these design features by teachers and students are summarised, as well as critique that arose. Evidence shows that students are beginning to notice and become confident with 21st Century skills through their Tech School experience, particularly in the areas of group work, design thinking, and problem solving.

Theoretical developments in social semiotics and multimodalities research in science

Wendy Nielsen¹, Jennifer Yeo², Kok-Sing Tang³

¹ University of Wollongong, New South Wales
² Singapore University of Social Sciences
³ Curtin University, Western Australia

In this panel discussion, the international collection of authors of papers for the RISE Special Issue on Multimodal Meaning-Making in Science (due out in March/April) build on the published work and discuss further developments in this interesting area of science education. Across the many representational forms found in science learning contexts, research in this area also includes learner-generated representations. We approach multimodal meaning-making through a lens in social semiotics that is grounded in Kress and van Leeuwen (2001). Modalities include visual, auditory, textual, gestural and graphical forms, among others. Representations are the many ways to present ideas, some of which are discipline-specific or unique to particular learning contexts. We aim to synthesise key findings across the Special Issue paper set in this flexibly delivered panel discussion. Voices from around the world will illustrate the many intersections across social semiotics, representations, multiple modalities, creativity, reasoning, teacher knowledge and practices, inclusive classrooms and inquiry more generally. There are also methodological challenges to this work and panel members will highlight and explore some of these during the session. In addition to the proposal submitters, panel members include: Sarika Kewalramani, Kevin Tai, Joe Ferguson, Russell Tytler, Christine Preston, Hanna Wanselin.
What do integrated STEM projects look like in classrooms? A systematic literature review of empirical studies of iSTEM projects

Felicity McLure¹, Kok-Sing Tang², John Williams²

¹ Charles Darwin University, Australia
² Curtin University, Western Australia

The past 20 years has seen a growing focus on integration of Science, Technology, Engineering and Mathematics (iSTEM) disciplines in schools to provide students with authentic experiences to solve real-world problems. A frequently stated aim for iSTEM projects has been increasing engagement and interest in pursuing STEM subjects in senior high school and tertiary studies. In order to better understand the iSTEM projects landscape in school classes, this systematic literature review analysed empirical studies of integrated STEM projects carried out in secondary schools to answer the following questions: What types of projects are described in empirical studies of middle/high school integrated STEM/STEAM/STEMM? What results or observations are reported when iSTEM projects are implemented in middle school/high school? In what ways are disciplines explicitly (or implicitly) integrated in these projects? 44 peer-reviewed publications were identified from database searches that met the following review inclusion criteria: (a) integrating two or more of the STEM areas, (b) middle/high school education and (c) explicitly describing the research intervention. The review revealed a diversity of iSTEM approaches in the literature as well as a gap detailing how teachers and students enact integration of STEM skills in these projects.

Intentional teaching and STEM learning in a play-based setting

Shukla Sikder

Charles Sturt University, Bathurst

Whilst the Early Years Learning Framework (EYLF) was published in 2009, the pedagogical relationship between intentional teaching and play-based learning is still somewhat difficult for educators to conceptualise and enact their role in the play-based context (Edwards, 2017; Grieshaber et al., 2021). In particular, educators are not confident enough in teaching STE (science, technology, and engineering) in a play-based context (MacDonald et al., 2021). However, there is a growing demand to incorporate teaching practice for STEM learning activities in early childhood settings (Lippard et al., 2017). Play is the leading source of children’s learning as part of their social and cultural experiences (Vygotsky, 1966), and adults can enhance children’s STEM learning in a play-based setting (Sikder & Fleer, 2015). This paper examines how intentional teaching could support children’s STEM learning in a play-based context. Digital visual observation was used to collect data in an early childhood centre, and 95 minutes of video data of children’s (3 to 5 years of age) play has been analysed using the dialectical interactive approach (Hedegaard & Fleer, 2008). The 4P phases (Plan, Play-based action, Product, and Pedagogical reflection) model is developed, which provides a conceptual framework for STEM-based learning in a culturally valued play.
**Room 418.205**

**Professional actors’ difficulties and educational effects who participated in the production of Science Play**

Shinchoeil Kang (HDR), Jinwoong Song (Supervisor)

Seoul National University, Korea

The focus of science culture is changing from Popularization of Science (PS) to Public Engagement in Science (PES). This qualitative single-case study explores the difficulties and educational effects experienced by professional actors who engaged in the production and performance of the Science Play, “Quantum Warfare”. The plot deals with the debate of scientists in the early stages of Quantum mechanics. Various data such as the script, recording of the play, and interviews with a director and four actors were collected and repeatedly analyzed. Unfamiliar scientific jargons were burdensome for the actors to pronounce correctly so they appear to be scientists to the audience. Actors had to understand scientific theories, not just to memorise them. They felt that scientists’ consultations are needed for their understanding. Also, it was difficult to convey the scientific theories to the audience who were unfamiliar with science. To overcome this, they tried to provide multiple experiences: visual materials, dances, and songs. The experience of science play has provided opportunities for the actors to broaden their understanding of the NOS and scientific theories and to become more friendly towards science.

**Room 418.206**

(OFFLINE)

**Upcycling systems thinking oriented education research into science teaching practice**

Seamus Delaney, Madeleine Schultz

Deakin University, Victoria

Young people expect to be educated about climate change and sustainability, in order to take an active role in addressing the disproportional anthropogenic mass to biomass globally, and the current imbalance between species on Earth. Considerable international action has focused on the design and implementation of school programs targeting systems thinking competency, as an approach to equip young people to deal with these challenges and thrive in a green economy situated in the Anthropocene. Our contribution has been to develop, implement and evaluate co-designed professional learning programs with teachers and educators, who then implement systems thinking-oriented activities in their classrooms, either as hands-on practicals or online. Our findings are having influence on ongoing policy being developed to inform how systems thinking in chemical education (STICE) can be implemented. In the Year of Basic Sciences for Sustainable Development (IYBSSD 2022), this presentation will also consider how this research can feed back into other science disciplines which have a more storied history with systems thinking, such as environmental science and engineering.
Room 418.203

Early learning of powers of ten for understanding concepts of modern Physics

Anastasia Popkova (HDR), David Blair (Supervisor)
University of Western Australia

To allow children to understand the scales of the universe from atoms and galaxies, we need to rethink mathematics education. Understanding the main concepts of Einsteinian Physics requires the development of students’ mathematical concepts in three important ways a) understanding of the vast range of scales of the universe, which necessitates the development of logarithmical thinking b) the development of probabilistic thinking, and c) the development of vector understanding d) Fermi estimations. These skills also have importance for understanding the financial world, global issues such as environmental problems, gambling and risks, and skills such as drone navigation. We are creating and testing a mathematical curriculum Maths for Einstein’s Universe that complements and reinforces the physics learning progression that begins in early primary school. In my talk, I will present the part program called Early learning of powers of ten for Year 5 and Year 6 students.

Room 418.204

(ONLINE)

Analysing students’ collaborative drawings using discourse maps

Jina Chang¹, Joonhyeong, Park², Kok-Sing, Tang¹, David F, Treagust³, Mihye, Won³

¹ Seoul Seongil Primary School, Korea
² Nayang Technological University, Singapore
³ Curtin University, Western Australia

This study analysed how students made collaborative drawings and how this process contributed to elaborating students’ ideas. To this end, we examined how 5th and 6th-grade students developed group drawings in terms of increasing explanatory levels of drawing about sound transmission. Especially, in relation to the progressions of their drawings, we generated a new analysis tool called “discourse maps” to analyse and visualise students’ discourse patterns. We focus on two cases of group drawing processes that showed a large difference in the explanatory levels in their drawings. In the first case, the students successfully co-constructed sound transmission drawings following a Demand-Give-Acknowledge discourse pattern. The students continuously questioned how to visualise particle vibration, used multimodal resources to generate alternative drawings, and produced mostly scientific drawings. In the second case, the students did not reach a consensus on how to visualise particle vibrations, following a repetitive Give-Refute discourse pattern. While the teacher intervened and mediated these students’ conflicting ideas, the students did not generate any new ideas. The results of this study provide a pedagogical lens to investigate collaborative drawings as well as insights into using productive discourse patterns to show the development of students’ scientific explanations about sound transmission.
Leadership perspectives on mutually beneficial relationships between school and local STEM centres

George Aranda
Deakin University, Victoria

Interest in the STEM curriculum, skills and capabilities has seen an increase in the development of relationships between schools and local STEM centres. The Victorian Tech Schools Initiative aims to work with schools to provide young people with STEM skills for future employment in local industry growth sectors. Drawing on findings from our evaluation of this Initiative, this paper explores the question: How can schools interact with local Tech Schools to develop curriculum and STEM programs that are mutually beneficial? Interview data with school leaders whose schools have used Tech School facilities, co-developed STEM programs and curriculum were analysed. Thematic analysis identified five ways that characterise mutually beneficial relationships between STEM centres and schools: a shared history; common values between Tech School and school; Tech School committee representation; liaison between Tech School and school; and key contacts. The values that are placed on these interactions by leadership are summarised, as well as critiques that arose. Evidence shows that leadership values the unique collaborative partnership between Tech Schools and schools that enhance the school curriculum and ensure that STEM programs are relevant to school needs. Reciprocally, school leadership and liaisons are pivotal in communicating Tech School offerings, ensuring their relevance to students and teachers.

Development of a project-based early STEM module and a teacher workshop integrating biomedical engineering and medical care

Ching-Ting Hsin¹, Chun-Yu Chuang², Hsin-Kai Wu³

¹ Department of Early Childhood Education, National Tsing Hua University, Taiwan
² Department of Biomedical Engineering and Environmental Sciences, National Tsing Hua University, Taiwan
³ Graduate Institute of Science Education, National Taiwan Normal University, Taiwan

Respiratory infectious diseases are closely related to the lives of young children. During the COVID-19 pandemic, young children often hear about coronavirus and its impact. However, few curricula have been developed for young children to learn about the diseases. Project-based STEM learning modules have been developed to engage young children in learning STEM related ideas and concepts, but modules related to biomedical sciences are rather scant. Additionally, kindergarten teachers often are not confident and tend to have low self-efficacy in teaching STEM. Therefore, this study aimed to develop a project-based STEM module focusing on respiratory infectious diseases and to use the module developed by the interdisciplinary research team to hold a teacher workshop. The module contained 18 lessons and covered five main concepts: Causes of diseases (3 lessons), lung damage (4 lessons), disease prevention (7 lessons), medical treatments (2 lessons), and immune enhancement (2 lessons). 48 kindergarten teachers attended the workshop. Their average age was 32.7 years with 98% were female. Consent was collected and then they filled the Self-efficacy in Science Teaching Questionnaire before and after the workshop. The result showed that these teachers’ self-efficacy significantly increased ($p < .001$) after the workshop.
Dialogic Teaching in Secondary School Science – A Case Study in a High Performing All-Girls School in Singapore

Han Pin Goh (HDR), Yann Shiou Ong (Supervisor), Yew Jin Lee (Supervisor)
National Institute of Education, Nanyang Technological University, Singapore

Teacher-student talk interactions in many classrooms are mainly brief, used for evaluative purposes or for eliciting student ideas without follow-up. Reticence during whole class discussions could be magnified among high-performing and female secondary students who tend to experience a fear of failure. This on-going case study investigates how practices associated with dialogic teaching are carried out by a teacher-researcher journeying with colleagues in a Community of Practice (CoP) within a high-performing, all-girls secondary school in Singapore. We primarily intend to observe whether and how a culture of dialogic teaching develops in two science classrooms (Grades 7-8 integrated science and Grade 9-10 Physics) taught by the teacher-researcher over two years. A range of indicators of dialogic teaching are defined for coding of dialogue moves observed in selected lessons. Findings from classroom video recordings will be triangulated with CoP notes of discussions, teacher interviews, student focus groups, and student surveys about engagement. Overall, we seek to strengthen the link between theory and practice of dialogic teaching, understand how dialogic teaching can be enacted in the discipline of science education, and gain a more nuanced understanding of how students from these academic profiles are socialised into a community of science learners in this school.

