## Program

All times Australian Eastern Time [GMT +10]. Use Daily Tabs on Conference Website for session links and playlists.

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tuesday June 23</strong></td>
<td>6:00-7:00pm</td>
<td><strong>Welcome Reception Live on Zoom</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wednesday June 24</strong></td>
<td>8:45-9:30am</td>
<td>8:45-9:30am Watch Session 1-01</td>
<td>8:45-9:30am Watch Session 1-01</td>
<td>8:45-9:30am Watch Session 1-01</td>
</tr>
<tr>
<td></td>
<td>9:30-10:00am Live</td>
<td>Session 1-01</td>
<td>Session 1-02</td>
<td>Session 1-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9:30-10:00 Interactive Q&amp;A</td>
<td>9:30-10:00 Interactive Q&amp;A</td>
<td>9:30-10:00 Interactive Q&amp;A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introducing Digital Technologies into Play-Based Learning in Early Childhood</td>
<td>Examining the Inclusive Perspectives and Practices of Canadian Science Teacher Educators</td>
<td>Examination of Climate Change Conceptualization within Upper Secondary Victorian Curriculum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>George Aranda, Joseph Ferguson, Coral Campbell, Chris Spaldwine</td>
<td>Karen Goodhough, Ságu Azam, Todd Milford, Christine Tippett</td>
<td>Efraf Elam, Vevrenda Prasad, Helen Widdop-Quinton</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The Development and Effects of an Inquiry-Based Early STEM Curriculum on Taiwanese Kindergarteners’ Science and Engineering Practices</td>
<td>Exploring Micro-Cultural Diaspora and Emotions in a Chinese Primary</td>
<td>It’s Very Complicated: Expanding Students’ Views on Relationships in Socio-scientific Issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ching-Ting Hu, Hsin-Kai Wu, Sung-Pai Chien</td>
<td>Validating the SECIM (Scales of Evolutionary Conflict Measure) Instrument</td>
<td>Majd Zouh, Dimitris Tsoubaris, Sarah El Hayawy, Minja Milanovic, Zoya Padamoo, Nadia Qureshi, Larry Bengtson</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learning about Science in Society: A Case Study of Learning Processes from Student Participation in Citizen Science</td>
<td>Garia C. Siaglia, Ross H. Nehm</td>
<td>Climate Change: The Impact of Culture on Students’ Willingness to Act on Their Beliefs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yasla Columbic, Alicia Motion</td>
<td></td>
<td>Keith Skamp, E. Boyes, M. Staniferstreet</td>
</tr>
<tr>
<td></td>
<td>10:00am 10:45am Watch</td>
<td>10:00-10:45am Watch Session 2-01</td>
<td>10:00-10:45am Watch Session 2-02</td>
<td>10:00-10:45am Watch Session 2-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Session 2-01</td>
<td>Session 2-02</td>
<td>Session 2-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10:45-11:15 Interactive Q&amp;A</td>
<td>10:45-11:15 Interactive Q&amp;A</td>
<td>10:45-11:15 Interactive Q&amp;A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exploring Innovative Pedagogies Through Interdisciplinary Mathematics and Science Learning in the Primary School</td>
<td>Primary Science and Technology Education in Australian Universities: An Overview of Context and Practice</td>
<td>Exploring Elementary Teacher’s Challenges With the Perspective of Structure and Agency When First Implementation of Social Action-Oriented SSI Education Classes in Korea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Russell Tyler, Peta White, Vaughan Prain, Lipha Xu</td>
<td>James Deashan</td>
<td>Sang-Eun Lim, Jong-Uk Kim, Chan-Jong Kim</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teaching Strategies and Interdisciplinary Science Teaching</td>
<td></td>
<td>Science Centres and Affective Teacher Change – An</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bruce White, Yoonne Zeegers, Karen Sloan</td>
<td></td>
<td>Overview of the Research and Implications for Future Studies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chod Nelson, Jan van Driel, Victoria Miller</td>
</tr>
<tr>
<td></td>
<td>11:15am 12:00pm Watch</td>
<td>11:15-12:00am Watch Session 3-01</td>
<td>11:15-12:00am Watch Session 3-02</td>
<td>11:15-12:00am Watch Session 3-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Session 3-01</td>
<td>Session 3-02</td>
<td>Session 3-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12:00-12:30 Interactive Q&amp;A</td>
<td>12:00-12:30 Interactive Q&amp;A</td>
<td>12:00-12:30 Interactive Q&amp;A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lipha Xu, Christoph Skolimowski, Vaughan Prain</td>
<td>Matthew Hill, Alison Gates, Katie Terrett</td>
<td>Brandy Michael-Jack</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exploring the Impact of Teacher’s Implementation on Student’s Participation in Modeling-Based Learning about Solar Rotation</td>
<td>“It’s kind of a mix and match of the syllabus”: One Teacher’s Experience of Enacting the Queensland Earth and Environmental Science Syllabus</td>
<td>Development of Winter Socio-Scientific Issues to Assess Argumentation Skills with Year 7 Students</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hyon Jung Cha, Chan Jong Kim</td>
<td>Lesia Tomas, Weaco Mmilo, Fiona Gibson</td>
<td>Valle Davidson</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Christine Preston, Sally Bursic</td>
<td>Juls Reardon, Manjula Sharmas</td>
<td>Gillian Ridlen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thursday June 25</strong></td>
<td>9:30-10:00am Live</td>
<td><strong>Lunch</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10:30-11:00pm Live</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Friday June 26</strong></td>
<td>9:00-10:00am Watch</td>
<td>9:00-10:00am Watch Session 6-01</td>
<td>9:00-10:00am Watch Session 6-02</td>
<td>9:00-10:00am Watch Session 6-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Session 6-01</td>
<td>Session 6-02</td>
<td>Session 6-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9:45-10:45 Interactive Q&amp;A</td>
<td>9:45-10:45 Interactive Q&amp;A</td>
<td>9:45-10:45 Interactive Q&amp;A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Christopher Banks, Caya Gilbert, Narissa Jones</td>
<td>Ang Hoi Yuen, Tan Ahk Ling</td>
<td>Vazif Diba, Dev-France, Sally Birdsell</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Investigating Science and Religious Education Teachers’ Variations of Argumentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10:45-11:45 Interactive Q&amp;A</td>
<td>10:45-11:45 Interactive Q&amp;A</td>
<td>10:45-11:45 Interactive Q&amp;A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introducing Digital Technologies into Play-Based Learning in Early Childhood</td>
<td>Examining the Inclusive Perspectives and Practices of Canadian Science Teacher Educators</td>
<td>Examination of Climate Change Conceptualization within Upper Secondary Victorian Curriculum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>George Aranda, Joseph Ferguson, Coral Campbell, Chris Spaldwine</td>
<td>Karen Goodhough, Ságu Azam, Todd Milford, Christine Tippett</td>
<td>Efraf Elam, Vevrenda Prasad, Helen Widdop-Quinton</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The Development and Effects of an Inquiry-Based Early STEM Curriculum on Taiwanese Kindergarteners’ Science and Engineering Practices</td>
<td>Exploring Micro-Cultural Diaspora and Emotions in a Chinese Primary</td>
<td>It’s Very Complicated: Expanding Students’ Views on Relationships in Socio-scientific Issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ching-Ting Hu, Hsin-Kai Wu, Sung-Pai Chien</td>
<td>Validating the SECIM (Scales of Evolutionary Conflict Measure) Instrument</td>
<td>Majd Zouh, Dimitris Tsoubaris, Sarah El Hayawy, Minja Milanovic, Zoya Padamoo, Nadia Qureshi, Larry Bengtson</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learning about Science in Society: A Case Study of Learning Processes from Student Participation in Citizen Science</td>
<td>Garia C. Siaglia, Ross H. Nehm</td>
<td>Climate Change: The Impact of Culture on Students’ Willingness to Act on Their Beliefs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yasla Columbic, Alicia Motion</td>
<td></td>
<td>Keith Skamp, E. Boyes, M. Staniferstreet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ASERA 2020 Online conference Book of Abstracts
<table>
<thead>
<tr>
<th>Time</th>
<th>Session 7 - Thursday</th>
<th>Session 8 - Thursday</th>
<th>Session 9 - Thursday</th>
<th>Session 10 - Thursday</th>
<th>Session 11 - Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:45am-9:30am</td>
<td>Watch Session 7-01</td>
<td>Watch Session 8-01</td>
<td>Watch Session 9-01</td>
<td>Watch Session 10-01</td>
<td>Watch Session 11-01</td>
</tr>
<tr>
<td>9:30am-10:00am</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
</tr>
<tr>
<td>10:00am-10:30am</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
</tr>
<tr>
<td>10:30am-11:15am</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
</tr>
<tr>
<td>11:15am-12:00pm</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
</tr>
<tr>
<td>12:00pm-12:30pm</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
<td>Interactive Q&amp;A</td>
</tr>
<tr>
<td>12:30pm-1:30pm</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
</tr>
<tr>
<td>1:30pm-2:30pm</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
<td>Higher Education</td>
</tr>
<tr>
<td>Time</td>
<td>Session</td>
<td>Title</td>
<td>Presenter(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-----------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00-10:45</td>
<td>14-01</td>
<td>Watch Session 14-01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:45-11:15</td>
<td>14-02</td>
<td>Interactive Q&amp;A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:15-12:00</td>
<td>14-03</td>
<td>Watch Session 14-03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00-12:30</td>
<td>14-04</td>
<td>Interactive Q&amp;A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:30-13:00</td>
<td>14-05</td>
<td>Watch Session 14-05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:00-13:45</td>
<td>14-06</td>
<td>Interactive Q&amp;A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:45-14:15</td>
<td>14-07</td>
<td>Watch Session 14-07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14:15-15:00</td>
<td>14-08</td>
<td>Interactive Q&amp;A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Friday, June 26**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Title</th>
<th>Presenter(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:45-09:30</td>
<td>15-01</td>
<td>Watch Session 15-01</td>
<td></td>
</tr>
<tr>
<td>09:30-10:00</td>
<td>15-02</td>
<td>Interactive Q&amp;A</td>
<td></td>
</tr>
<tr>
<td>10:00-10:30</td>
<td>15-03</td>
<td>Watch Session 15-03</td>
<td></td>
</tr>
<tr>
<td>10:45-11:15</td>
<td>15-04</td>
<td>Interactive Q&amp;A</td>
<td></td>
</tr>
<tr>
<td>11:15-12:00</td>
<td>15-05</td>
<td>Watch Session 15-05</td>
<td></td>
</tr>
<tr>
<td>12:00-12:30</td>
<td>15-06</td>
<td>Interactive Q&amp;A</td>
<td></td>
</tr>
<tr>
<td>12:30-13:00</td>
<td>15-07</td>
<td>Watch Session 15-07</td>
<td></td>
</tr>
<tr>
<td>13:00-13:45</td>
<td>15-08</td>
<td>Interactive Q&amp;A</td>
<td></td>
</tr>
<tr>
<td>13:45-14:15</td>
<td>15-09</td>
<td>Watch Session 15-09</td>
<td></td>
</tr>
</tbody>
</table>