Digital play and young children’s creative science inquiry

Katie Fielding (HDR), Emma Cross, Karen Murcia (supervisor)
Curtin University, Western Australia

Educators are challenged to engage today’s 21st century learners in science inquiry in ways which develop their creative and critical thinking skills. Increasingly, children are using digital technologies as a part of their everyday life, and as a tool for learning and representing what they know. Taking a connected and integrated view of children’s learning with digital technologies generates opportunities for science inquiry to be embedded with and across curriculum areas. STEAM (Science, Technology, Engineering, Arts and Mathematics) inquiry projects present opportunities for young children to engage in cross-disciplinary experiences where they think creatively, collaborate, problem solve and communicate scientific questions and ideas. In order to identify evidence of the creative potential of using digital technologies with young children (4–8-year-olds), a systematic review of the literature was conducted. The findings of this study revealed that the technologies we choose to use can be indeed powerful in engaging young children in their learning and in giving them outlets to communicate their newfound understandings and excitement. In this session, we will share an illustrative example of a STEAM inquiry project conducted by practitioner researchers in a Western Australian early year learning centre with 4-
year-old children. We will share findings from the study that demonstrate how young children’s playful learning with technologies can provide rich opportunities to develop their questioning, planning and communicating skills in science, as well as across other learning areas.

Room 418.205

On Four Different Senses of Embodiment in Science Education

Magdalena Kersting¹, Jesper Haglund², Rolf Steier³

¹ University of Copenhagen, Denmark
² Karlstad University, Sweden
³ Oslo Metropolitan University, Norway

Science deals with the world around us, and we understand, experience, and study this world through and with our bodies. While science educators have started to acknowledge the critical role of the body in science learning, approaches to conceptualising the body in science education vary greatly. Embodiment and embodied cognition serve as umbrella terms for different approaches to bodily learning processes. Unfortunately, researchers and educators often blur these different approaches. This talk will disentangle key ideas of embodiment to provide a comprehensive overview of how the body bears on science learning. Specifically, we propose four senses of embodiment that conceptualise the body in physical, phenomenological, ecological, and interactionist terms. By illustrating the multiple senses of embodiment through examples from the recent science education literature, we show that embodied perspectives bear on science education research and practice. We hope that future work can recognise the different senses of embodiment and show how they might work together to strengthen the many roles of the body in science education.

Room 418.206

A reading group for science educators: An approach for developing personal and collective pedagogical content knowledge in science education

Jared Carpendale¹, Ange Fitzgerald², Rebecca Cooper³

¹ Massey University, New Zealand
² RMIT, Victoria
³ Monash University, Victoria

Reading is a basic, yet critical way to undertake learning and growth. This presentation shares a professional learning initiative for science educators, which was underpinned by the premise of the reading group. In moving from being a vehicle for targeted discussion, the reading group facilitators sought to support the participants in making a deeper examination of their practice with the impact ultimately being changes to their personal pedagogical content knowledge (PCK) for science. This small-scale qualitative study was informed by the voices of three science educators at different stages and career trajectories, each of whom was interviewed. Data revealed that their participation in the reading group informed the development of their personal and collective PCK by: (i) creating conditions that encouraged meaningful links to be made between theory and practice; (ii) encouraging the adoption of an inquiry stance as a means for engaging purposively with professional knowledge; and (iii) initiating a transformation of their contemporary understandings of science and science education. By
drawing on the participants’ narratives, this presentation will showcase both the simplicity and depth of complexity that can be achieved through a reading group focused on professional learning and development.

**Room 418.207**

**Changes in pre-service teacher understanding of the STEAM inquiry model**

Harry Kanasa¹, Ben Barlow¹, Kate Thompson², Susan Chapman²

¹ Griffith University, Queensland
² Queensland University of Technology

The STEAM inquiry model was designed to assist students and teachers to more effectively engage in inquiry-based learning to a) select the most appropriate inquiry process, knowledge and tools to complete an inquiry and b) facilitate student-student and student-teacher interactions about the project. Pre-service teachers are engaged in a 3-week inquiry project, utilising the STEAM inquiry model. Changes in their understanding of the model and STEAM inquiry and perceived utility of the model for their future teaching will be measured pre- and post-unit. This presentation will explore the model and how it was implemented into the PST program at X University. The findings still to be collected and finalised will explore if Pre-service teachers are a) better able to define STEAM inquiry, b) have more positive views about the use of model in their future teaching and, c) will be better able to use the model to identify the types of inquiry within their projects.

**9.10 – 9.50**

**Room 418.203**

**Investigating the use of engineering notebooks in scaffolding school students’ communication and collaboration skills.**

Michael Graffin, (HDR Student), Rachel Sheffield (Supervisor), Rekha Koul (Supervisor)

Curtin University, Western Australia

This ongoing PhD study explores the use of scaffolded engineering notebooks to support students’ development of 21st Century / transversal collaboration and communication skills in the context of the international FIRST LEGO League Challenge educational robotics competition. It addresses a gap in the literature regarding effective pedagogical approaches and instructional strategies teachers and coaches can use to teach and formatively assess these STEM skills in informal project-based-learning environments. Conducted in two phases during the 2021-22 and 2022-23 competition seasons, the study will involve 8 robotics teams in a qualitative multiple case-study methodology based on an interpretivist paradigm. This presentation will explore the findings of the Phase 1 case studies, which involved 5 coaches and 30 students (5 teams) across two non-government school sites and a home-school in Western Australia. Early results suggest that the successful integration of engineering notebooks in FLL is influenced by coaches’ prior experience facilitating collaborative projects and their use of scaffolding instructional strategies, including guided questioning and graphic organiser tools, to support students’ articulation and reflection upon their learning and team processes. Many teams found the scaffolded notebooks useful for keeping track of their progress; however, their perceived value and use of the notebooks varied dramatically.
The Aspects of Elementary Students’ Productive Disciplinary Engagement (PDE) from the Perspective of Practical Epistemology

Seungho Maeng (Supervisor), Arim Kim (HDR) Phil Seok Oh

1 Seoul National University of Education, Seoul, Korea
2 Myeongil Elementary School, Seoul, Korea
3 Gyeongin National University of Education, Seoul, Korea

This study investigated the aspects of elementary students’ productive disciplinary engagement from the perspective of practical epistemology. The context of the study was for 23 fifth-grade students in an elementary school to construct explanatory models about condensation. Students observed a phenomenon in which they opened a pet bottle cap compressed by an air pump. The method of practical epistemology analysis was administered to examine the aspects of PDE from the students’ classroom discourses. Also, how the principles of facilitating PDE were realized in each PDE discourse was investigated. The results showed that students perceived a gap between water droplets and being foggy inside the bottle. To fill this gap, similarity or difference relations between a hazy bottle, smoke, and water droplets were needed. Among the facilitating PDE principles, accountability to the norms was the most critical for realizing PDE. In conclusion, the aspect of elementary students’ PDE through PEA revealed: Recognizing gaps is the starting point for conducting PDE. To promote students’ productive disciplinary engagement in science classes, a teacher should consider the order of problematising contents students meet, give them authority to notice gaps, and use epistemological moves for them to take accountability to promote gap filling.

The role of community connections in STEM teacher education

Emma Stevenson, Jan van Driel (Supervisor), Victoria Millar (supervisor)

The University of Melbourne

The rise of science, technology, engineering and mathematics (STEM) education during the twenty-first century has seen a recent focus on teacher education in this field. With many teachers, particularly in secondary fields, prepared for and experienced with disciplinary approaches to teaching and learning, challenges have arisen with implementing integrated approaches to STEM education. Existing literature highlights that STEM teacher education is a flourishing field, with many professional learning (PL) and initial teacher education (ITE) opportunities available. Research in the area of STEM teacher education has also arisen, with studies commonly exploring the impact and characteristics of individual programs. This study, however, takes a broader and deeper exploration of STEM teacher education with the aim of investigating multiple programs across primary, secondary, ITE and in-service PL offerings at various universities. Utilising a qualitative and phenomenological approach, this study explored the experiences of course coordinators, teacher educators and teachers (preservice and in-service), aiming to gather their perceptions of valued STEM teacher education curriculum features. Inductive analysis of data gathered from qualitative surveys and semi-structured interviews highlighted a range of valued curriculum features, however this presentation will consider the role that community connections play in STEM teacher education.
Positioning teachers as active co-researchers examining problem-based learning in school-based STEM education

Jennifer Mansfield¹, Kathy Smith¹, Peter Ellerton², Amanda Berry¹, Nicoleta Maynard¹, Deb Corrigan¹

¹Monash University, Victoria
²University of Queensland

To explore Problem Based Learning (PBL) as a way to enhance Australian school-based STEM education, researchers from Monash University and Queensland University (UQ) are working with Melbourne Archdiocese of Catholic Schools (MACS) and Brisbane Catholic Education (BCE). One of the key intentions of this research is to actively position teachers as co-researchers to ensure they are translating research findings in ways which reshape their professional thinking and PBL practices in the area of STEM education. This has required researchers to strategize the conditions that position teachers as self-directed learners. The analysis of data from the first of five professional learning (PL) days indicated teachers expressed passive expectations for learning, where they were waiting for input to develop their thinking. This required facilitators to strategize ways future PL sessions could position teachers as key decision makers about their own learning and their contribution to the research overall. This required facilitators to think and work differently to actively create conditions that enabled teachers to notice and attend to their practice in ways that were both personally meaningful and contextually relevant. Findings from this research have implications for how teacher focused PL is structured, particularly in STEM education.

Jurassic World as an educational resource encouraging science education

María del Mar López-Fernández¹ (HDR), Antonio Joaquín Franco-Mariscal²

¹Universidad de Granada, Science Education, Granada, Spain
²Universidad de Málaga, Science Education, Málaga, Spain

We often find science-related topics on TV series and movies, which constitutes an excellent resource in science education. This study presents the results of activity on Jurassic World as an educational resource carried out with 56 pre-service science teachers studying a subject on educational innovation in the Masters Degree in secondary education teaching at Malaga University (Spain). Participants watched the Jurassic World trailer and, working in groups for 30 minutes, were asked to look for sequences that could be used to learn science in secondary school. They selected different frames and proposed scientific driven questions. Then, they explained the proposal and how it would be implemented in the class. Finally, a sample of students was interviewed to know their perceptions about the activity. The findings were numerous proposals made by the PSTs in different science fields. Some examples were: is it sustainable to maintain an ecosystem of only carnivorous animals on the island? (biology), what forces are involved when the dinosaur climbs the wall? (physics), how would you calculate the age of a dinosaur bone using the C-14 technique? (chemistry), what geological landscapes and relief modelling are present in the trailer? (geology). Also, pre-service teachers reported high satisfaction with the intervention and noted the usefulness of movies for secondary school students to learn science. [Acknowledgements: PID2019-10576SGA-I00].
9.50 – 10.30

Room 418.203

(ONLINE)

Science and Digital Technology - An evidence-based integration

Brigitte Glasson¹, Ben Egerton²

¹ Science Education Consultant, Christchurch, New Zealand
² Victoria University, Wellington, New Zealand

This presentation reports on a case study of a Year 9 science class (13–14-year-olds) undertaking an integrated inquiry: Can humans live on Mars? The unit of work focused on the students’ ability to interpret and use scientific evidence, and also embedded aspects of New Zealand’s new Digital Technology (DT) curriculum. As part of the unit, students contributed to an online citizen science project, Planet Four. Through this and a range of other practical activities, students developed their own body of evidence to better inform their response to the inquiry question: Can humans live on Mars? In this presentation we will share insights into how teachers can effectively plan to develop students’ scientific thinking, and to integrate DT learning outcomes, in science.

Room 418.204

From generalist primary teacher to specialist STEM teacher: Opportunities and challenges encountered by an educator making the shift

Frances O'Brien, Kimberley Pressick-Kilborn

Newington College, Stanmore NSW

There has been recent emphasis in primary initial teacher education courses in Australia on specialisations/specialisms, including in the STEM disciplines. For teachers already in the profession, however, what are the pathways to develop a specialised focus in teaching, in particular, through on-the-job opportunities created by appointment to a specialised role? This paper investigates one primary teacher’s decision to become a specialist STEM teacher after 10 years in the profession as a generalist classroom teacher. The research draws on qualitative case study and self-study methodologies to examine the factors that led to the teacher’s decision and the lived experiences of the first 6 months in a specialist role. Emergent themes arose from analysis of a series of in-depth interviews conducted at three timepoints in the first semester of the school year. Themes include identity shifts and challenges, the value of Professional Learning Networks in growing pedagogical content knowledge, and the realities of day-to-day collaborative planning and delivery of STEM programs in Kindergarten to Year 6. Implications for practice are considered, in relation to identification of generalist teachers who may be suited to specialisation in primary STEM, and how schools and school systems can best support teachers to make the shift.
**Room 418.205**

(ONLINE)

**Co-constructing an interdisciplinary framework in context: connecting science and sustainability education through environmental learning**

David Zandvliet¹, Connie Cirkony²

¹ Simon Fraser University, Vancouver, Canada
² University of Tasmania

This paper highlights how a science education curriculum was integrated within the context of environmental learning and sustainability education. The Environmental Learning and Experience resource was conceived as a guide for teachers to implement interdisciplinary practice — where teaching ‘about the environment’ is an organizing theme for teaching and learning and fosters connection to other core curricular skills and competencies, including science education. Using case study method, we describe how this guide, originally the product of an action research agenda was later developed into a framework and adopted by the British Columbia Ministry of Education, in Canada. The development of the Framework was informed by teacher inquiry, focus groups and interviews, which fed into a collaborative writing process involving teachers, academics, and a broad range of community stakeholders. The Framework offers a conceptual view for science learning in all settings provides principles of teaching and learning to guide science teachers in their activities in a variety of learning contexts. We draw on the stories of how science educators implemented these principles across the K-12 curriculum, and outline our strategies for preparing the next version, which prioritises indigenous perspectives. Our research has implications for educators, policymakers, and other stakeholders who are interested in cross-disciplinary approaches to science curriculum implementation.

**Room 418.206**

**Science Head Teachers’ Perspectives on Writing in the Discipline**

Wendy Nielsen, Honglin Chen, Helen Georgiou

University of Wollongong, New South Wales

There is widespread concern that writing is rarely taught in the secondary school (Wyatt-Smith & Jackson, 2020) or not taught effectively in relation to the subject area demands (Derewianka, 2020). Recent assessment data in Australia show a steady increase in the number of students not meeting minimum standards for basic writing skills: 5.6% (Year 5), 9% (Year 7), 16% (Year 9) (ACARA, 2019). This ‘writing skills slump’ (Myhill & Chen, 2020) needs a new approach to teaching writing in the high school, especially since secondary teachers across disciplines have tended to prioritise content learning over writing skills (Litman et al., 2017). Because Head Teachers are discipline leaders in high schools, the current research begins with the question: What are science head teachers’ perspectives on the disciplinary thinking and writing demands in science? We interviewed Head Teachers from three NSW schools. They confirmed the strong emphases on content knowledge, and not surprisingly, felt that writing was not really their concern or, more hopefully, were unsure how to integrate a writing focus into teaching. This paper considers the notion of ‘literacy integration’ from the Head Teachers’ perspectives. The findings have implications for ways to enable and support such an integration.
Balancing teaching scientific practice and addressing content knowledge: A case of two science classrooms in Singapore

Jing Da Tanabashi (HDR), Wan Hsuan Shermayne Soh, Miechie, Leo

Nanyang Technological University - National Institute of Education, Singapore.

Integrative activities (IA) have been introduced in Singapore’s 2021 Lower Secondary Science syllabus. IAs are short 2 hours activities that aim to not only consolidate students’ content learning across various chapters, but to also impart essential practices of science. A comparative analysis of two Secondary 2 (Grade 8) classes of from the Express and Normal Academic (NA) stream was conducted to determine the effectiveness of one such IA. The Fruit Battery IA was intended to let students explore how electrochemical cells function by conducting investigations to experimentally discover the parameters that influence the voltage output of a fruit battery and to encourage students to use their own collected data to attempt evidence-based explanations. Three sessions were conducted to introduce the fundamental concepts behind a fruit battery, followed by the conducting of the investigation, and finally the analysis and sharing of the experimental data gathered. All 3 sessions had audio and video recordings of students’ interactions and responses to the teacher. Additionally, focus group discussions were held with the students and pre- and post-IA interviews were conducted with the teachers as well. These recordings showed that the teacher’s perception of students’ abilities influenced the core ideas that they wanted to teach. The Express teacher focused on higher order thinking skills while the NA teacher focused on the content taught in the IA. Recommendations are made on the balance between teaching epistemic and content knowledge based on these 2 case studies.

Exploratory discussions in immersive virtual reality to learn hydrogen bonding within snowflakes

Dewi Ungu¹, Henry Matovu¹, Mihye Won (Supervisor)¹, David Treagust¹ (Supervisor), Mauro, Mocerino¹ (Supervisor), Roy Tasker², Chin-Chung, Tsai³

1 Curtin University, Western Australia
2 Western Sydney University, New South Wales
3 National Taiwan Normal University

Inside an immersive virtual reality (IVR) environment, two students can explore 3D molecular models as if they were real objects. This realistic visualisation opens a new way of collaboratively learning chemistry concepts, such as hydrogen bonding between water molecules to form snowflakes. We investigated how students collaborate in IVR to explain the 3D structure of ice lattice and snowflakes. Twenty pairs of first-year university students spent 30-50 minutes completing an IVR learning activity about hydrogen bonding in ice lattices. Pre- and post-interviews and IVR sessions were video-recorded, transcribed, and qualitatively analysed for collaborative exploratory discussions—depth of conceptual explorations and social dynamics. Although all student pairs explored the 3D structure in IVR to describe the similarities between ice lattice and snowflakes, only half of them moved beyond such description to explain how snowflakes would grow different shapes of
branches. Students who engaged in deeper conceptual discussions posed tentative statements to question their ideas and sustain exploratory discussions. In contrast, the other group of students gave more definitive explanatory answers to stop them from reflecting and elaborating on their ideas. Investigating how students initiated conceptual discussions helped understand the different paths of students’ joint conceptual explorations in a collaborative IVR environment.

Room 418.204

(ONLINE)

Features of and Representational Strategies in Instructional Videos for Primary Science Classes

Joonhyeong Park¹, Jina Chang², Jisun Park³, Hye-Gyoung Yoon⁴

¹ National Institute of Education, Nanyang Technological University, Singapore
² Seoul Seongil Elementary School, Seoul, South Korea
³ Ewha Womans University, Seoul, South Korea
⁴ Chuncheon National University of Education, Chuncheon, South Korea

The utilisation of instructional videos for science teaching has become more widespread due to the expansion of the online teaching and learning environment and the well-known awareness of the benefits of videos, such as enabling the use of effective multiple representations. With this in mind, this study aims to examine the features of instructional videos for teaching scientific practices, a key element of science education, and learners’ engagement, a crucial issue in instruction in terms of representational strategies used. For this, we analysed 16 instructional videos for science teaching generated by pre-service teachers. We found that the instructional videos focused on posing a question related to the scientific phenomenon and its explanation conceptually, as opposed to conducting experiments and interpreting the results. It was also found that there were alternations between providing relevant and conceptual resources and affording learners opportunities to answer questions verbally and visually to prompt their engagement. Various representational strategies, such as summarising, comparing, highlighting, sequencing, and presenting vivid phenomena, were also employed for better teaching scientific practices as a part of learners’ ongoing cognitive activities. Based on the findings, we argue that the potential for using instructional videos for teaching science, considering the representational strategies in terms of scientific practices and learners’ engagement.

Room 418.205

(ONLINE)

An investigation of indigenous Tao students’ learning about biological taxonomy

Yun-Ping Ge

National Taipei University of Education, Taiwan

Biological taxonomy embedded in indigenous culture is often variant with those of scientific knowledge. For example, the Tao tribe who live in a southeast island of Taiwan classifies fish taxonomy into ‘male’ and ‘female’ fish rather than ‘bony’ and ‘cartilaginous’ fish. The intention of this study is to investigate how the indigenous Tao students’ biological taxonomy disagrees with scientific knowledge and the other dominant group of Taiwanese students. The instrument is composed of a triad classification task, where 5 sets of photo cards with living things are presented. Individuals are then asked to select two out of the three in each set that are most
closely related. The participants, including 25 Tao year 7 students and 23 Han students, were invited and their tests were compared. The test of nonparametric statistics revealed that Tao students did have significant variation of biological taxonomy compared with Han students. Those participants inherited very little from their indigenous taxonomy. However, their diet still reflects specific fish taxonomy. Our findings indicate that students had some alternative conceptions which were not revealed by any prior studies. Implications and suggestions about science curriculum are discussed.