**Closing Session**

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Presenter(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:30-1:00</td>
<td>Conference Wrap up and Closing</td>
<td></td>
</tr>
</tbody>
</table>
Contents

Program ................................................................................................................................................... 1
Contents .................................................................................................................................................. 4
Paper presentations ................................................................................................................................ 9
Development of Pre-service Teachers’ Conceptualisation of Science as a Human Endeavour: Bridging the Gap Case Study ............................................................................................................................... 10
Introducing digital technologies into play-based learning in early childhood ........................................ 11
Inquiry-based learning in an Indigenous context: Evaluation of the Inquiry for Indigenous Science Students (I²S²) program ........................................................................................................................ 12
Promotion of EcoJust Engineering Design, Production and Mobilization in/through School Science .... 13
Crises, Capitalism and Critical and Altruistic Science and Technology Education ................................ 14
AEQ-PhysicsLec: Measuring first year students’ emotions with Physics Lectures ................................ 15
THE AEQ-PhysPrac: Measuring first year students’ emotions in Physics Practicals ................................ 16
Preparing Teachers to Enhance the Potential of After-School STEM Clubs for Rural Students .......... 17
Exploring the impact of teacher’s implementation on students’ participation in modeling-based learning about solar rotation ................................................................................................................ 18
Characterising pre-service science teachers’ incoming usable knowledge for teaching science ...... 19
Examining the impact of the undergraduates’ metacognition on their analogical reasoning about thermodynamic concepts construction: an eye-tracking analysis ............................................... 20
Multilevel Effects of Student and School Factors on CPS Performance in Taiwan ................................. 21
Exploring micro-cultural diaspora and emotion in a Chinese primary STEM classroom .................... 22
Development of water socio-scientific issues to assess argumentation skills with Year 7 students .... 23
Primary science and technology education in Australian universities: An overview of context and practice ................................................................................................................................................. 24
“Inquiry-based learning in Years 11 and 12 Science: Seeking a model for open-inquiry” ..................... 25
Examination of Climate Change Conceptualization within Upper Secondary Victorian Curriculum ... 26
Epistemic core of chemistry in chemistry education: Implications for teacher education ................ 27
Investigating science and religious education teachers’ perceptions of argumentation .................. 28
K-6 Teachers’ Professional Learning Network (PLN) activities: Perceived value for professional development in science education ........................................................................................................... 29
Exploring the Night Sky: A guided-inquiry approach to teaching Celestial Mechanics in Middle School Science .................................................................................................................................................. 30
How scientists use models in their inquiry practice ............................................................................. 31
The Development of STEAM Education Program: .............................................................................. 32
Focused on Empowering Scientific-Computational Action Competence for a Better Society ......... 32
Cultivating Filipino students’ submicroscopic understanding of a ....................................................... 33
single replacement reaction via sketching and feedback synergism ..................................................... 33
Primary Teacher Science Education Online Laboratory Portfolio Activity Enhances Confidence and Engages Learners in Online and On-campus Learning Environments ..................................................... 34
Teachers’ perceptions of creativity in primary and secondary science: similarities and differences .. 35

ASERA 2020 Online conference Book of Abstracts
Learning about science in society: A case study of learning processes from student participation in citizen science

Examining the inclusive perspectives and practices of Canadian science teacher educators

Science and Religious Education Teachers’ Views of the Comparison of Argumentation in Science and Religion

Harnessing the power of talk: Interplay of teachers’ dialogic scaffolding practices and students’ expressions of argumentative agency

A Present Future: Interrogating ‘Sociotechnical Imaginaries’ through Science Education

Discrete emotions of Year 8 students during role play in a middle years science classroom

Principal attitudes towards out-of-field teaching

Tech Schools Evaluation: Applying An Innovation Framework

The Development and Effects of an Inquiry-based Early STEM Curriculum on Taiwanese Kindergarteners’ Science and Engineering Practices

The Relations between Epistemic Beliefs, Metacognition, and Self-Regulated Learning of Science Learning: A Review of Studies from 2010 to 2019

“What counts as scientific?” Teachers’ understanding and views of scientific methods

Predicting genuine learning interest in ethics-related socio-scientific issues (E-SSI)

How are Pre-service Teachers developing their espoused theories and theories-in-use to motivate science students in the lower secondary school years?

Building Leadership for change in STEM through mentoring Kingdom of Saudi Arabian teachers

In Dialogue with Nature – A classics reading approach to nurture epistemic insight in a multidisciplinary and higher education context

Transgressing boundaries: Developing attitudes and actions for sustainable development

Development and validation of an instrument to assess STEM students’ perceptions of Classroom Emotional Climate

Designing Problem-Centric STEM Activities

Exploring elementary teacher’s challenges with the perspective of structure and agency when first implementation of Social Action-Oriented SSI education classes in Korea

Student understanding of scale in astronomy

The influence of career advice and perceptions on girls’ physics identity and subject choice

How Recent Community College to University Transfer Students Experience Supported Science & Engineering Internships

Graduate Students’ Perceptions of Participating in a Science/Engineering and Education Interdisciplinary Collaboration: Developing Community and Navigating Boundaries

Measuring stuff: A big idea bridging science and mathematics education in primary school

‘We do STEM as well’: the role of Vocational Education and Training in Australia’s STEM workforce development

Primary Specialisation in Initial Teacher Education

Pre-service Teachers’ Lived Experiences

The Analysis and Solutions of Steam Teacher Education Practice in Taiwan
Enhancing Project-Based STEM Education through Student Participation and Autonomy: Implementing a STEPWISE framework ................................................................. 64
Science centres and affective teacher change – an overview of the research and implications for future studies ............................................................ 65
Exploring design thinking using Dewey’s theory of pragmatist inquiry and aesthetic experience .......... 66
Moving on from getting started: mathematics and science specialist primary/middle preservice teachers’ experiences and perceptions of indigenous knowledges and practices ........................................ 67
How students say they choose their subjects at school and its impact on the choice of science ........ 68
Instructional practices facilitating argumentation in science and religious education classrooms: A case study of lower secondary teachers in England ......................................................... 69
Student representations - Impact of Immersive Habitat Classrooms on science learning at Taronga Zoo ........................................................................................................... 70
A Chinese science education community’s perceptions about teaching socio-scientific issues ........ 71
Factors Influencing Science Teachers’ Action Research Process in a Secondary School in Bhutan .... 72
A study into the impact of the changes in high syllabus in 2002 till 2018: What stayed constant over 16 years? ........................................................................................................ 73
Understanding the Out-of-Field Teaching Experience through Positioning Theory: Perceptions of Career Research Scientists Who Became Teachers ............................................................ 74
Enacting the middle-ground: An approach using Indigenous sky stories ........................................... 75
Validation of the SECM (Scales of Evolutionary Conflict Measure) Instrument .................................. 76
Inquiry based instruction with Science Writing Heuristic (SWH) approach on pre-university students’ on understanding of stoichiometric concepts using green chemistry activities .............................................. 77
Climate change: The impact of culture on students’ willingness to act on their beliefs ....................... 78
Scientists’ right to say “I do not know”: science education for contemporary Australia ........................ 79
The Learning Assistant Model: Supporting Faculty Teaching Transformation and Student Success ... 80
Discourse Patterns & Strategies in Science Classrooms: A Synthesis of Classroom Discourse Frameworks ......................................................................................... 81
Development of an Interdisciplinary STEM Classroom Observation Protocol ..................................... 82
Teaching strategies for integrative STEM education ............................................................................ 83
“It’s kind of like a cut and paste of the syllabus”: One Teacher’s Experience of Enacting the Queensland Earth and Environmental Science Syllabus, and Implications for Education for Sustainable Development ......................................................... 84
Characterising deep and superficial learning in science: a case study of preservice teachers’ knowledge building in an assessment task ............................................................................. 85
Exploring innovative pedagogies through interdisciplinary mathematics and science learning in the primary school ........................................................................................................ 86
How might we enable Generalist Teachers to become confident Science and STEM Practitioners? .. 87
Enhancing STEM understanding for pre-service teachers ..................................................................... 88
Effects of Metacognitive Scaffolding on Students’ Performance in Simulation-based Inquiry .............. 89
Teaching strategies and interdisciplinary Science teaching ....................................................................... 90
Planning interdisciplinary maths/science learning sequences for system impact ................................ 91
Exploring the challenges and enablers of growing a STEM PBL program in a low SES junior secondary context .............................................................................................................. 92
Using Immersive Virtual Reality to Improve Science Learning: A Review of Literature and Future Directions ................................................................. 93
The viewpoints of teachers and career advisors regarding enablers and barriers in STEM for female students ................................................................. 94
Multiple representations in student learning of optics: An interdisciplinary approach ................................................................. 95
Student Exploration of the Particulate Nature of Matter in a Secondary Science Classroom: A Social Semiotic Perspective ................................................................. 96
Designing Solution-centric STEM activities ................................................................. 97
‘It’s Very Complicated’: Expanding Students’ Views on Relationships in Socioscientific Issues ................................................................. 98
Poster presentations ........................................................................................................ 99
Development of a High Quality Instrument Measuring Primary Students’ Attitudes toward Science in China ................................................................. 100
The effect of colour and story on student emotion during physics practical tasks ................................................................. 101
Do worksheets make a difference in the 1st year physics? A study in Thailand ................................................................. 102
Elementary preservice teachers’ game designs to promote science learning ................................................................. 103
The Fire Within ........................................................................................................ 104
Development of a High Quality Instrument Measuring Primary Students’ Attitudes toward Science in China ................................................................. 105
Research into girls’ Lived Experiences of STEM Education as they Transition from Primary to Secondary School ................................................................. 106
Integrating technology with model-based inquiry to improve student engagement in physics laboratories ................................................................. 107
Multifaceted effects of self-efficacy on Taiwanese high school students’ learning engagement ................................................................. 108
Exploring the Transformative Agency of Youth Activists for Climate Change in Korea ................................................................. 109
Call on me! Undergraduates’ perceptions of voluntarily asking questions in front of large-enrollment science classes ................................................................. 110
Designing a role-play school science lesson including programming activities for pre-service teachers: Focusing on the concept of electric current ................................................................. 111
Exploring the current education design of socio-scientific issues in zoo exhibitions ................................................................. 112
The Impact of Climate Change SSI-STEAM Classes on Students’ Knowledge, Perception, and Action regarding Climate Change ................................................................. 113
Designing a Coherence- and Concept-Based Modular Course to Facilitate Students’ Understanding of Crosscutting Concepts ................................................................. 114
Identification of Climate Change Action Competence Through Exploring Youth Environment Activists in Korea ................................................................. 115
Educational Practices of Sommerfeld School and Its Implications: What is a Good Science Education? ................................................................. 116
Student Confidence, Riddles and Reflections ................................................................. 117
Incorporating Both-Ways Thinking about Time into the Science Curriculum ................................................................. 118
Examining the Physical Science Misconceptions of Middle Primary Students ................................................................. 119
Exploration of a Science Teacher’s Personal Practical Knowledge ................................................................. 120
of Socio-scientific Issues in the SSI-STEAM Class Context ................................................................. 120
ASERA 2020 Online conference Book of Abstracts
Development of inquiry-based courses about biomedical technology in general education classroom ............................................................................................................................................................ 122
How does visual representation construction facilitate learning in science classroom? Affordances of teacher-centered and students-centered visual representation construction ........................................ 123
Symposia ............................................................................................................................................. 124
STEM, Creativity and Critical Thinking in 21st Century Education ...................................................... 125
Surveying the primary science education landscape: What is happening in initial teacher education across Australia? ................................................................................................................................. 127
Workshops .......................................................................................................................................... 128
Science Games Nights Workshop ....................................................................................................... 129
Corresponding Author Contacts ......................................................................................................... 130
............................................................................................................................................................ 133
Paper presentations
Development of Pre-service Teachers’ Conceptualisation of Science as a Human Endeavour: Bridging the Gap Case Study