Keywords: biological taxonomy, indigenous students, Tao tribe

**Room 418.206**

**Science for the Community: Pre-Service Teachers’ Developing Understandings**

Tristan Orbeta\(^1\) (HDR), Frederick T. Talaue\(^2\), Alex L. Torres\(^2\), Hanny Pearl S. Camerino\(^2\), Heidi Gibson\(^3\), Logan Schmidt\(^3\), Sheryl Lyn C, Monterola\(^4\)

\(^1\) University of the Philippines - Diliman  
\(^2\) Center for Integrated STEM Education, Inc., Philippines  
\(^3\) Smithsonian Science Education Center, Washington, DC, USA  
\(^4\) University of the Philippines - Diliman, Philippines/ Center for Integrated STEM Education, Inc., Philippines

Education for sustainable development aims to develop learners who understand and act on the many interconnected challenges facing society today, such as poverty, loss of biodiversity and environmental degradation. Preparing teachers to design and enact learning environments that realise learner empowerment and informed action towards sustainable futures is a real challenge. A shift in educational goal is always an occasion for teachers to reassess and re-form their knowledge and practices. The problem of enacting new pedagogical frameworks is especially acute for pre-service teachers who may have limited to no teaching experiences to inform their engagement. In this study, we investigate how pre-service teachers’ participation in the field testing of community research guides on Biodiversity and Sustainable Communities mediated their understanding of learning and doing science. We draw from data collected throughout the semester of implementation, which includes activity outputs, individual and group reflections, group work recordings, and focus group discussions. Our preliminary analysis suggests, among others, that pre-service teachers are re-positioning science as a tool for understanding and serving their communities. During the presentation, we will discuss other findings and their implications on identity development as science learners but also as prospective science teachers.

**Room 418.207**

**Influencing high school students to continue with science at school**

Tracey-Ann Palmer

University of Technology Sydney, New South Wales

The supply of scientifically educated individuals needed for a modern society is interrupted when students fail to choose post-compulsory science at school. Developing strategies to encourage students to choose science relies on understanding the influences that impact this decision. This paper presents an overview of the (pre-Covid) subject selection environment in four schools. Seven subject selection events were observed, and all the
documents given to students at these events were reviewed. Semi-structured interviews were held with 15 adults within these schools who were identified by school representatives as being in a position to influence student subject choice. The events, materials and interviews provide evidence that science is promoted as being of value for a narrow range of occupations. This restricted perception of the utility of science may be a factor in students choosing to discontinue science in their final years of school.

11.40 – 12.20

Room 418.203

(ONLINE)


Maria Veronica Torralba (HDR)
De La Salle University, Manila

It has been known that for critical thinking to have an impact on teaching, there should be efforts on professional development and elaboration of course design and implementation. Anchored on the view that critical thinking is domain-specific and prompted by the need to develop instruments for measuring critical thinking in Physics, this study aims to conduct context analysis for future designing of programs for curriculum materials development and teacher training in Physics. A survey was deployed to secondary Physics teachers to look into their current assessment practices and perceptions about critical thinking. Results identified which forms of assessment are not as often used compared to others, and that there is correlation among familiarity, perceived skill, and frequency of use of these assessments. The survey also probed which critical thinking indicators teachers assess in their Physics classes and for which they were able to perceive evidence among student performance. It was found that the number of indicators that teachers elicit from students through assessments and for which they have identified concrete examples manifested in student performance differ significantly depending on whether the teacher has an education degree or not, and if the teacher has taught four Physics subjects or less.

Room 418.204

(ONLINE)

Conceptual PlayWorlds: An educational experiment into the place of Imagination in STEM in K-6 classrooms

Marilyn Fleer
Monash University, Victoria

Imagination as a psychological function is brought to bear on scientific problems, but also for children thinking about the place of the Earth in the universe or microscopic organisms in a petri dish or compost bin. Children imagine when thinking scientifically – as thought experiments (Albert Einstein), reconciling both the study of the universe and the molecular world (Stephen Hawking) or when engaging with genetics through imagining going down a microscope to study genes (Barbara McClintock). In this presentation the focus will be on imagination
and creativity in STEM, where drama and emotions are brought into the study of STEM through a model of teaching called a Conceptual PlayWorld. Findings from an ARC Laureate programmatic study designed to better understand the dialectical nature of imagination and abstract thinking in STEM will be presented. Funded over five years, the study focuses on 1) the development of students’ thinking under the conditions of a STEM Conceptual PlayWorld, 2) teachers’ confidence and competence in STEM teaching in the early years, and 3) the development of motives and motivation in families to support STEM conversations.

**Room 418.205**

**Rethinking passivity as the essence of agency in STEM learning contexts**

James Davis  
Queensland University of Technology

This paper explores learner experiences of passivity in a primary school STEM classroom situated in Shanghai, China. Passivity is often attributed to learners from societies influenced by Confucian philosophy, where it is commonly associated with the notion of suggestiveness, giving the learner space to engage in deep thinking and exploration of ideas. In contrast, common Western perspectives of passivity are attributed to quietness, silence, and withdrawal as evidence of a paucity of learner agency or actions orientated toward learning. Drawing on an authentic learning context, this study aims to illustrate how passivity may be understood as an essential facet of learner agency, and I challenge contemporary perspectives of passivity and agency through analysis of empirical data. My multi-logical, event-orientated methodology draws on an ethnomethodological orientation to analyse video and audio data showing the actions of a group of students as they learn to use a digital technology during a teacher-directed STEM lesson. Data are further analysed through contemporary conceptualisations of agency in terms of intentionality, forethought, self-reactiveness, and self-reflectiveness, and Confucian concepts such as suggestiveness. The findings contribute to an earlier, tentative theorisation of passivity documented in Cultural Studies of Science Education, but not empirically explored in science education research.

**Room 418.206**

**Mobile Learning in University Science Education: A Systematic Literature Review**

Le Quan Ly (HDR), Matthew Kearney (Supervisor)  
University of Technology, Sydney, New South Wales

Mobile technologies, such as mobile phones, laptops and tablets, have become valuable tools in past decades due to their flexibility, portability and ease of access. Use of these devices has subsequently become valuable for supporting science teaching and learning. Nevertheless, there is a lack of literature on the use of mobile devices to support learning (mobile learning) in university science education. This systematic review examines the adoption of mobile learning exclusively in science education in universities by investigating 24 high-quality studies published in the period 2011 to 2021. The findings provide a cross-analysis of the results from the selected studies, including research foci, methodological design, study outcomes, technologies, study settings and pedagogical approaches. The review concludes by highlighting implications for stakeholders, as well as providing suggestions for future research directions.
Evaluating the accuracy and coherence of scientific explanations constructed by lower secondary students in Singapore

Wei Jian Chua (Undergrad. Student), Miechie Leo, Wan Hsuan Shermayne Soh
Nanyang Technological University - National Institute of Education, Singapore

One of science education’s primary goals is to instil scientific practices such as the ways of thinking and doing science. One of such skills to be fostered includes the ability to construct scientific explanations. This study looked at lower secondary (grade 7-8 equivalent) students in Singapore and their ability to craft accurate and coherent scientific explanations on lactose intolerance. Students were given six plausible evidence cards and three claims about the population distribution of lactose intolerance globally during the activity, with the expectation to choose one or more evidence cards to support the most probable claim. A total of 71 students from two classes participated in the study. To serve triangulation, multiple data are collected, including pre-lesson and post-lesson interviews with teachers, video recordings of the lessons, students’ focus group interviews, and students’ worksheets. The collected data revealed that students had ample understanding of good scientific explanations, but that knowledge did not translate to improved performance in crafting scientific explanations. Preliminary findings suggest that the students’ comprehension of the resources was a more significant factor affecting the quality of the explanations. These findings are used to improve the design of the activity and implications will be discussed in the presentation.
Studies of inquiry-based learning (IBL) in senior secondary science education are under-represented in the literature compared to the earlier years of schooling and studies of Years 11 and 12 science often report a reliance on transmissive forms of teaching. Recent curriculum changes in NSW, Australia have attempted to change this emphasis and promote IBL. However, teachers have been provided very little guidance or support to implement IBL and little is known about the approaches that teachers have taken in response to the new curriculum. This paper presents research that addresses this critical gap. This paper reports on the findings of a study of the IBL practices of four Year 11 Biology and Chemistry teachers at three schools in Sydney, NSW. The research questions explored in this paper are: ‘What are expert teacher practices in inquiry-based learning in senior secondary science?’ and ‘What are student perceptions of their teachers’ practices?’. A grounded theory methodology is employed for this study which includes observation of the teacher participants. The analysis of teacher practices revealed a range of approaches that were generally positively received by students.

**Room 418.204**

**SYMPOSIUM (Running over 2 session blocks) 2.00-3.20**

**Investigating an interdisciplinary mathematics and science approach in primary schools**

Peta White (organiser)

Deakin University, Victoria

**Overview**

This symposium presents three papers sharing findings the ARC project ‘Enriching Maths and Science Learning: An Interdisciplinary Approach’ involving a Representation Construction pedagogy where students invent, evaluate, refine and extend representational systems in each of mathematics and science to support key disciplinary concepts and epistemic practices. The papers explore three distinct aspects of the project. Paper 1 reports on a Grade 2 learning sequence on ‘Fast Plants’ to show how mathematics and science mutually reinforce in the approach, and highlight the significant learning in measurement, data modelling, and plant structure and function. Paper 2 explores how the approach supports differentiation through innovative task design features and pedagogies. Paper 3 investigates the complexity of teacher change processes in response to the innovative pedagogy, raising questions for researchers regarding how to respond to such complexities.

**Paper 1: An interdisciplinary approach to teaching and learning the science and mathematics of plant structure and function**

Peta White, Russell Tytler, Joanne Mulligan, Melinda Kirk

Deakin University, Victoria

In this paper we describe the application of the IMS Representational Construction pedagogy through a case study of a Grade 2 learning sequence on plant growth using Lehrer and Schauble’s (2004) application of Fast
Plants. We describe the design principles through which the sequence was structured to open up new learning in each subject, the pedagogy used by teachers to support interdisciplinary learning, and present evidence of significant learning gains in knowledge of plant growth and reproduction. We focus on skill development in measurement and data representation through examination of student representational artefacts, interviews with students, and pre- and post-test results of student mathematical representational work. Through these analyses we argue for an approach to interdisciplinarity that operates with explicit design principles that open up mutually reinforcing epistemic practices particular to science and mathematics.


**Paper 2: Exploring differentiation within an Interdisciplinary Guided Inquiry Pedagogy: IMS Learning Project**

Melinda Kirk (HDR), Peta White (Supervisor), Russell Tytler

Deakin University

Differentiation is essential to quality curriculum design and effective teaching for all students. How to differentiate however is an ongoing challenge for teachers, with even experienced teachers commonly demonstrating a lack of confidence and competency to cater for all student learning needs. Within mathematics and science, teachers often resort to streaming and the provision of more; or different - harder or easier tasks, for individual students. We argue however that an innovative task design, with students engaging in the same task at different levels, coupled with enabling pedagogies can empower a more inclusive approach. The IMS Learning Project has developed learning sequences based on guided inquiry. Students are challenged and supported at their own level to build both science and mathematics conceptual understanding and practices through the invention, evaluation and refinement of multimodal representations. In this paper we use data from two sequences Grade 1 ‘Day and Night’, and Grade 2 ‘Water Investigation’ to analyse how this semiotically-focused, guided inquiry approach can differentiate for a wide range of student needs. We identify and illuminate effectual differentiation, the enabling learning design attributes, approaches and pedagogies.

**Paper 3: An exploration of teacher change in the context of adopting an interdisciplinary science and mathematics education innovation**

Chris Nielsen (HDR), Russell Tytler (supervisor)

Deakin University, Victoria

The IMS research project resulted in the provision and refining of curriculum materials and collaboration with primary school teachers in their classrooms to develop an interdisciplinary, representational approach to learning that deepens student understandings of foundational principles in both science and mathematics. The project has reported on student outcomes over a period of three years as the students generated, revised and presented representations and models, incorporating scientific and mathematical skills and concepts, for lesson sequences for specific topics. The IMS project supported participating teachers to adopt a very particular guided inquiry pedagogy based within a socio-semiotic constructivist epistemology. It was evident that the teachers participating in the IMS project were undertaking a journey of change and professional growth, as a consequence of adopting new pedagogical practices. This presentation provides an overview of four case studies which examined pathways of change for individual teachers, using the Clarke and Hollingsworth (2002) Interconnected Model of Professional Growth as a basis for data analysis. Each case study considers factors which might either support or inhibit teachers to adopt new approaches to student learning within their
classroom practice. The presentation is intended to provide insights into and raise questions about the complexity of change processes aimed at establishing innovative approaches to science and mathematics teaching and learning, and how researchers might respond to this.


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**Room 418.205**

**(ONLINE)**

**Thinking When Problem-solving: How Students Think in an Integrated STEM Curriculum**

Tang Wee Teo

National Institute of Education, Nanyang Technological University, Singapore

According to John Dewey, individuals think only when problem-solving. Abstract thought-processes become visible when manifested in the form of actions and verbal exchanges. STEM (science, technology, engineering and mathematics) education is espoused due to its curricular affordances in promoting problem-solving competencies much needed in the 21st century. This paper reports on an integrated STEM curriculum that entails coding and translation of the coded product into embroidered artefacts that are subsequently sewn digitally. During the lessons, students learn to code, inquire about the properties of different materials, and manipulate digital sewing machines. Emergent coding and constant comparative approaches were adopted to analyze the video data collected over three days at a student care centre. The findings illuminated the thought-processes that students engage with during the lesson. These thought processes were: (a) procedural (e.g., How to re-thread the sewing machine?), (b) technical (e.g., How to write the code to create a shape?), (c) knowledge-based (e.g., What is the code to move the cursor?), and (d) affective (e.g., Who should I sew something for?). The findings of this study will be used to inform the design of rubrics of assessing the learning outcomes and outputs of this curriculum.
The Effect of Community-based SSI Instruction on Risk Perception and Perceived Risk of Chemicals in Cosmetics of High School Students in South Korea

Gahyoung Kim¹, Hyunyoung Na²

¹ Monash University, Victoria
² Yonghwa Girl’s High School, Seoul, South Korea

The purpose of this study was to develop and implement community-based issue instruction for behavioural change in high school students by increasing the risk perception of chemicals in cosmetics. The study participants consisted of 61 high school girls (26 experimental group: 26, control group: 35). The program was conducted in the school and community for six weeks. Pre- and post-program surveys were issued to find out about the students’ perceptions of the risk of using cosmetics. Additionally, a group interview was conducted with 16 students about the effects of the program, including risk perception, interdisciplinary context, and make-up behaviour. ANCOVA analysis of the survey results was conducted. Among the perceived risks, the ‘knowledge’ category showed a statistically significant difference, but the fear category was not significant between the experimental group and the control group. The community-based cosmetic issue program, centered on a topic closely related to students’ daily lives and how to affect behavioural change by improving the risk perception through school and community activities.

Research on the effects of online versus lab collaborative problem solving and students' achievement levels on 8th graders' electrochemistry problem solving

Meng-Jun Chen (HDR) Student  Hsiao-Ching She (Supervisor)

Institute of Education, National Yang Ming Chiao Tung University, Taiwan

The present study examines the effect of online versus laboratory collaborative problem solving and the level of achievement (high vs. low) on electrochemical problem-solving performance. Participants were randomly assigned to either the laboratory collaborative problem-solving group (N=44) or the online collaborative problem solving group (N=53). Tests of electrochemical concept learning and problem solving were administered before and after learning, while a questionnaire on the enjoyment of collaboration was administered after learning. The collaborative problem-solving processes and documents generated by students were all collected throughout their learning process. Results indicated that all students significantly improved their concept and problem-solving performances after learning, regardless of collaborative problem-solving type and achievement level. Regardless of the type of collaborative problem solving, only low-achieving students made significant progress in proposing problem-solving strategies after peer discussion. In particular, the
ANCova result indicated no significant difference between high and low achievers’ proposed problem-solving strategies after group discussion. Furthermore, low-achievers perceived significantly higher cooperation engagement than high-achievers. In conclusion, the low achievers evidently enjoy collaborative problem solving more, which resulted in better performance in generating problem solving strategies and a significant improvement in electrochemical concept and problem-solving performance.

Room 418.205

Exploring relationships between novice teachers’ science backgrounds, science identities, and NOS pedagogies

Renee Schwartz, Robert Bennett, Emily Little
Georgia State University, USA

This study explored connections between understandings of Nature of Science (NOS), science identities, and instructional practices among novice secondary science teachers with (1) little or no professional science experience; or (2) more extensive professional science experience. Professional science experiences included industry or academic work involving scientific research. Participants were preservice and early career teachers in a master’s level NOS course. Data included VNOS survey, course discussions, written reflections, lesson plans, and interviews. All participants showed improved NOS understandings. We found differences in how the groups self-identified. Those with more professional science experience tended to identify as a scientist or as both scientist and science teacher. Those with less professional experience tended to identify as either a scientist or a science teacher. When asked how others see them, both groups held higher recognition as scientist or as science teacher. Few felt recognized as both. Lesson plans and reflections were examined for attention to explicit NOS pedagogy. Only 50% of all participants included explicit NOS someway, suggesting they struggled with the concept of “explicit/reflective.” Differences existed between the groups in targeted NOS aspects. Those with professional science experience included more creative NOS, while those without professional science experience included more tentative NOS.

Room 418.206

(ONLINE)

Two-eyed Seeing: Exploring the interface of two instructional models for science education

Connie Cirkony¹, David Zandvliet²

¹ University of Tasmania
² Simon Fraser University, Canada

Worldwide, education jurisdictions are looking for authentic ways to include indigenous perspectives in the K-12 curriculum, including science education. At the same time, there have been ongoing efforts to integrate more authentic approaches to teaching and learning of Western school science, including those that are flexible, imaginative, multimodal, and contextually meaningful. Taken together, both goals may be realised through the Two-eyed Seeing approach, which seeks to integrate the strengths of Indigenous ways with one eye, along with the strengths of Western ways with the other eye, for the benefit of all. Drawing on the Two-eyed Seeing perspective, this paper compares two pedagogical models: A representation-focused 5Es Instructional Model and the 8ways pedagogy. The 5Es model scaffolds five phases for teaching and learning (i.e., engagement, exploration, explanation, elaboration, and evaluation), each can integrate the use of multiple representations, some of which are generated by the students themselves, as they engage in authentic discipline-specific meaning-making processes. The 8ways pedagogy is a general teaching approach that integrates narrative, place-
based, visual, non-verbal, kinaesthetic, non-linear, holistic, and community-oriented approaches in knowledge-building practices. The framework supports teachers to apply these pedagogies as an interface between the different knowledge systems of aboriginal and non-aboriginal cultures. This paper explores the compatibility between these two approaches that foreground dialogue, use of visuals, and experiential learning in relevant contexts in supporting other meaning-making systems that would improve learning and engagement for all students learning science.

Room 418.207

**Empowering Thai Teacher Candidates Transform their Pedagogical Beliefs for Effective Inquiry-based Science Teaching through Virtual Lesson Study in the Covid-19 Pandemic Era**

Witchayada Nawanidbumrung¹ (HDR) Noriyuki INOUE¹ (Supervisor), Parinda Limpanont Promratana² (Supervisor)

¹ Waseda University, Japan
² Chulalongkorn University, Thailand

Due to the global challenges in the face of the Covid-19 pandemic, not only teaching in conventional classroom settings, but also supporting the teachers’ professional developments is adversely affected. This paper discusses the efforts to initiate virtual lesson study with science teacher candidates in Thailand, where they were guided to transform their pedagogical beliefs for effective implementations of inquiry-based science lessons. Teachers’ beliefs have been argued to have a strong influence on their teaching. Multiple data sets, including videos of research lessons, debriefings and audios of online teacher interviews, contents of the discussions in virtual meetings, and online reflection forms, were analyzed to make inferences about the teacher development process. The content analysis suggests that online lesson study helped teacher candidates develop their pedagogical beliefs, especially in terms of engaging students in scientifically oriented questions before inquiry activities, placing students at the centre of lessons, supporting students to perform like scientists, and helping students relate their science classroom experiences to their daily life. The findings also include that online lesson study served as an effective professional development model for teacher candidates, which seems to have functioned to help teachers develop their pedagogical beliefs for effective inquiry lessons in the COVID-19 pandemic era.
Friday 1st July

9.10 – 9.50

Room 418.203

Promoting students’ engagement in learning about stereoisomers of phenylalanine in immersive virtual reality

Henry Matovu¹, Dewi Ungu¹, Mihye Won (Supervisor)¹, David Tregast¹ (Supervisor), Mauro, Mecerino¹ (Supervisor), Roy Tasker², Chin-Chung, Tsai³

¹ Curtin University, Western Australia
² Western Sydney University, New South Wales
³ National Taiwan Normal University

Immersive virtual reality (IVR) can help to support students’ 3D visualisation of abstract science concepts. We designed IVR learning activities in which students collaborated to create stereoisomers of phenylalanine and their electron density maps to learn concepts of stereochemistry and polarity. The IVR program prompted students to reconsider their answers and did not let them progress to the next step until they had solved each task. We investigated students’ interactions and strategies when they were stopped from progressing to the next steps. Participants were 34 pairs of university chemistry students. Students’ interactions in the IVR sessions were video-recorded and analysed. Initially, each pair of students generally divided their work and constructed the stereoisomers and their electron density maps without thoroughly discussing ideas with their peer. After failing to progress, the students generally talked more to one another. Most students reflected on their understanding and made their reasoning explicit to each other to refine their answers. Some students, however, engaged in superficial talk, making more unsuccessful attempts without explaining their reasoning. This study shows that when challenged, students are able to reflect and reconsider their answers collaboratively in IVR environments, but the prompts need to be catered to accommodate learners’ needs.