Carol Aldous, Flinders University, carol.aldous@flinders.edu.au
Aidan Cornelius-Bell, Flinders University, aidan.corneliusbell@flinders.edu.au
Abby Sesterka, Flinders University, abby.sesterka@flinders.edu.au

The implementation of the Australian Curriculum (AC) in 2014 saw the introduction of ‘Science as a Human Endeavour’ (SHE) as a strand in science education, nationally. This approach, along with the introduction of the AC in general, had significant implications for initial teacher education programs in universities Australia wide.

Bridging the Gap, a STEM curriculum studies program run by Flinders University since 2016, has facilitated engagement for pre-service teachers with industry partners and research scientists to focus on ‘real-world’ STEM-centred problem solving. Research has been conducted with each Bridging the Gap cohort by means of quantitative surveys and qualitative interviews which included specific enquiry around the concept of Science as a Human Endeavour.

This paper draws on the data collected and uses Bridging the Gap as a case study to track the development of pre-service teachers’ understanding of SHE over a period of four years. Further, it discusses how broader engagement and work-integrated learning experiences enhance pre-service teachers’ conceptualisation and application of Science as a Human Endeavour in the classroom context. The findings point to a changed mind set from viewing science in abstract theoretical terms towards one of an in-depth appreciation of the complex interactions arising between science and industry.
Introducing digital technologies into play-based learning in early childhood

Paper Presentation

Dr George Aranda, Deakin University, george.aranda@deakin.edu.au
Dr Joseph Ferguson, Deakin University, jpe.ferguson@deakin.edu.au
Prof Coral Campbell, Deakin University, coral.campbell@deakin.edu.au
Mr Chris Speldewinde, Deakin University, chris.speldewinde@deakin.edu.au

The digital technologies curriculum has been taken up by early childhood (EC) centres worldwide with various levels of educator experience and confidence. Our research includes: exploring digital pedagogical practice development and EC educator strategies; tracking educator growth in expertise; and the impact on children’s digital technology play and practice in their preschools. Working with three early childhood centres, we provided professional learning to educators in the use of tangible coding technologies (TCTs) that emphasised the physicality of robots used in play, supporting educators to construct a sequence of experiences that introduced ‘Beebots’ to their children. This paper reports on preliminary findings from one centre, based on educator interviews and researcher observations of children’s play. We identified the growing confidence of educators as they introduced these TCTs to their children; their observations of how students incorporated TCTs into their play; and the enablers and blockers when incorporating TCTs into play-based learning of STEM. We argue that the experience and confidence of EC educators can be developed and consideration needs to be given to their ability to connect digital technologies to curriculum, existing practices, their role in children’s learning and their own understanding of STEM concepts.
Inquiry-based learning in an Indigenous context: Evaluation of the Inquiry for Indigenous Science Students (I²S²) program

Paper presentation

Dr Christopher Banks and Caja Gilbert
Monitoring and Evaluation, Education and Outreach
CSIRO christopher.banks@csiro.au

Indigenous Australian scientific knowledges and practices have not been effectively implemented into the Australian Curriculum. In response, the Inquiry for Indigenous Science Students (I²S²) program, funded by the BHP Foundation and delivered by CSIRO, uses hands-on inquiry-based projects in an Indigenous context to increase engagement and achievement in science. In 2019, an evaluation was conducted of I²S² to assess the degree to which the program was meeting its intended outcomes, as outlined in a program Impact Pathway. The mixed-methods evaluation comprised interviews and focus groups with students, teachers, and community members, and analysis of engagement and academic achievement results. The findings indicated that the program was successfully engaging students, including non-Indigenous students, in the science curriculum, and having positive impacts on academic achievement, particularly for low-achieving students. The program was also found to be positively impacting cultural capability at a school level. Several areas for improvement were identified, including providing more support to schools to partner with Elders and Traditional Owners. School, teacher, community, and program factors that influenced the achievement of the program’s outcomes were also identified. Recommendations for program and practice improvements in terms of science education in an Indigenous context will be presented.
Promotion of EcoJust Engineering Design, Production and Mobilization in/through School Science

Paper Presentation


In many contexts worldwide, educators are encouraged to integrate/interrelate aspects of science, technology, engineering and mathematics (STEM). Among STEM education variants, promotion of engineering design and appreciation of engineering products and services seems particularly prevalent. While there are many defenders of such foci, several scholars and others suggest that many STEM education initiatives compromise students’ consciousness of broader relationships among these fields, other members of societies and environments — including adverse effects on living and nonliving things of influences of powerful people (e.g., financiers, entertainers, etc.) and groups (e.g., corporations, transnational trade organizations, banks, etc.) on STEM fields and beyond (e.g., including civic subjectivities). Accordingly, we report action research findings involving a secondary school science teacher’s efforts to educate students about such problematic relationships and, for areas of students’ interest, enable and motivate them to design and implement functional engineering products that also address their social and/or ecological justice priorities. Results indicate much student success in development of such ‘ecojust’ engineering products and services, but some struggles imagining complex networks of living, nonliving and symbolic entities (actants) supporting them. Accordingly, work still seems necessary integrating concepts like sociotechnical imaginaries into secondary school science education.
Crises, Capitalism and Critical and Altruistic Science and Technology Education

Paper presentation

Larry Bencze larry.bencze@utoronto.ca

Much of the world is experiencing a crisis in which many ‘instructional packets’ (CoViD-19 viruses) have commandeered ‘machinery’ of living beings for their propagation. This crisis, while causing massive dislocation, sickness and death, was predicted and, moreover, crises often are welcomed. Klein (2007) suggests that capitalists and others have routinely exploited natural and anthropogenic disasters — using societal destabilization to further implement pro-capitalist policies, often at expense of well-being of many people (e.g., gig workers), societies (e.g., under surveillance) and environments (e.g., climate change). Like viruses, many capitalists may commandeer ‘machinery’ (e.g., workers, technologies, etc.) to propagate ‘themselves’ (e.g., more capitalists and their values) — often at expense of surrounding entities. Key types of ‘machinery’ under capitalist control are fields of science and technology (S&T) and their educational counterparts — which, often like Trojan horses, promise better futures for all while contributing to ongoing wealth concentration and environmental degradation. The current crisis, however, may be different. While enabling, for instance, more surveillance capitalism, it also may have enlightened many people about pre-crisis neoliberal and populist infrastructures that may have contributed to this and other crises and emboldened many to work for better futures. S&T education seem natural vehicles for such societal transformation.
AEQ-PhysicsLec: Measuring first year students’ emotions with Physics Lectures

Paper presentation

Aesha Bhansali\textsuperscript{a}, Elizabeth Angstmann\textsuperscript{b}, and Manjula Devi Sharma\textsuperscript{a}
\textsuperscript{a} School of Physics, The University of Sydney, Sydney, NSW 2000, Australia
\textsuperscript{b} The University of New South Wales, Sydney, NSW 2052, Australia

Students feel different emotions in the Physics discipline. But emotional engagement of students in physics is still an under researched area. We adapted the valid tool Achievement Emotions Questionnaire - PhysicsPrac (AEQ- PhysicsPrac) to measure the emotions of students with first year physics undergraduate lectures. Our research aim is to validate the questionnaire in Physics lecture context and to probe students’ emotions towards two lecture streams. The Control lectures with black and white lecture slides with just the Physics content. The Intervention lectures which incorporate colourful slides with one short historical story, seeking to produce more positive emotions. Confirmatory Factor Analysis, descriptive statistics are conducted as a Preliminary analysis. Observational field notes, Statistical analysis through SPSS, and focus group interviews are triangulated to understand students’ emotional engagement. The detailed results will be presented at the conference to indicate the AEQ-PhysicsLec utility in physics education.
THE AEQ-PhysPrac: Measuring first year students’ emotions in Physics Practicals

Paper presentation

Aesha Bhansali\textsuperscript{a}, Elizabeth Angstmann\textsuperscript{b}, and Manjula Devi Sharma\textsuperscript{a}

\textsuperscript{a} School of Physics, The University of Sydney, Sydney, NSW 2000, Australia
\textsuperscript{b} The University of New South Wales, Sydney, NSW 2052, Australia

Although research showing the importance of emotional engagement, students emotions in physics is a less explored territory. We set out to measure and study students’ emotions in first year Physics laboratory at Sydney University. We adapted the valid tool Achievement Emotions Questionnaire (AEQ) for our context. We set out to seek ways to generate more positive emotions. The Control practical had black and white lab notes with just the Physics content. The Intervention practical had incorporated short colourful historical story. Descriptive statistics and Confirmatory Factor Analysis (CFA) were conducted with a sample of 320 students at the University of Sydney, which confirm the reliability and internal validity of the adapted AEQ (AEQ-PhysPrac). Intervention is able to generate more positive emotional engagement compared to Control implicating that the AEQ-PhysPrac can be useful in monitoring emotions in physics.
Preparing Teachers to Enhance the Potential of After-School STEM Clubs for Rural Students

Paper presentation

Dr. Margaret R. Blanchard¹ (Meg_Blanchard@ncsu.edu), Kristie S. Gutierrez² (kgutierrez@odu.edu), and Kylie J. Swanson³ (kswanson@uccs.edu)
North Carolina State University¹, Old Dominion University², University of Colorado Colorado Springs³

This paper focus on teacher professional development (PD) to help develop 24 Teacher-Coaches' multicultural education competency (Atwater, 2000) for working with students in STEM Clubs at four rural middle schools in the southeastern U.S. Teachers who are culturally competent are able to use pedagogical strategies (i.e., culturally responsive pedagogy, culturally sustaining pedagogy) that “tap into the diverse cultures of their students to make learning meaningful and comprehensible” (Pang et al., 2011, p. 560). A primary project goal was to increase students' interest in STEM and related careers (Gutierrez, 2016; Habig et al., 2018) for diverse students underrepresented in STEM careers: first generation, minorities, and females. Quantitative (e.g., STEBI (modified), TPACK, STEM Club Leadership Survey) and qualitative (e.g., Teacher Beliefs Interview (TBI), yearly reflections, pre-Club meeting audio, DoS ratings) data were collected and analyzed over 3 years. T-Coaches gained confidence and self-efficacy in STEM, increased technological and pedagogical content knowledge, and became more student-centered in their beliefs about teaching. T-Coach teams that developed stronger communities of practice rated higher on measures of STEM Club success (Hoyle, 2017). T-Coach levels of participation were critical to the development of team relationships, positive Club experiences, and more desirable Club outcomes with diverse students.

References
Exploring the impact of teacher's implementation on students' participation in modeling-based learning about solar rotation

Paper presentation

Hyun-Jung Cha¹, Chan-Jong Kim¹*
¹Seoul National University
*chajokim@snu.ac.kr

One of the goals that science learning pursues is to encourage students to observe a scientific phenomenon and generate a model to explain it based on data and evidences. Having students participate in modeling-based learning is regarded as one of the best ways to achieve the goals of science learning. The modeling-based learning, however, is challenging for both students and a teacher, especially the teacher who prepares and implements the practice has a great impact on the way and quality of the students' participation. The purpose of this study is to understand the experience of students (age 13-14) and a science teacher participating in modeling-based learning about solar rotation using SOHO data, with the process videotaped and recorded, and to find out detailed and practical implications for teachers who conduct the practice. The results of study show that students constructed models using various conceptual resources, and going modeling activities, students expanded the diversity of conceptual resources and developed their models which have received a significant influence from the practice of teacher. In addition, the study confirms that teacher had both positive and negative impacts on the conceptual activation of the students, thereby influencing the quality of the students' participation.
Characterising pre-service science teachers’ incoming usable knowledge for teaching science

Paper presentation

Kennedy Kam Ho CHAN
The University of Hong Kong
kennedyckh@hku.hk

Although many studies on pre-service science teachers’ (PSTs’) professional knowledge for teaching science exist, many have focused on PSTs’ declarative knowledge but not the knowledge that PSTs activate and use in contexts close to authentic classroom situations. This study characterised two forms of usable knowledge: knowledge that informs PSTs’ analysis of classroom situations and knowledge that informs their in-the-moment instructional decision-making.

A cohort of PSTs (n=14) attempted two video-based tasks at the beginning of a science major methods course. Qualitative analysis of their responses revealed that the PSTs readily identified the general pedagogical knowledge (PK) and topic-specific pedagogical content knowledge (PCK), but only two identified the discipline-specific PCK displayed by the teacher in the videos. Second, while the PSTs identified examples of students’ cognitive thinking (55 out of the 75 comments on students), the PSTs tended to describe rather than activate their knowledge of student understanding to interpret the examples. Third, the PSTs relied primarily on PK (29 out of the 53 suggestions), not PCK, to suggest alternative instructional strategies/representations. Finally, the PSTs’ on-the-fly instructional responses were seldom connected with emergent student thinking (18 out of the 24 responses) and were primarily informed by their PK rather than PCK (17 out of the 24 responses).

The study delineated and characterised two forms of PSTs’ incoming usable knowledge for teaching science. Findings have implications for developing PSTs’ professional knowledge.
Examining the impact of the undergraduates’ metacognition on their analogical reasoning about thermodynamic concepts construction: an eye-tracking analysis

Paper presentation

Sheng-Chang Chen1 & Yu-Lun Wu2

1,2 Institute of Education, National Chiao-Tung University, Taiwan
Email addresses: 1sengechen@nctu.edu.tw; 2doublemeiwu@gmail.com

In the past three decades, it has been believed that applying analogical reasoning was beneficial for learners to gain scientific concepts. However, learners may not construct scientific conceptions via analogical reasoning due to lack of arousing their metacognition to monitor and judge the matched correspondences and inferences between the source and target domain. Therefore, this study aimed to develop the online multimedia science learning courses applying different analogical reasoning with metacognition and sought to examine the impact of the undergraduates’ metacognition on their analogical reasoning. The study also explored the relationships between the processes of undergraduates’ analogical learning before and after metacognition intervention with their eye movements. A total of 60 undergraduates were recruited to participate in the study and were randomly assigned to the two groups. A half of undergraduates received analogies with initial integration, the others received analogies with initial alignment. Results showed that undergraduates allocated significantly more effective attention after the metacognition intervention than before the metacognition intervention, regardless of receiving with initial-projection materials or initial-alignment materials. The implication of the study may go further, suggesting that learners’ metacognition influences their analogical reasoning ability and they have better performance when learning scientific concepts.
Multilevel Effects of Student and School Factors on CPS Performance in Taiwan

Paper presentation

Su-Fen Chuang*, Chow-Chin Lu
Department of Science Education, National Taipei University of Education, Taipei, Taiwan

*t1160407@gmail.com, luchowch@tea.ntue.edu.tw

As been highlighted by many researches, such as the Programme for International Student Assessment (PISA), Collaborative Problem Solving (CPS) is a critical and necessary skill in 21st century. How was the performance of Taiwan students in PISA 2015 CPS? It was urgent to be understood. This research was designed to distinguish the students’ individual characteristics and school characteristics, and take both into account to examine the CPS achievement. It was to ascertain the relationship among the gender difference (GD), the attitude of collaboration (AC), students’ socioeconomic status (ESCS), school location (SLOC), school-mean socioeconomic status (SESCS) and school-mean attitude of collaboration (SAC) of CPS performance. The two-level hierarchical linear model was used to analyze 7,708 15-year-old students’ data. The results showed that: 1) As the importance of predictors of student level as concerned, GD>ESCS>AC. Furthermore, Taiwanese boys achieved significantly lower average scores than girls in the same school. 2) AC, SAC and SLOC variables were minimally related to CPS scores. 3) Higher ESCS at student level and higher SESCS at school level yielded higher CPS performance.
Exploring micro-cultural diaspora and emotion in a Chinese primary STEM classroom.

Paper presentation

Dr James Davis
Queensland University of Technology
Email: jp.davis@qut.edu.au

In this paper I explore the notion of diaspora, as being in an unfamiliar micro-culture, and emotive experiences of diaspora, in the context of a primary school STEM inquiry in Shanghai, China. This empirically grounded study is significant because it extends previous science education research of Confucian Heritage Cultures, and it informs other cultural studies by illustrating the notion of diaspora and the micro-cultural heterogeneity of emotions in learning science. The aim of this paper is to illustrate the notion of micro-cultural diaspora involving the influence of neo-Confucian thinking, emotional experiences, and practices of a STEM inquiry. I adopt an interpretive, participatory research methodology with data collection, transcription and fine-grained description informed by ethnomethodology. The interpretive aspect of this study is informed by Ancient Confucian philosophy, re-interpreted by Twentieth Century Chinese scholars, reflecting contemporary China. Emotions are interpreted through a model of emotional energy, describing emotive experiences as an individual-collective sense of togetherness evident through mutual bodily entrainment, the fluency of interactions, and the achievement of ideas as micro-social structure. My findings conceptualise East Asian science learning contexts where the confluence of Confucian, Buddhist, Taoist, and/or Western thinking may be evident through classroom practices, learning events, and emotive learning experiences.

*Keywords:* Confucian, cultural, diaspora, emotion, learning, science
Development of water socioscientific issues to assess argumentation skills with Year 7 students

Paper presentation

Vaille Dawson, The University of Western Australia

Given the current climate change related issues impacting Australia, there has never been a more important time for young people to develop the skills to make decisions about socioscientific issues. The aim of this study was to test a methodology to construct water-related SSI scenarios that could be used to develop and assess Year 7 science students’ argumentation skills. The three phases of the methodology included (1) development of the SSI scenarios, (2) trialling with 68 students with teacher support, and (3) trialling with 69 different students to assess argument quality. The findings showed that all students, including those with low literacy skills, were able to engage with the SSI scenarios and construct an argument that could be assessed for quality based on Toulmin’s argument structure, and number and type of reasons. Factors that facilitated engagement with the SSI were personal relevance, whole class discussion, scaffolding, and explicit literacy support. The methodology can be used by teachers, curriculum resource developers and researchers to construct SSI scenarios linked to the state and territory science curricula.
Primary science and technology education in Australian universities: An overview of context and practice

Paper Presentation

Dr James Deehan
Faculty of Arts and Education, Charles Sturt University, Bathurst, NSW
jdeehan@csu.edu.au

Stagnating test scores, underwhelming student scientific literacy and declines in post-compulsory science enrolment are major issues in Australian science education (Kennedy et al., 2014; Norton et al., 2018). Universities must be key contributors, as a relatively small group of 33 higher education providers can directly influence generations of primary teachers responsible for foundational science learning. Since a major review of primary science practice at Australian universities (Palmer, 2008), factors including, but not limited to, changing employment conditions (Hitch et al., 2018; Klopper & Power, 2014; Williams & Beovich, 2017), shifts in study modes (Norton et al., 2018) and an ever-expanding research literature base need to be considered. This paper aims to describe the reported primary science and technology practices, challenges and strengths of Australian Teacher Education through semi-structured interviews with 17 academics and analyses of public materials on university websites. Thematic analyses, conducted both manually and via NVIVO, reveal noteworthy diversity in approaches, united by authenticity and student-centred learning. Key strengths included: robustness of educational approaches, relevance and teaching team compositions. Key challenges included time, external pressures, resources and student capacity. Yet, these seemingly unchanged issues were linked to themes of resilience. Potential implications will be presented for wider discussion.