Room 418.204

(ONLINE)

GoPro-I-Spy-At-The-Zoo: Watching teachers learn

Timna Garnett (HDR Student), Yvonne Zeegers (Supervisor)

Flinders University, South Australia

During a one-day PD workshop at the zoo, teachers were observed learning with and from each other, the environment (zoo exhibits) and with and through the tablet technologies within their hands (grouped as mobile technologies). GoPro™ camera worn on the head of participants collected a unique point-of-view for teacher participants during outdoor zoo activities. Using visual analysis (Jewitt & Van Leeuwen, 2001) and systemic network analysis (Bliss et al., 1983; Tunnicliffe, 1996) conversations were transcribed and analysed for what they said with a conversation (unit) while visual indicators from the video footage were systematically mapped for what they saw during each conversation (unit). This method of assessing video data as content gave an insight to what teachers talk about when exploring the zoo, but also how they source new information. The visual footage identified that groups spent on average 5 minutes at each exhibit (n = 70 exhibit) and that the time increased or decreased based on observable influences including seeing the animal and weather. The most common source of information discussed was linked to the exhibit (44.9%), followed by their tablet device (32.9%) and then their peers (22.2%). The implications of these findings are influential for teachers when planning to use the zoo for a location for learning with children.
Culturally responsive pedagogy for transdisciplinary STEM

Kathy Paige, Lisa O’Keefe

University of South Australia

Pre-service primary/middle teachers in Australia are predominantly European Australian with a small minority of Aboriginal First Nations people. This challenges us as teacher educators to reflect on how we prepare pre-service teachers to develop confidence and competence to firstly engage and teach Aboriginal and Torres Strait Islander students (1.4) and secondly to embed Aboriginal and Torres Strait Islander ways of knowing (2.4) across learning areas. In this presentation we draw on Paige, Lloyd & Smith’s (2017, 2019) eco-justice principles to consider how a transdisciplinary, culturally responsive approach to mathematics and science education can build knowledge and capabilities for sustainable futures with final year primary /middle preservice teachers. These eight eco-justice principles focus on imaging preferred futures, nature education that might rewild our minds, connections to place, active participation/activism and prioritising of culturally responsive pedagogies. Aboriginal and Torres Strait Islander’s connection to place is illustrative of the ecojustice principles, which focuses on developing eco-social wisdom—ways of thinking, feeling and acting within places which they inhabit. This research builds on our previous work which explored the confidence of pre-service teachers to engage with Aboriginal and Torres Strait Islander ways of knowing (O’Keeffe, Paige & Osborne, 2018) to investigate the ways in which two pre-service teachers’ have integrated Aboriginal and Torres Strait Islander knowledge and/or ways working into their own planning and teaching. This planning forms part of their final assignment in a mathematics and science curriculum course, where they are required to construct a whole year planner for science and mathematics for a selected year level and select one transdisciplinary topic to plan detailed sequence of lessons outlining both the ‘what’ (concepts, thinking and working scientifically and mathematically) and the ‘how’ (5Es, critical praxis).


based curriculum, such as having flexibility and being student-centred. They also indicated challenges at different levels. The most mentioned challenges were micro-level factors (e.g., teachers’ knowledge and ability), followed by the macro-level ones (e.g., education policies) and the meso-level factors (e.g. Interdisciplinary teaching). Furthermore, teachers set multiple goals for inquiry teaching. The most common goals were to increase students’ motivation, to create connections between science and everyday life, and to engage students in scientific inquiry. In this study, we also divided the inquiry process into five phases and investigated the goals teachers set for different phases of inquiry. We found that less attention was paid to the phases of analyzing and interpreting data, argumentation and modelling. Based on the findings, suggestions and implications are provided.

9.50 – 10.30

Room 418.203

The ‘Sonaphor’ as tool for secondary science education using sound

Alice Motion, Alexis Weaver, Genevieve Firmer, Chiara O’Reilly, Daniel Yeadon, Jadey O’Regan

The University of Sydney, New South Wales

Sonification is a powerful tool for science communication and education. Sound can be used to transcend the visual constraints of scientific data and diagrams and has the potential to make information more accessible and experiential. However, the Australian secondary science curriculum leaves little room for the incorporation of artistic learning methods. We have identified the potential to supplement current secondary science education with a sound-based learning tool which creatively interprets scientific concepts to increase engagement and comprehension. In this paper, we will present our creative response: the Sonaphor, a short segment of audio which combines narration, musical elements and sound design to creatively evoke scientific concepts relevant to the Australian secondary science curriculum. Stemming from the words, “sonic metaphor”, the Sonaphor features an inherently artistic response to scientific descriptions and aims to strengthen the listener’s current understanding of the given scientific topic. We will share prototypes of the Sonaphor aligned to the NSW Chemistry Curriculum and our development process as interdisciplinary (science, education, sound design, composition and museum and heritage studies) scholars. We seek to start a conversation on the role of interdisciplinary collaboration in science education and to propose a pathway for more creative teaching methods in STEM subjects.

Room 418.204

Co-designing an interdisciplinary climate science course: Hearing the educators’ voices

Chris Eames, Cathy Buntting, Marcus Wilson, Martina Pietsch-Brown

University of Waikato, Hamilton, New Zealand

In this session, we will outline a study at the University of Waikato in which tertiary teaching colleagues from different science disciplines worked together to co-design and implement an integrated curriculum for a climate change science course within our world-first Bachelor of Climate Change programme. More accustomed to single discipline-focussed traditional lecture and laboratory teaching, these educators navigated learning from each other, and teaching across disciplines within a novel (for them) flipped learning context. These colleagues participated in individual and group interviews focusing on their experiences of the process of planning,
implementing and reflecting on outcomes of integrating different disciplines into their course. Key themes have been drawn from the interviews and discussed with the participants. From this co-analysis process, we will discuss the emergence and understanding of a rationale for integrated teaching, integrity and compromise in relation to course content and pedagogy, and collaborative processes in planning and implementing a co-designed interdisciplinary tertiary science course.

**Room 418.205**

**STEM Career Readiness of Senior High School Students**

Edwehna Elinore Paderna, Alvin Barnachea

University of the Philippines

Before the implementation of the Department of Education’s K to 12 Program in 2013, the Philippines was the only country in the Southeast Asian region implementing a 10-year combined elementary and secondary education. The K to 12 Program covers Kindergarten and 12 years of basic education (six years of primary education, four years of Junior High School, and two years of Senior High School [SHS]) to provide sufficient time for mastery of concepts and skills, develop lifelong learners, and prepare graduates for tertiary education, middle-level skills development, employment, and entrepreneurship. One of the strands in the academic track in the SHS curriculum is the STEM strand. As such, this study aimed to determine whether SHS students, after going through the K to 12 STEM curriculum, possess necessary skills to be in a STEM Career. The study involved, as survey respondents, 642 Grade 12 students (346 males and 296 females) from 14 intact classes who were enrolled under the STEM strand. The 48-item STEM Career Readiness Scale (SCRS) (Cronbach’s alpha = .912) developed by the researchers cover Science Process Skills, Mathematical Skills, Critical Thinking, ICT Skills, and Work Ethics. The weighted mean of each sub-variable of the 4-point SCRS ranged from 2.95 to 3.33.

**Room 418.206**

**(ONLINE)**

**The Effects of College Students’ PM2.5 Environmental Literacy, Critical Thinking and Project Citizen Performance through Project-based Reflective Journal Teaching**

Teng-Shun Yang¹, Chiung-Fen Yen¹, Tsai-Liang Hsu²

¹ Providence University, International College, Taichung City, Taiwan
² Taichung Municipal Bo-Ai Elementary School, Taiwan

The purpose of this research was to examine the effectiveness of the Project-based Reflective Journal Teaching (PBRJT) on students’ PM2.5 environmental literacy, critical thinking, and project citizen performance in environmental education curriculum. This study adopts a single-group pre-test-post-test design. A total of 38 undergraduates were selected from a university in Taiwan through convenient sampling, they have accepted 9 reflective tasks of PM2.5 air pollution issues on 5 environmental education goals (Engleson & Yockers, 1994) and 4 curriculum models of project citizen (Center for Civic Education, 2008). PM2.5 environmental literacy scale, air pollution reflective worksheets, PM2.5 campus preventive action projects, and semi-structured interviews (30 minutes for each participant) were employed to collect students’ PM2.5 environment literacy, critical thinking, and project citizen performance. These skills were compared and contrasted through descriptive analyses, paired sample t tests, and content analyses (Patton, 2002). The results revealed that college students have a better understanding of PM2.5 cognition, risk perception, and prevention behaviours. In addition, this study provides evidence to support that PBRJT significantly improve undergraduates’ PM2.5 environmental literacy,
critical thinking, and project citizen performance. The implications of the findings and recommendations for future environmental education research are discussed.

11.00 – 11.40

Room 418.203

Raising a scientifically literate and culturally competent population: are senior chemistry courses in Australia up the task?

Genevieve Firmer (HDR), Alice Motion (Supervisor), Siegbert Schmid (Supervisor)

The University of Sydney, New South Wales

The first national senior science courses in Australia were published in 2012. As these courses were designed, there was considerable pressure from the science education research community for the science curriculum to shift focus away from fostering science researchers and industry professionals, towards improving scientific literacy for all young people. Scientific literacy can be defined as a skill that enables people to engage in science-based problems in their lives, which is essential for the development of ‘active and informed citizens’. There was also a broad consensus that Aboriginal and Torres Strait Islander Histories and Cultures should be embedded in the science curriculum. This paper will use content analysis methodology to evaluate the extent to which each year 11-12 chemistry course in Australia has taken up suggestions for curriculum that fosters scientific literacy and integration of the Aboriginal and Torres Strait Islander Histories and Cultures Cross-Curricular Priority. Our findings indicate that there are critical differences between state systems. We will discuss the potential implications of our findings, specifically regarding the scientific literacy and cultural competency of young people. This method could be utilised similarly in other disciplines and will contribute to future research that identifies curriculum-related challenges for chemistry educators.

Room 418.204

(ONLINE)

Far-reaching Ripple Effects for primary and secondary students – Learning By Doing the Citizen Science Way

Thant Sin Phway\(^1\), (HDR), Chris Preston\(^1\), Alice Motion (Supervisor)\(^1\), Yaela Golumbic\(^1\), John Martin\(^2\), Peter Rutledge\(^1\), Ciara Keneally\(^1\)

\(^1\) The University of Sydney, NSW
\(^2\) Taronga Conservation Society Australia, NSW

The Learning By Doing project aims to integrate curriculum aligned citizen science programs into schools. The project strives to better engage students, enhance their experiences, and strengthen science learning outcomes. Learning By Doing is assessing the learning outcomes and impacts for students participating in citizen science projects and developing an evaluative framework. This paper explores teachers’ and citizen science project leaders’ perspectives on students’ outcomes and impacts from participating in citizen science. Focus groups with Australian teachers (n=13) identified how they engaged with citizen science in schools, their experiences, and perceptions. Corresponding focus groups were conducted with citizen science project leaders (n=17). From inductive thematic analysis findings include the perceived outcomes and impacts on students’ learning from participation. Teachers and project leaders identified purposeful learning as a prominent outcome. Perceived
long-term impacts include fostering meaningful behaviours and positive attitudes towards science, and acquisition and understanding of science process skills and curriculum outcomes. Both groups believe citizen science can potentially enhance science education through ‘hands-on’ experience as students learn by doing. Critically, the outcomes are opinion as no formal analysis of citizen science in Australian schools has yet been conducted; this is an aim of the Learning By Doing project.