References
“Inquiry-based learning in Years 11 and 12 Science: Seeking a model for open-inquiry”

Paper presentation

Deborah de Ridder, University of Technology Sydney, Email: Deborah.L.deRidder@student.uts.nsw.edu.au; dderidder@trinity.nsw.edu.au

Inquiry-based learning (IBL) has become a feature of recent changes to curriculum across Australia and across the globe and the recent introduction of the “Depth Studies” requirement of the Years 11 and 12 Science syllabuses in NSW has allowed for a variety of approaches to IBL that include structured, guided and open-inquiry approaches. The compulsory IBL requirement also accompanies a content-rich curriculum and occupies a relatively short part of the curriculum. This study seeks to research the features of good existing approaches to Years 11 and 12 IBL that facilitate open-inquiry in the NSW context and seeks to develop a conceptual model.

This study is a Grounded Theory Design study which focuses on the features of good IBL teaching and learning in the Year 11 and 12 context. The study has three phases which include semi-structured interviews, three case studies and model conceptualisation. The paper will include a summary of Phase 1 of the study which includes a series of semi-structured interviews with secondary science education leaders and will also discuss the proposed methods for Phases 2 and 3.
Examination of Climate Change Conceptualization within Upper Secondary Victorian Curriculum

Paper presentation

Efrat Eilam, PhD, (corresponding author), College of Arts & Education, Victoria University
Email: Efrat.eilam@vu.edu.au
Veerendra Prasad, Master student, College of Arts and Education, Victoria University
Email: veerendra.prasad@live.vu.edu.au
Helen Widdop-Quinton, PhD, College of Arts & Education, Victoria University
Email: Helen.Widdop-Quinton@vu.edu.au

Climate change (CC) is widely accepted as a major threat, posing unprecedented challenges to humanity. Yet very little is known regarding the ways in which upper-secondary curricula address the need to educate about this crisis. This study contributes to the field of CC education theoretically and empirically. From the theoretical perspective, two CC frameworks were developed: a characterisation of the nature of CC, and a mapping of the scope of CC content knowledge. The empirical contribution consists of examining CC education implementation within upper-secondary study designs in the state of Victoria, Australia. A total of 10 out of 94 study designs qualified for examination. The findings suggest that none of the study designs present a complete conceptualisation of the nature of CC. Common conceptualisations within the study designs perceive CC as a cause or an outcome, a problem of management, or of technological efficiency. CC content within the study designs is limited, and presents misconceptions. A cross-curriculum integration approach within the study designs is found to be ineffective. We conclude that there is a need for curricula reforms to address and incorporate CC as a coherent body of knowledge.
Epistemic core of chemistry in chemistry education: Implications for teacher education

Paper presentation

Sibel Erduran, University of Oxford, United Kingdom (Sibel.Erduran@education.ox.ac.uk)
Ebru Kaya, Bogazici University, Turkey (Ebru.Kaya@boun.edu.tr)

Many students in school chemistry lessons find it difficult to understand why they should believe in knowledge claims about chemical knowledge such as atoms and molecules, where such knowledge comes from and how it is justified. As school chemistry rarely engages students in epistemic themes, it is not surprising that teachers including pre-service teachers also have limited understanding of knowledge is produced and justified. In order to understand how to support students and teachers, it can be informative to look into literature in foundational and theoretical disciplines such as philosophy of chemistry that can shed some light of how knowledge works in chemistry. However, it is not simply enough to understand such theoretical accounts of knowledge. As educators, we need to draw from empirical and practical accounts in chemistry education as well so as to make some intelligible and relevant recommendations for improving how chemistry knowledge is covered in the classroom. In this presentation, we target the interphase of three areas in relation to chemistry education: theoretical accounts from philosophy of chemistry; empirical research on teacher education; and impact of implementation of interventions on teacher education to enhance pre-service teachers’ understanding of how chemistry knowledge works. We present some findings from a funded project where the epistemic aims, values, practices as well as forms of knowledge in chemistry (collectively referred to as the “epistemic core”) are integrated into pre-service teacher education. Empirical findings from pre-service teachers’ engagement in the epistemic core are discussed.
Investigating science and religious education teachers’ perceptions of argumentation

Paper Presentation

Sibel Erduran, Liam Guilfoyle & Wonyong Park, University of Oxford, United Kingdom

In recent years, argumentation, or the justification of knowledge claims with evidence and reasons, has emerged as a significant educational goal, advocated in international curricula and investigated through school-based research. Research on argumentation has made connections to other areas such as indigenous knowledge and ethics in science. Surprisingly, however, the contrast of argumentation in science and religious education has been under-investigated although some educators have been concerned with the manifestation of science-religion debates in schools, particularly in relation to topics such as evolution and intelligent design. The purpose of this paper is to investigate how science and religious education teachers perceive argumentation in their subject and the other subject. Twenty-nine teachers were presented with an online survey in order to collect data on various aspects of their perceptions about argumentation. The empirical study used qualitative and quantitative methodology. Findings suggest that teachers of both subjects consider argumentation as a significant aspect of their subject although differences exist in how the teachers interpret argumentation in their discipline. Data suggest that there are statistically significant differences in terms of the frequency of use of pedagogical strategies that support argumentation in lessons. Contributions to broader research in science education are discussed.
K-6 Teachers’ Professional Learning Network (PLN) activities: Perceived value for professional development in science education

Paper presentation

Ruth Fentie, UTS student (PhD), Ruth.A.Fentie@student.uts.edu.au

Online PLN activities, according to previous research, offer significant learning value for teaching professionals of various disciplines. Primary teachers are noted as needing and seeking more accessible, flexible, sustained professional development options to build their science content knowledge (CK), and science pedagogical content knowledge (PCK). This interpretivist-predicated, mixed methods study explored the science education professional development value that primary teachers perceived from their informal PLN activities. This three-phased study involved quantitative survey data from primary teachers internationally, analysed and integrated with qualitative data from a smaller subset of participant interviews and artefacts. Primary teachers’ initial and evolving online PLN construction across multiple contexts and the detailed nature of participants’ interactions were explored. Perceptions of value focused on teachers’ developing their professional knowledge of primary school science teaching and learning. Primary teachers who are active in their online PLN activities articulated considerable self-directed professional development value. Findings have implications for effective teachers’ professional development, inclusive of general pedagogical knowledge (PK), and primary school science PCK and CK. Findings indicated possibilities for actualising greater value for aspects of primary teachers’ professional development, in science education through PLN activities.
Exploring the Night Sky: A guided-inquiry approach to teaching Celestial Mechanics in Middle School Science

Paper presentation

Michael Fitzgerald - Edith Cowan University - m.fitzgerald@ecu.edu.au
Saeed Salimpour - Deakin University - ssalimpour@deakin.edu.au

The night sky with all its beauty and complexity, presents an enormous spatial reasoning challenge to most students, and adults. The transformation from 2D projections to a 3D spatial orientation, and relative motions in 3D space, requires intense cognitive load. There is much research suggesting inquiry-based approaches provide a more effective way for students to intuitively understand these concepts. Although inquiry-based learning is much researched there is no consensus on what it actually looks like in the classroom. Depending on the context, there can be various approaches. This paper highlights an implementation of a guided-inquiry approach to teaching Celestial Mechanics at Middle School using Stellarium as a visualisation and exploration tool. We will present a pilot implementation and theoretical framework that is suited to implementing the guided-inquiry approach in the classroom, and allowing students to easily move between 2D and 3D orientations. We will also describe student experiences, during the process, the successes, challenges and dilemmas they face. We summarise some of the implications for implementing guided-inquiry in the classroom and the pitfalls, and how these are influenced by teacher knowledge.
How scientists use models in their inquiry practice

Paper presentation

Bev France, The University of Auckland, b.france@auckland.ac.nz

This research is based on the assumption that models and modelling are central to a scientists’ work in that they provide the tools of scientific thinking that can be accessed by students when learning about the Nature of Science. Two scientists (identified via a snowball sample) are interviewed about how they use models to generate scientific knowledge in order to understand this epistemological relationship. The research question underpinning this narrative analysis is: What are their understandings between model use and knowledge development? Siouxsie (a microbiologist) develops surrogate model systems that provide information about source organisms that are suitable for drug testing. Laura (a perinatal systems integrated physiologist) uses the data collected from a fetal sheep model to critique the capacity of the model to provide the best clinical data that can be used for treatment of newborns. These research accounts provide evidence of the power of narrative analysis to provide examples of the private language and personal experiences of science knowledge development rather than a bland edited scientific explanation. By using this analysis a narrative can be constructed that provides an opportunity for Nature of Science components to be illustrated through a scientist’s voice.
In the meantime, education has stayed in education but has not been successful in practice. Education was different from the context of one's life, and education could not be used to solve life problems. Learners could not change their surroundings, which soon led to skepticism of education. To overcome these limitations, recent education emphasizes “action”. This is different from “behavior” in behaviorism. Action should be self-directed, research-informed, and meaningful. Action is also emphasized in science education. Beyond understanding scientific knowledge, it requires direct action in solving social problems. Action is also emphasized in computer education. Rather than simply coding as recipes under the teacher’s guidance, it requires the creation of artifacts for solving social problems. In this study, we developed a STEAM education program that combines scientific action with computational action to foster science-computing action. Computing plays a role in expanding the ability of actors in scientific action. We use computing to collect, analyze, and share these findings with others. The program is expected to foster the science-computing action competence and the computational thinking essential for future citizens.

**Keywords:** STEAM, computational thinking, computing, computer education, action competence, scientific action, computational action
Cultivating Filipino students’ submicroscopic understanding of a single replacement reaction via sketching and feedback synergism

Paper presentation

GARRY D. GALVEZ*, PhD Candidate, Presenter and Corresponding Author, gg48@students.waikato.ac.nz

MAURICE M.W. CHENG, PhD*, Associate Professor and Research Supervisor, Co-author maurice.cheng@waikato.ac.nz

* The University of Waikato, Hamilton, New Zealand

The ability to move between the three levels of representation, i.e., macroscopic, submicroscopic and symbolic (Johnstone, 1997) is the central tenet of chemical thinking. Yet, this remains a challenge for students (Taber, 2018). They need mediation to help them cultivate such crucial ability. This paper presentation will demonstrate the synergistic effects of using sketching and feedback as teaching-learning strategy in cultivating students’ submicroscopic understanding of the reaction between magnesium and copper (II) chloride.

Participants were Grade 11 STEM students taking General Chemistry 1 during the first semester of academic year 2018–2019 together with their teacher from a laboratory high school in the Philippines. Two classes were randomly assigned in either of the two experimental group conditions: teacher-feedback and peer-feedback. Both groups performed practical work, sketched their submicroscopic understanding, and received feedback either from their teacher or peers.

Results show that students in the teacher-feedback group have better quality of revised sketches compared to those in the peer-feedback group. Also, the teacher and the student-peers exhibited distinct feedback contents and moves, which can account for the difference in the quality of their revised sketches. This study reveals a way that was likely to promote better learning from sketching.

References:


Primary Teacher Science Education Online Laboratory Portfolio Activity Enhances Confidence and Engages Learners in Online and On-campus Learning Environments

Paper presentation

David Geelan, School of Education and Professional Studies, Griffith University
d.geelan@griffith.edu.au

Portfolio assessment is often proposed as a more metacognitive approach to facilitating, collecting and assessing evidence of students’ learning activities. 7116EDN An Inquiry Approach to Science is a science teacher education course offered as part of Griffith University’s Master of Primary Teaching degree. It is offered in both online and on-campus modes. Online students complete experiments at home, while on-campus students attend laboratory sessions. In summer semester 2019-20, rather than a paper lab book, a web-based portfolio using PebblePad software was used by both student groups to record and reflect on their experiences and the results of the experiments. Each week students completed a ‘Collection’ of Assets – video, audio, text, presentations, spreadsheets and other media – which constituted their lab report. After 6 weeks, student completed a Portfolio, which was a selection from among all the Assets generated, along with some reflective text about what had been learned and about their development of Science Understanding, Science Inquiry Skills and Science as a Human Endeavour. Participating students enjoyed their experiences and reported increased confidence to teach science and a more inquiry-focused understanding. This paper is focused on benefits and lessons learned from this educational innovation in primary science teacher education.
Teachers’ perceptions of creativity in primary and secondary science: similarities and differences

Paper presentation

Helen Georgiou helengeo@uow.edu.au
Annette Turney aturney@uow.edu.au
University of Wollongong

It is well known in the creativity literature that ‘creativity’ is difficult to define. Studies have shown that individuals’ interpretations of creativity differ by context, cultural background and individual differences. As we move to a new era in education where creativity is a central aim, understanding current perceptions is crucial, particularly the nuances that cannot be captured in survey data. In this study, we interviewed six teachers, three each from primary and secondary contexts, to explore perceptions about creativity in the teaching and learning of science. Thematic coding reveals a range of views related to the perceived importance of creativity, the understanding of its nature and what creativity looks like in the classroom, with some differences noted across the primary and secondary samples. These findings will have implications for the work needed to translate idealised goals related to creativity into teaching and learning in science classrooms.
Learning about science in society: A case study of learning processes from student participation in citizen science

Paper presentation

Yaela N Golumbic & Alice Motion
School of Chemistry, Faculty of Science, Sydney University
yaela.golumbic@sydney.edu.au; alice.motion@sydney.edu.au

Science has not developed in a vacuum. It is influenced by social and cultural norms, political values and financial considerations. While this notion may be evident to researchers and scientists, it can be a difficult concept for non-scientists to recognise and relate to. In this paper, we aim to investigate some processes involved in learning about the complexity of science through student participation in Breaking Good - a citizen science project that engages high school and university students in chemistry and health research.

Using interviews, questionnaires and guided conversations we examine learning processes and outcomes that support a broad understanding of science and its complexity; facilitating fruitful engagement with science and informed decision making. We discuss issues related to equity in science and access to health systems and medication, as students engage in synthesis of new molecules designed for health applications. The results of this research provide insight into the processes of learning and engaging with science through hands-on, real life, active investigation. It highlights the potential of citizen science to contribute to high-level learning and increased understanding of the nature of science.
Examining the inclusive perspectives and practices of Canadian science teacher educators

Paper presentation

Karen Goodnough, Memorial University of Newfoundland, kareng@mun.ca
Saiqa Azam, Memorial University of Newfoundland, sazam@mun.ca
Todd Milford, University of Victoria, tmilford@uvic.ca
Christine Tippett, University of Ottawa, ctippett@uottawa.ca

A critical avenue for the improvement of inclusive science teacher education is studying the work of science teacher educators, who play a key role in preparing future science teachers. In turn, these prospective teachers need to develop the necessary abilities and skills to create inclusive learning environments for K-12 children. In this proposal, the authors will report on the first year of a study that examined the perspectives and practices of Canadian science teacher educators (STEs) as it relates to inclusive science education. While a substantial body of research focuses on inclusive education and teacher education, a limited body of research exists on the teaching and work of STEs and inclusion (Atwater, Butler, Freeman, Carlton Parsons, 2013; Koomen, Kahn, Atchison, & Wild, 2018).

Questionnaire data from 30 STEs were analyzed. Outcomes focus on three broad themes: STEs’ views of inclusion, STEs’ inclusive pedagogical perspectives and practices, and factors that enhance or hinder the adoption of inclusive practice in initial teacher education. Detailed examples illustrating each theme will be shared with the audience.

References
Science and Religious Education Teachers’ Views of the Comparison of Argumentation in Science and Religion

Paper presentation

Liam Guilfoyle, Sibel Erduran, & Wonyong Park, Department of Education, University of Oxford, liam.guilfoyle@education.ox.ac.uk

Everyday citizens often face problems and dilemmas about which they need to make decisions and choices that impact their everyday lives. Some of these issues are related to the interplay of science and religion. Students’ acquisition of argumentation skills has thus emerged as a significant educational goal. Although curriculum standards of school subjects such as science and religious education (RE) include references to argumentation, and teachers are expected to teach to these standards, there is often limited opportunity for teachers of conventionally disparate subjects to express their understanding of how argumentation is broadly conceptualised relative to other school subjects. The primary purpose of this paper is to investigate how science and RE teachers view the nature of argumentation in science and religion, particularly how argumentation is different or similar between them. The data sources are responses from 16 science and 17 RE teachers to a survey consisting of 6 questions analysed for teachers view argumentation in science and RE. The findings include indications that teachers do not view their subjects in conflict. Instead, teachers describe both distinguishing features (such as the forms of evidence acceptable for substantiating a claim) and similarities (such as the structures and processes of argument construction).
Harnessing the power of talk: Interplay of teachers’ dialogic scaffolding practices and students’ expressions of argumentative agency

Paper presentation

Sally Barica Gutierrez\textsuperscript{1,2} and Heui-Baik Kim\textsuperscript{1}
sbgutierrezupd@snu.ac.kr, sbgutierrez@up.edu.ph, hbkim56@snu.ac.kr.

\textsuperscript{1}Department of Science Education, College of Education, Seoul National University, South Korea
\textsuperscript{2}University of the Philippines National Institute for Science and Mathematics Education Development

Focusing on the importance of the social aspect of learning, argumentation necessitates an enterprise of inquiry that is dialogically co-constructed by both the teacher and the students. This case study examined the dynamic interplay of two high school biology teachers’ dialogic scaffolding practices and their students’ expressions of argumentative agency. Following the constant comparison method of analysis, results of the thematic analysis on each teacher’s five lesson transcripts showed their unique dialogic scaffolding practices in the contingency and fading phases of their argumentative discussions. Teacher 1 used appropriation strategies by: 1) building abstract concepts from students’ prior knowledge and experiences, and 2) providing contextualized scenario-based issues and students responded by sharing their personal experiences. Teacher 2 on the other hand, used negotiation strategies by: 1) offering neutral statements as prerequisites for integrative negotiation, and 2) converging disparate ideas leading to collective consensus. Students’ response was presenting two-sided stances. In the fading phases, Teacher 1 popularized the science content and students responded by identifying the place of the science concepts to their daily lives. Teacher 2 used power distribution of discursive ideas and in response, the students valued turn-taking during their dialogic exchanges.
A Present Future: Interrogating ‘Sociotechnical Imaginaries’ through Science Education

Paper presentation

El Halwany, S., Zouda, M., Milanovic, M., Hassan, N., Rahman, S., and Bencze, L.

This is a theoretical paper that highlights notions of ‘sociotechnical imaginaries’ (Jasanoff, 2015) from fields of Science and Technology Studies (STS) that seem relevant to science education aimed at preparing critical and activist citizens. We extend our discussion to fields of future studies in science education to argue that a needed direction is not merely to get students to imagine desired (often personalized) futures (especially given social and environmental harms), but to interrogate how products of science and technology seem to delimit kinds of future we ought to desire. That is, technoscientific futures are not just ‘out there’, but are already present, actively fashioning current practices and values. Drawing from STS literature, we demonstrate how ‘sociotechnical imaginaries’ are enacted through two technoscientific products that have become more or less ubiquitous, self-tracking devices and algorithms. Roles of material technologies in normalizing moral and political visions and orientations need to be explicitly addressed if students are to act for more socially and environmentally just futures. Moreover, such discussions may offer fields of future studies in science education tools to overcome perceptions of individualized futures. We hope this paper initiates discussions around merits, challenges and vehicles for bringing such views into science education.
Discrete emotions of Year 8 students during role play in a middle years science classroom

Paper presentation

Senka Henderson & Donna King, Queensland University of Technology
s10.henderson@qut.edu.au
d.king@qut.edu.au

This study builds on our previous work where specific science activities, such as demonstrations and laboratory activities, evoked students’ positive emotional responses and focused students’ attention on the science content they were learning. We were interested in students’ discrete emotions in a Year 8 science class expressed during a role-play activity in a Biology unit on skin burns. Two groups of students from the class are presented as cases. Drawing on multiple data sources, including classroom video recordings, observations of the classroom, thinking prompts, field notes and emotion diaries completed at the end of each lesson, the analysis gave us insights into individual student’s emotions. Using a theoretical perspective drawn from theories of emotions, we have identified that students expressed the emotions of happiness, joy, pride and enthusiasm during the role play. These positive experiences aligned with a high interest score reported by students when the class results were averaged. Importantly, the thinking prompts which were written before and after the role play, showed evidence of students’ learning and understanding of the science concepts related to skin burns. This study suggests that role play can be used successfully as a teaching strategy in the middle years contributing to a student’s positive association with science.
A new frontier in secondary science education: Teaching scientific research to high school students.