Room 418.205

(ONLINE)

‘Researcher’, ‘teacher’, ‘other’? Considering a non-scientist’s role in a science-focused research project

Ben Egerton
Victoria University of Wellington, New Zealand

What does it mean to be part of a science-focused interdisciplinary project as a non-science specialist? Before I joined the project, my colleagues exploring the affordances of online citizen science in New Zealand primary science education described the “web of connections” (Bunting et al., 2020) necessary for interdisciplinary research. They identified how connections made “between researchers, teachers and others” (p.69) lead to the “development of a rich and interconnected research ecosystem” (p.73). With a creative PhD in religious poetry, a classroom career as a primary-trained English teacher, and now a technology academic in Initial Teacher Education, I find myself reflecting on—with more than a little imposter syndrome—my current participation in the project, and my role in its ecosystem: am I ‘teacher’, ‘researcher’, or ‘other’? Drawing on this notion of ‘interconnectedness’, and partially framed by George Siemens’ concept of connectivism (2005), I share my journey as a non-scientist into the science education research world and consider skills and knowledge I have had to acquire. In doing so, I reflect further on what unique perspectives an ‘other’ might bring to a research project.

Room 418.206

Drawing explanatory diagrams to understand balanced and unbalanced forces

Sherab Tenzin (HDR), Mihye Won (Supervisor) David Treagust (Supervisor)
Curtin University, Western Australia

Research has shown that students have difficulty understanding the concept of balanced and unbalanced forces. This study investigated how a teaching approach with a focus on student-generated diagrams supported students’ science sense-making. Interacting with the teacher and their peers, students drew conceptual, explanatory diagrams of balanced and unbalanced forces in the contexts of three experiments on friction, air resistance, magnetic force, tension, and gravity. Videos of classroom interactions and students’ diagrams were analyzed using a qualitative, inductive approach to examine the development of students’ ideas through diagrammatic and verbal representations. For this presentation, the data from four groups of students in Year 7 science classes were analysed. The results indicated that students generated extensive explanations on why they drew certain features in their diagrams and how they were related to explaining the experiments. Many students did not exhibit immediate understanding of the underlying concepts initially. However, by the end of the third lesson, students showed greater understanding of the concepts through their diagrams and conversations. The study illustrates the educational benefits of students generating their own diagrams to understand scientific phenomena and demonstrates the importance of appropriate teacher scaffolding for learning through drawing.
An Integrative Review of STEM Integration in Early Childhood Education
Andrea Ng (HDR), Sarika Kewalramani, Gillian Kidman
Monash University

STEM has been advocated as the contemporary education priority. However, there is no clear definition of integration despite the vast effort to integrate STEM (iSTEM) education into the existing curriculum. The purpose of this study is to disclose the existing STEM education that is integrated into the early childhood settings (ECE). The integrative review is the employed methodology to conceptualise how STEM is being integrated into ECE. The data synthesis will be based on the different levels of iSTEM proposed by Vasquez et al. (2020) - disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary. The findings are based on the reviews of 17 papers, attempting to provide some insights on what and how to integrate STEM into ECE through an integration and navigation STEM (inSTEM) conceptual framework. The literature revealed how STEM integration was perceived, current approaches to integration, the factors to consider, and the challenges of iSTEM in ECE. The overall results were then consolidated and presented into a transdisciplinary STEM framework. This framework aims to provide some guidance to integrate and navigate STEM (inSTEM) in the ECE. Even though the inSTEM framework was specifically based on previous ECE-focused studies, it may still be beneficial to other schooling levels' teachers and students.

Student’s perceptions of their STEM Learning Environment
Nicole Fairhurst (HDR), Rekha Koul (Supervisor), Rachel Sheffield (Supervisor)
Curtin University, Western Australia

Australia’s economic need for technology and innovation has led to Science, Technology, Engineering and Mathematics (STEM) education becoming an essential investment in its future. This research explores upper-primary student perceptions of their STEM Learning Environment (SLE), relationship with their teacher, and the impact these have on their attitude towards STEM education. A mixed-methods study utilising a quantitative questionnaire and qualitative semi-structured focus groups was conducted across four Year 5 classrooms with 100 students, to determine factors that may influence their engagement to further pursue these disciplines. The questionnaire comprised of scales from three different instruments: the Classroom Emotional Climate, Test of Science Related Attitudes and Questionnaire on Teacher Interaction. Additionally, the students outlined their perceived preferred perceptions of their STEM Learning Environments, and potential ideas for improving STEM education. The findings indicated that the students generally perceived their Classroom Emotional Climate, their relationships with their teachers and attitudes to STEM to be positive across all the four classrooms. Several themes (e.g. Student Freedom, Peer Collaboration, Problem Solving, Communication, Time, and Preferred Environments) arising from the data were derived through the qualitative data generated through student focus group responses.
Secondary school teachers’ perceptions of developing critical thinking in integrated STEM

Violetta Pristel (HDR), Vaille Dawson (Supervisor), Christine Howitt (Supervisor)

University of Western Australia

Critical thinking is an important skill to develop in school. Integrated STEM curricula approaches may assist development of students’ critical thinking abilities. However, what critical thinking in integrated STEM may look like in the classroom is ill defined and there are few studies about how it is perceived by teachers. An interpretive case study approach was used to explore five secondary school teachers’ perceptions of critical thinking in integrated STEM. Five teachers who taught integrated STEM in Western Australian secondary schools were interviewed regarding their thoughts on integrated STEM and critical thinking, implementation approaches, teaching strategies and assessment. Interview data were analysed using thematic analysis with teachers’ perceptions described individually and then compared. Findings were that teachers shared similar perceptions of the role of integrated STEM and teaching strategies. However, their implementation approaches, perceptions of critical thinking and assessment in STEM differed depending on their own teaching context. These findings provide an insight into how teachers’ perceptions and teaching context may influence critical thinking development and can be used to support teachers new to integrated STEM education.
**Posters**

**STEM-Hub – Bundle resources, support networking, transfer science**

Janne-Marie Bothor (HDR), Catrin Grabowsk, Elisabeth Eckel, Julian Maguhn, Sandra Wilhelm, Alexander Grabowski (HDR), David-Samuel, Di Fuccia (Supervisor), Andreas Meister, Rita Borromeo Ferri

University of Kassel, Germany

An important educational goal is to transfer an adequate understanding of science, its knowledge, its research and its nature into society. The STEM-Hub of the University of Kassel is intended to make an overarching contribution to this. The project focuses on four target groups: Public, Schools, Companies and Science itself. Various educational offers will make research in the STEM field visible and transparent to the ‘outside world’. Measures will also be developed to increase the participants’ interest in STEM and to contribute to an improved understanding of science. During the project, the following questions will be evaluated: ‘Do the measures have lasting effects on the participants?’ ‘Will the interest in STEM be increased and understanding of science improved?’ Our poster aims at starting a discussion with international actors in the STEM-Center community by presenting measures already developed as well as the instruments for evaluating the research questions. For example, regarding schools’ current research content or current research methods are carried out with students in teaching-learning laboratories to help them gain an insight into the university beyond the school content. To optimize our efforts, activities like these shall be networked and expanded within the international STEM centre community.

**Using VR-technology as a tool for understanding selected aspects of chirality**

Mareike Frevert, David-Samuel Di Fuccia (Supervisor)

University of Kassel, Germany

Chirality is an important phenomenon and offers unique possibilities to grasp the microscopic levels of nature. For understanding chirality, it is meaningful to have an adequate spatial ability. Durmaz (2018) shows that many students have difficulties in this respect and therefore cannot comprehend many aspects of chirality. As helpful alternatives, digital media could be used to (1) promote students’ spatial ability (Bamford, 2011) and (2) offer an access to the three-dimensionality as well as to the dynamics of molecules for a better, modern understanding of chirality. With the use of the Virtual Reality Technology both could be realized because a user could learn in an interactive and multisensory three-dimensional space. The VR-technology could furthermore be helpful to confront learners with modern aspects of chirality like imaging the detection of R-, S-enantiomers (Pitzer et al., 2017). This poster will show the problems concerning the understanding of chirality, the use of VR to foster students’ spatial ability (Frevert, Di Fuccia, 2021), and even how modern aspects of chirality like the use of coulomb explosion (Pitzer et al., 2018) for a direct detection of chirality can be considered in a VR-environment.

**References**


Relationship among STEM measurements

Shoraro Naganuma

Kyushu University, Japan

Various measurements have been developed to measure students’ attitudes toward STEM: general interest (e.g., I am interested in science); topic interest (e.g., Biosphere); activity interest in science classes (e.g., RIASEC+N model). However, relationships among them have not been fully explored. For example, would students who agreed with the statement “I am interested in science” also be highly interested in the biosphere topic? Lack of empirical evidence in answering such questions may encourage misunderstanding of students’ attitudes. Therefore, in this study, 201 high school students in Japan responded to a total of 25 items: general interest items (13 items), topic interest items from PISA (5 items), and activity interest items from the RIASEC+N model (7 items). The data were subjected to correlation analysis. As a result, out of a total of 300 combinations of correlation coefficients, more than 35% were below $r=0.40$, while more than 10% were below $r=0.30$. In particular, interest in math classes, biology classes, craft making, careers related to technology and engineering, and “artistic” activity had many low correlations with other measures. These results should warn thoughtless predictions about students’ attitudes toward STEM and suggest that we need to focus on discipline-specificity and activity characteristics.

University teachers’ perspectives on fostering flipped classroom pedagogy: A qualitative study

Punithalingam Youhasan, Yan Chen (Supervisor), Mataroria Lyndon (Supervisor), Marcus Henning (Supervisor)

University of Auckland, New Zealand

Flipped classroom pedagogy is an innovative blended teaching-learning method. Prevailing evidence about flipped classroom pedagogy shows it is an effective and beneficial teaching method from the student perspective. There is a dearth of evidence about teachers’ perceptions of the flipped classroom and their implementation in low-resourced educational contexts. To assess the feasibility of flipped classroom pedagogy in the Sri Lankan undergraduate nursing education from university teachers’ perspectives. An exploratory qualitative research design using focus group discussions was conducted in three public universities in Sri Lanka. The participants were 24 university teachers who are involved in undergraduate nursing education programmes in Sri Lanka. Four focus group interviews were conducted. Data were transcribed and analysed using inductive thematic analysis. Four themes emerged. Three themes explained the feasibilities available for implementing flipped classrooms: educational technology, acceptability of the flipped classroom pedagogy, and the educational environment. A further theme refers to future requirements for implementing the flipped classroom. The study revealed teachers’ readiness to use flipped classroom pedagogy. Nevertheless, limited resources and existing teacher-centric practice were identified as challenges to implement the flipped classroom. Overall, the findings indicate there are promising feasibilities for the implementation of flipped classroom pedagogy.
Online Posters

Connecting chemical topics in teacher training studies

Marina Birkenstock (HDR), David-Samuel Di Fuccia (Supervisor)
University of Kassel, Germany

The aim of this approach is to support chemistry teacher students to better interconnect chemical contents during their studies. This is formally focused on university level and thereby refers to university course contents as we assume that at this point students are missing obvious and relevant interconnections among chemical sub-disciplines. This might cause many teachers-to-be to not realize and implement interconnected content knowledge in their later profession as a chemistry teacher in an appropriate interconnected and meaningful way. With the help of advanced organizers, it is envisaged by giving future teachers a stable and expansible framework of knowledge along their way, so that the first stage of training simultaneously impacts the fundamentals of teacher’s professional knowledge, especially content knowledge, in a more qualified and more interconnected manner. Therefore, we performed a case study to investigate the effect of concept maps as advanced organizers on the interconnections chemistry students can detect or construct in their subject specific knowledge-base. Teacher students were interviewed three times to see how they developed. They performed eye-tracking while working with a concept map and created interconnecting questions on university level afterwards to see if they could adapt the ideas of the interconnections.

Linking engineering and natural sciences in a “nano” student laboratory in Germany

Tim Göbel (HDR Student), Prof. Dr. David-S. Di Fuccia
University of Kassel, Germany

Research shows that students often fail to recognize the relevance of scientific knowledge. In addition, engineering science issues that would show the usefulness of scientific knowledge, are hardly found as subjects of teaching in general schools in Germany. The aim of our work is therefore to link engineering and natural sciences by merging the process of technical development with the path of knowledge acquisition in natural science to contextualise scientific knowledge. A link between the two sciences is desirable, as it could increase the students’ motivation and interest in technical and scientific issues. Moreover, in this way the learners could better understand the fundamental process from basic research to the finished technical application. In the English-speaking world, first concepts have been developed that show a positive effect in this merger, but a corresponding adaptation is still lacking for Germany. In our approach, the pupils are to be offered insights into both methodologies and content-related aspects of current technical and scientific research in the field of “nanostructures” in a prepared learning environment, containing an atomic force microscope. The topic of nanostructures has important implications within ‘pure’ chemistry, as it leads to relevant developments in terms of technology and has a lot of well-known everyday applications. Therefore, it seems perfectly suited for our approach.
SDGs Educational Program Design for Biodiversity Awareness: Focus on Endangered Species for Adolescents

Shiho Miyake
Kobe College, Japan

To promote Sustainable Development Goals (SDGs) for all people is a key educational focus worldwide. Recent studies on socio-scientific issues (SSIs) in science education research have noted that promoting awareness of the relationships between humans and nature among adolescents can increase environmental sustainability. However, adolescent education on SDGs and SSIs in Japan has had low penetration in the concept of biodiversity. Thus, in this study, the author focuses on endangered species that are well known to university students to develop teaching materials to raise biodiversity awareness and promote concepts and understanding. This presentation is of a pilot program in which students create an “endangered species sheet (ESS)” by collecting information on an endangered species. The information includes animal ecology (name, classification, length, weight, food habits, and habitat distribution), hand-drawn illustrations of the animal, reasons for extinction problems, and what the students can do to solve the problem. As a result of multiple questions and free description of 85 participant students, they realized that popular animals seen in zoos are endangered species, and human activities lead to these biodiversity problems. Furthermore, this material of the ESS allowed students to think about what they could do to solve the problem.

The effect of positioning the role of “observers” in pre-service teachers’ role play-based science lessons

Hayashi Nakayama¹, Tomokazu Yamamoto²
¹University of Miyazaki, Japan
²Hyogo University of Teacher Education

In Japan, “role play-based lessons” are commonly conducted in the “science education method” class of the teacher training course. There, students play the roles of “teachers” and “school children” to produce primary school science lessons and pursue better primary school science lessons. We added the role of “observers” in the role play-based lessons. This is because we believe that an “observer” would enable a kind of learning which might not occur through the “teacher” and “school children” roles. This study aimed to clarify what pre-service teachers could learn as “observers.” Five role play-based lessons were held for the third-year undergraduate class of 2021. Fifty-five students were divided into five groups and took turns playing the roles of “teachers” and “observers” once each and that of “school children” thrice. After completing all the role play-based lessons, we asked students to write about their learnings from each role. Upon text mining the answers and extracting the words that were characteristic of the observer’s role, the word “objectively” was obtained. On examining the descriptions containing the word “objectively,” we found that many students could pay attention to the teacher–child interactions.
Explorations of Canadian STEM educator pedagogical responses to the COVID-19 pandemic: Adapting inquiry in virtual spaces

Christina Phillips
Cape Breton University & OISE/University of Toronto, Canada

Al Darayseh (2020) reports that closures to educational institutions as a mitigating response to the ongoing COVID-19 pandemic have impacted approximately 60% of the global student population. In response, educators have had to undergo a rapid type of pedagogical evolution to adapt to the swiftly changing classroom landscape. Varea and Gonzalez-Calvo (2020) comment how global lockdowns have shifted education to various online modalities which have had significant impacts on subject areas that have traditionally focused on ‘hands-on’ methodologies, such as science and science, technology, engineering and mathematics (STEM) disciplines. This small-scale, funded qualitative research project focused on how STEM educators in Canada adapted their inquiry-based teaching practices in response to the ongoing pandemic. Participants from secondary schooling and higher STEM educational contexts completed online survey questions and engaged in semi-structured interviews. Key findings converged on the use of more direct instructional practices in virtual spaces; successes with creative approaches to inquiry (e.g., sending home lab kits to students) and the use of STEM-associated virtual simulations. Challenges included safety concerns with STEM inquiry at home and with conducting assessments virtually (i.e., particularly in higher education STEM courses). Additionally, participants viewed their classrooms as ‘less social’ spaces compared with pre-pandemic learning environments.

Exploring primary student teachers’ uses of and rationales for integrating ICTs in their science lessons

Nadya Rizk
University of New England, New South Wales

Notwithstanding their benefits for promoting science learning, information communication technologies (ICTs) are often underutilised and their potential underexplored by science teachers. A deciding factor for integrating ICTs in teaching is the extent to which a teacher’s pedagogical paradigm collides with their beliefs about ICTs’ affordances. Such collisions can compromise ICTs’ attractiveness to teachers. Therefore, to understand issues with ICTs use in science teaching, it is imperative to explore cases of ICT integration in tandem with teachers’ underlying pedagogical rationales. In this qualitative study, I investigated how 70 primary school student teachers integrated ICTs in their science lesson plans. My aims were to (1) identify and characterise teachers’ use of ICTs in their plans, and (2) explore the pedagogical justifications for such uses. Using the SAMR model developed by Puentedura, I categorised ICT uses in 70 primary science lesson plans that student teachers submitted as part of their assessment in a 3rd year science education unit. The accompanying pedagogical rationales were analysed for levels of sophistication using theoretical models of pedagogical reasoning. The findings revealed that ICT uses were mostly enhancement-focused with some exceptions reflecting transformative uses, and that increased sophistication in rationalising ICT use did not always correspond with transformative ICT use.
Science education associated with children’s love: One case study of cell biology “Which organelle do you have?”

Sayuri Tanabashi
University of Tokyo, Japan

Currently, learning materials have had drastically extended horizons owing to the inclusion of technologies. Interactive, hands-on activities, and 3D models, have been associated with diverse learning settings. The presenter, a biology educator, has developed learning materials, such as 3D printed cells for gaining K-12 understanding for organelle structures. In this case study, the presenter highlights developing learning materials associated with children’s love like national cultural sweets. Each organelle, with its characteristic functions, presents the unique structure of its membrane compartment. As such, the presenter aims to build several sets of learning materials that help gain an understanding of organelle’s structure for K-12 children. The presenter expressed organelles by presenting them in their resemblance to sweets based on Japanese culture, as these items were familiar with children’s daily life. For example, the Golgi apparatus, which is a single membrane structure looks like sanshoku-dango, and mitochondrion, which is a double membrane-bound structure looks like daifuku, both of which are well-known Japanese cultural sweets. This case study demonstrated that ameliorated K-12 level of understanding in the structure of several organelles. It was indicated that the development of learning materials suitable to the national culture was efficacious for K-12 children.

Physics Problem Solving in High School Students: The role of Executive Functions and Mathematical Skills

Konstantinos G. Tsigaridis (HDR), Rui Wang (HDR), Michelle R. Ellefson (Supervisor)
University of Cambridge, United Kingdom

Previous research has focused on investigating the role of executive functions in students’ conceptual change when learning physics yet developing students’ physics problem solving skills is one of the primary goals in physics curriculums and is closely related with executive functions. Through several studies there have been descriptions concerning the links between executive functions and mathematical skills as well as the role of mathematical skills in physics problem solving. Nevertheless, there is limited research that has examined the contribution of both executive functions and mathematical skills on physics problem solving. To address this gap, this small-scale experiment administered executive functions, physics problem solving and mathematical skills tasks to 20 Greek students (Mean age = 16.81 years, SD = 1.87). All the physics and mathematical skills assessments demonstrated a strong positive correlation among them. The figure matching executive function task presented a positive correlation with the physics problem solving and the mathematical skills assessments, when testing for response time and efficiency subsequently. These results offer the opportunity to create a new theoretical approach for physics problem solving that could be the springboard for further investigation, which could result in designing pioneer teaching interventions and better prepare students for challenging academic events.

Contribution of Executive Functions on the Suppression of Naïve Scientific Thinking: A Pilot Study

Rui Wang (HDR), Michelle Ellefson (Supervisor)
University of Cambridge, United Kingdom

Correcting students’ naïve misunderstandings of scientific theories is crucial for effective scientific learning and is seen as a central goal in primary science education, but amending such thinking is not easy. Even adults are
prone to making basic scientific mistakes, as naïve thinking is not simply replaced by scientific thinking but is suppressed upon encountering counter-intuitive conflicts. Previous studies suggest that executive functions such as inhibition, cognitive flexibility and working memory play important roles in this suppression process among children and adolescents, but it remains under-studied among adults. This small-scale experiment included 22 adults using seven computerised cognitive tasks, four measuring executive functions and three measuring suppression of naïve thinking. Results indicated that executive functions, especially cognitive flexibility and inhibition, are positively correlated with the ability to suppress naïve thinking in both physics and biology. This finding suggests that the suppression of naïve thinking and activation of scientific thinking occurs simultaneously when solving counterintuitive scientific questions. These results indicate the importance of executive functions for scientific learning, and hold promise for improving science pedagogy from a cognitive psychology perspective.