Paper Presentation

Matthew Hill, Alison Gates & Katie Terrett
Barker College
mhill@barker.nsw.edu.au, agates@barker.nsw.edu.au, kterrett@barker.nsw.edu.au

Science Extension was offered in the NSW HSC for the first time in 2019. This innovative new course posed a fresh set of challenges for secondary Science teachers. Based around a high level individual research project, culminating in a 3000 word scientific report, the course demands that teachers step from their classroom and into the world of research supervision. This paper presentation uses literature and ethnographic methodology to report on the challenges and benefits of amalgamating university-level research and supervision in a high-school context. From our unique perspective as teachers that have transitioned from postgraduate research and academic appointments to the secondary classroom, we feel positioned to contribute to this frontier in science education. Our research includes a review of the literature on undergraduate research supervision at the tertiary level to inform perspectives on equipping science teachers to meet the demands of this course. By drawing on this research and using an ethnographic frame to explore our own teaching experiences, this research identifies crucial skills in undergraduate research supervision and explores how these might translate into secondary settings. We provide a rationale for resourcing and developing specialist supervision skills in secondary science teachers.
Principal attitudes towards out-of-field teaching

Paper presentation

Linda Hobbs, Deakin University, Australia, lhobbs@deakin.edu.au
Raphaela Porsch, University of Magdeburg, Germany, raphaela.porsch@ovgu.de

Principals generally have oversight over what teachers are assigned to teach and often have no choice but to ask teachers to teach science and other subjects out-of-field. Research has shown that decisions about the allocation of teachers are often made on the basis of ill-informed understanding of the effects of out-of-field teaching on teachers’ well-being and their students. Little investigation, however, has been carried out examining the various attitudes that principals might have to this practice. This study investigates principal attitudes and school practices in relation to the out-of-field phenomenon, as well as any indicative differences between two countries, Australia and Germany. A qualitative multiple case study was conducted using data generated from projects in both countries focusing on systemic conditions influencing out-of-field teaching. Data included seven interviews conducted with a small set of secondary school leaders from Australia and Germany. A content analysis of the interviews identified two themes: (1) Principals’ attitudes towards teaching out-of-field; and (2) Principal’s views about how to support the learning of out-of-field teachers. Across all cases there were four distinct attitudes based on how they position the content knowledge and teaching: teaching as pedagogical, teaching as passion, teaching as capability and teaching as specialised. This positioning of content knowledge in relation to other teacher characteristics was seen to influence the type of support provided or promoted within the school.
Tech Schools Evaluation: Applying An Innovation Framework

Paper presentation

Linda Hobbs, Deakin University l.hobbs@deakin.edu.au
Peta White, Deakin University peta.white@deakin.edu.au
Seamus Delaney, Deakin University s.delaney@deakin.edu.au
John Cripps Clark, Deakin University john.crippsclark@deakin.edu
George Aranda, Deakin University george.aranda@deakin.edu.au
Chris Speldewinde, Deakin University christopher.speldewinde@deakin.edu.au
Bronwyn Sutton, Deakin University b.sutton@deakin.edu.au

In 2015 the Victorian Government established the Tech Schools Initiative. Each of ten Tech Schools in metropolitan and regional Victoria are unique in their approaches to learning program development and how they work with partner schools and local industry. A Tech Schools Evaluation (TSE) will provide a standardised evaluation process that can be used in the short- and medium-term to monitor, evaluate and inform the ongoing operations and strategic development of the Tech Schools Initiative. In this presentation we will outline the methodology used for this evaluation. Drawing on Jäger’s (2004) wave model of innovation, an Innovation Framework was developed to provide for an Impact analysis (focusing on the outcomes) and Ecosystem analysis (focusing on the conditions needed for innovation to occur). The three factors of the wave model facilitate analysis of the ‘ripples’ of the TS initiative by focusing on the content, structure and people involved. A suite of evaluation tools generate data pertaining to the impact of the Tech Schools overall as well as in-depth data pertaining to a selection of the Tech Schools to produce a set of case studies. This methodology enables analysis of the conditions under which the different Tech Schools progress and achieve their outcomes.
The Development and Effects of an Inquiry-based Early STEM Curriculum on Taiwanese Kindergarteners’ Science and Engineering Practices

Paper presentation

Ching-Ting Hsin (cthsin@gapp.nthu.edu.tw)
Department of Early Childhood Education, National Tsing Hua University, Taiwan
Hsin-Kai Wu (hkwu@ntnu.edu.tw)
Graduate Institute of Science Education, National Taiwan Normal University, Taiwan
Faculty of Education, University of Johannesburg, Johannesburg, South Africa
Sung-Pei Chien (cellist13@cc.ncue.edu.tw)
Graduate Institute of Science Education, National Changhua University of Education, Taiwan

STEM education has become a growing priority in primary and secondary education levels whereas little research has been done in kindergarten. The purpose of this study thus was twofold: to develop an inquiry-based early childhood STEM curriculum and to examine the effects of the curriculum on children’s science and engineering practices. We developed the curriculum by drawing upon policy documents and theories of project-based science and project approach in early learning. The curriculum contained four learning lessons guided by investigation questions and took up 19 class periods. We recruited 98 children (average age: 5.6 years old). Among them, 53 were from two kindergartens in cities, and 45 from three kindergartens in indigenous villages in Taiwan. A performance-based assessment regarding science and engineering practices was applied before and after the curriculum. Results of Rasch analysis and paired t-tests showed that both the city (mean difference: 1.05 logits, $t(52)= 13.69, p < .001, ES = 1.57$) and the village groups (mean difference: 0.89 logits, $t(44) = 11.91, p < .001, ES = 1.33$) had significant better performances after engaging in the curriculum. The results suggest that the curriculum could promote children’s STEM practices and support learning of children with different sociocultural backgrounds.
The Relations between Epistemic Beliefs, Metacognition, and Self-Regulated Learning of Science Learning: A Review of Studies from 2010 to 2019

Paper presentation

Ching-Sui Hung1  Hsin-Kai Wu2, 3
1Taipei Municipal Heping High School
2Graduate Institute of Science Education, National Taiwan Normal University
3Faculty of Education, University of Johannesburg, Johannesburg, South Africa

Author 1 (student): Ching-Sui Hung  (email address : sui20120401@gmail.com)
Author 2 (supervisor): Hsin-Kai Wu   (email address : hkwu@ntnu.edu.tw)

The impact of epistemic beliefs on learning is an issue continuing to attract research attention. Some psychologists indicated that epistemic beliefs exert their influence on learning through variables of metacognition and self-regulation learning. However, little is understood about the relations between the elements of epistemic beliefs (EB) and those of metacognition (MC) or self-regulated learning (SRL). We thus conducted a systematic analysis of 32 empirical papers published from 2010 to September 2019 in the Scopus database. The analysis focused on the research designs, theoretical bases, and the relations between EB and MC or SRL of these studies. The findings indicate that the most adopted EB model by the papers (43%) were the ones proposed by Hofer and Pintrich. As for MC or SRL, most studies were based on the work of Pintrich (20%) and Muis (20%). Regarding the relations between EBs and MC, participants with more “sophisticated” EBs demonstrated greater metacognitive knowledge and skills. Similarly, they employed more effective strategies, had stronger motivations, and demonstrated more positive emotions during the processes of SRL. Nevertheless, there is a lack of studies exploring MC knowledge, MC experiences and the enactment phase of SRL. Finally, suggestions for future research are provided.
“What counts as scientific?” Teachers’ understanding and views of scientific methods

Paper presentation

Olga Ioannidou, Department of Education, University of Oxford olga.ioannidou@education.ox.ac.uk
Sibel Erduran, Department of Education, University of Oxford Sibel.Erduran@education.ox.ac.uk

Scientific pluralism is one of the core concepts of “how science works”. Recent reforms in science education have promoted the appreciation of various scientific methods (e.g. NGSS Lead States, 2013). However, although science teachers are expected to teach beyond “the scientific method”, there are only a few studies examining teachers’ understanding of scientific inquiry (Schwartz et al., 2008) and scientific methods, in particular. This study aims to fill this research gap by examining the level of teachers’ understanding, as well as their views on scientific methods. To answer these questions, fifty-six (N=56) science teachers (25% male, 75% female) in the UK were surveyed. Two tasks were developed using Brandon’s Matrix as a theoretical framework. Descriptive statistics were performed revealing that, although the majority of the teachers (73%) showed a satisfactory level of understanding, more than half of the sample held naïve views of scientific methods (e.g. 57% agreed that “there is a universal scientific method that scientists follow”). These results highlight teachers’ misconceptions regarding “what counts as scientific” and have implications to the design of teacher training programmes. Furthermore, the study discusses the use of heuristics, such as Brandon’s Matrix, as the conceptual basis for the design of research instruments.
Predicting genuine learning interest in ethics-related socio-scientific issues (E-SSI)

Paper presentation

Brady Michael Jack
National Sun Yat-sen University
bradyjack@gmail.com

Genuine learning interest is a fundamental predictor of students’ authentic attitudes toward learning science-related content. Researchers investigated how latent factors of moral judgment are affected by textbooks (civics and science), media news, and student enjoyment from learning ethics-related socio-scientific issues (E-SSI) predicatively effect learning interest in E-SSI. Data from five participating metropolitan high schools in a southern Taiwan city were collected. Confirmatory factors analysis among the latent model predictors revealed good structural and convergent validity, and good model fit to the data. Results revealed (1) moral judgments affected by textbooks and media news have a partial indirect impact on learning interest in E-SSI; and (3) learning enjoyment directly predicts learning interest in E-SSI. This study concludes from these results the notion that learning enjoyment from E-SSI is a required precursor for awakening and sustaining genuine learning interest in E-SSI both inside and outside the science classroom.
How are Pre-service Teachers developing their espoused theories and theories-in-use to motivate science students in the lower secondary school years?

Paper presentation

Davis Jean-Baptiste, (PhD candidate, Davis.L.JnBaptiste@student.uts.edu.au)
Kimberley Pressick-Kilborn, (PhD Supervisor, Kimberley.Pressick-Kilborn@uts.edu.au)
Matthew Kearney, (PhD Supervisor, Matthew.Kearney@uts.edu.au)
University of Technology Sydney

Previous research internationally has documented the decline in motivation for learning science among school students, particularly at the lower secondary level. The Australian Professional Standards for Teachers indicate that teachers need to ‘know students and how they learn’; this includes knowing how to design engaging learning experiences to motivate students. As established in previous studies, the beliefs and professional identities of preservice teachers (PSTs) are particularly open to change. There has been limited research to-date, however, that has investigated PSTs’ beliefs about, and use of, strategies for motivating lower secondary students to learn science. Furthermore, the specific role that Professional Experience placements play in shaping PSTs’ beliefs and strategy use in relation to student motivation to learn science has not been examined. In phase one of our research study, 70 Australian secondary science PSTs responded to an online survey. The survey focused on PSTs’ beliefs about effective ways of motivating science students and the strategies they had previously used, and/or intended to use, during Professional Experience placements. In phase 2 of our study, case studies were conducted with 3 secondary science PSTs and their supervising teachers to more deeply investigate their beliefs about motivating students (individual interviews) and to observe the strategies used in lessons during their Professional Experience placements to motivate students (participant observations and lesson plan analysis). In this presentation, we will focus on one case; “Paula”, from phase 2 of the research to illustrate some of the emerging themes. Preliminary findings suggest that the participating PSTs’ beliefs about motivating students originated from their own school experiences as well as from observing other teachers teach. Moreover, although the PSTs gave responses that were in line with social constructivist approaches concerning strategies that can be used to motivate students, some gave responses that deviated from widely accepted contemporary approaches to teaching science.
Building Leadership for change in STEM through mentoring Kingdom of Saudi Arabian teachers

Paper presentation

Sarika Kewalramani, Monash University, sarika.kewalramani@monash.edu
Megan Adams, Monash University, megan.adams@monash.edu
Rebecca Cooper, Monash University, rebecca.cooper@monash.edu

This study aligns with the recent global need to find effective ways to build teacher capacity to manage the growing adaptive challenges faced in relation to Science Technology Engineering and Mathematics (STEM) integration. The study reports on a program that sponsored teachers (N=50) from the Kingdom of Saudi Arabia (KSA) to live in Australia for one year. The aim was to build leadership for change through immersion in a STEM professional learning program in Australia. Drawing on Clarke and Hollingsworth (2002) framework of teacher professional growth, we report on findings related to the transformation of teachers’ understanding in their attitudes and confidence, evolving STEM integration pedagogical knowledge and leadership skills after the immersion program. Employing a multiple case study approach, data includes individual semi-structured interviews with KSA teachers (N=5) and artefact analysis of the teachers’ Capstone projects. Analysis showed that although novice in their own STEM pedagogical knowledge, the teachers engaged and co-learnt together with their peers and university mentors. The teachers identified concerns around language barriers such as; meaning making and adapting and transferring STEM pedagogical knowledge skills into their KSA classroom contexts. Implications in relation to the design of such trans-national immersion programs are also discussed.
In Dialogue with Nature – A classics reading approach to nurture epistemic insight in a multidisciplinary and higher education context

Paper presentation

Kai Ming Kiang
Office of University General Education, The Chinese University of Hong Kong, Hong Kong

In this study, we argue that classics reading, a traditional way of implementing general education, can be effective in nurturing epistemic insight in a multidisciplinary arena in the higher education context. We think that epistemic insight is at the core of scientific literacy. The General Education Foundation Programme in The Chinese University of Hong Kong, which required students to read science-related classics, was studied. The ways in which these classics are used to nurturing epistemic insights are explained. Evaluation results show that the programme is in general well received by the students and is effective in nurturing epistemic insight. We hypothesized that the success is due to the underlying presence of what we call the nature-knowledge-value framework. This framework helped the students not just to be aware of the possibilities of different views related to science, but to understand and reflect on the origin, the inter-relationship, the complexity and the limitations of these views. It is expected that this result can be insightful for developing innovative ways for nurturing epistemic insight.
Transgressing boundaries: Developing attitudes and actions for sustainable development

Paper Presentation

Gillian Kidman
Monash University
E-mail: gillian.kidman@monash.edu

As the world faces potentially catastrophic environmental and health issues, we hear calls for Sustainability: the ability to maintain healthy environmental, social and economic systems in balance, indefinitely, on a global and local scale. To meet these calls, we also hear the call for improved ways to integrate knowledge from all perspectives, and use it for a better world. To achieve this we need collaboration between university, government and industry domains. Importantly, we also need improved educational practices to ensure we have informed citizens and a next generation of researchers with the ability to think and work in transdisciplinary teams. In this presentation, I will explore the nature of this improved Education for Sustainable Development and the links it has with STEM Education. Consideration needs to be given to how we educate so that disciplinary boundaries are transgressed; so that we build on our existing knowledge, seek out new knowledge and skills, make connections between our prior knowledge and the challenges we encounter, and to learn from our experiences. Thus we need a transdisciplinary approach to education for sustainable development that is both an attitude and a form of action.
Development and validation of an instrument to assess STEM students’ perceptions of Classroom Emotional Climate

Paper presentation

Rekha Koul – R.Koul@curtin.edu.au; Felicity McLure - Felicity.Mclure1@curtin.edu.au; Barry Fraser – B.Fraser@curtin.edu.au, Curtin University, Perth

In order to engage more students in Science, Technology, Engineering and Mathematics (STEM) subjects, schools are encouraged to introduce students to STEM through projects integrating skills from each or some of the STEM disciplines. However, little is known about the STEM classroom emotional climate and its effect on students’ attitude to STEM. In an attempt to understand these relationships, in the first phase of this project, a questionnaire was developed based on Ferguson (2010) constructs, to be widely applicable in probing student perceptions of the STEM Classroom Emotional Climate (CEC). The questionnaire was tested with six focus groups to determine student comprehension of items and applicability to students’ experience in STEM classrooms. The modified CEC questionnaire was then tested with 698 students from 20 schools and analysed using principal component analysis, Rasch analysis and confirmatory factor analysis techniques to determine the structure and validity of the CEC survey. The resulting 41 item CEC was found to satisfactorily model 7 dimensions describing student perceptions within the STEM classroom and revealed significant correlations with students’ attitudes to STEM as measured with the 10 item Attitudes scale. The CEC questionnaire provides insight into interaction between factors in STEM classrooms, attitudes towards STEM projects and intentions to continue studying STEM subjects.
Designing Problem-Centric STEM Activities

Paper presentation

Roxanne Lau Shu Xin, National Institute of Education, nie184289@e.ntu.edu.sg
Tan Aik-Ling, National Institute of Education, aikling.tan@nie.edu.sg

Abstract – In the 21st century where skills application and knowledge integration are prized, there is strong advocacy to include Science, Technology, Engineering and Mathematics (STEM) education in many education models. The goal of this study is to examine teacher’s and students’ questions raised as they engaged in a problem-centric STEM activity. We designed a science and engineering-focused activity on the theme of photosynthesis and agricultural engineering. The first of the three-lesson series was conducted by a science teacher, who had gone through a professional development course on STEM teaching, to a class of 19 secondary-two express students. Data sources include a video of the lesson that was directed at the whole class, a video of a randomly chosen group during group problem-solving, transcripts of the videos, and students’ notes. From the transcript, teacher’s and student’s questions were categorised and tabulated. Findings show that Socratic questioning was most frequently used by the teacher in the problematising phase. Productive questioning and making real-world connections allowed the class to effectively understand the problem. During group-problem solving and the design process, students raised mainly clarification, generic task-procedural and specific task-procedural questions. By looking at students’ thought processes, we found evidence of informed design patterns.
Exploring elementary teacher’s challenges with the perspective of structure and agency when first implementation of Social Action-Oriented SSI education classes in Korea

Paper presentation

Sung-Eun Lim1, Jong-Uk Kim1, and Chan-Jong Kim1*
1 Seoul National University
*E-mail: chajokim@snu.ac.kr

Human beings are forced to fight global environment issues. Vision III of Scientific Literacy is focused on the scientific participation, knowledge in practice, and socio-political action needed for climate change education. However, only a few programs have focused on authentic “social action-oriented” SSI education (SAO-SSIE). The major objectives of this study are 1) What are the structures when a teacher face challenges in SAO-SSIE classes? and 2) How does teacher agency emerge when facing the challenges?

An elementary school homeroom teacher and 13 sixth graders participated in SAO-SSIE from March to July 2019. Semi-structured interviews with the teacher and students, the teacher’s reflection notes, and videotaping and audio recordings of the classes were collected. The theoretical rationale is based on the structure and agency dialectic perspective. We conceptualized the classroom (micro), school (meso), and society (macro) as three fields. Major structures identified were students' lack of belief and experience in SA, school culture, the underdevelopment of learning communities among teachers, the lack of awareness of SA in society, and insufficient support for the reorganization of the curriculum in terms of time and resources. The implications of the study for teachers, school administrators and policy makers for implementing SAO-SSIE were discussed.

Keywords: structure & agency, social action-oriented SSI education, climate change
*Supervisor: Chan-Jong Kim(chajokim@snu.ac.kr)
Student understanding of scale in astronomy

Paper presentation

Christine Lindstrom\textsuperscript{1}, Vinesh Maguire-Rajpaul\textsuperscript{2}, Megan Engel\textsuperscript{3}, Sam Wait\textsuperscript{1}, and James L Thomas\textsuperscript{4}
\textsuperscript{1}School of Physics, UNSW Sydney, Australia
\textsuperscript{2}Department of Physics, University of Cambridge, UK
\textsuperscript{3}School of Engineering and Applied Sciences, Harvard University, USA
\textsuperscript{4}Department of Physics, University of New Mexico, USA

Email of presenting author: c.lindstrom@unsw.edu.au

Appreciating astronomical scale is essential for understanding the foundations of astronomy. However, the lack of direct ways to acquire this knowledge presents a challenge. Personal experience may even be detrimental, given that our direct experience is of the Earth as something very large, whereas stars are tiny pinpricks of light. To address this issue, it is first necessary to assess people’s knowledge of astronomical scale to identify common misconceptions. Previous instruments have generally only included a few questions about scale—mostly through multiple choice—limiting the number of objects simultaneously probed to three and often not probing all possible rankings. Consequently, we developed an instrument that allows for easy collection, analysis and presentation of data ranking multiple objects (we included up to ten objects). I will present this instrument and the disconcerting results from administering the survey to the population of first year students taking a course in introductory astronomy at the University of New Mexico, USA. The pre-test data (N = 205) revealed that 29\% of students believed planets to be bigger than stars, and 53\% believed stars other than our sun to reside within our solar system. The post-test data is currently being analysed.
The influence of career advice and perceptions on girls’ physics identity and subject choice

Paper presentation

Author: Adam Masri
PhD student at Deakin University
a.masri@deakin.edu.au
Supervisors: Principal: Dr Trace Ollis, Associate: Prof. Russell Tytler, Dr Cheryl Ryan

The gender gap within physics-related careers, which tend to provide better pay than female-dominated careers, contributes to the overall national gender pay gap leading to less financial security among women. The gender gap, which starts to be evident in senior school physics enrolments, reflects the failure of the education system to challenge embedded stereotypes. Family, teachers, peers and wider sources of career representations and advice are among the influences on girls’ physics identity and hence on their subject choice. This presentation aims to investigate the perceived usefulness of career advice and representations delivered by physics teachers and career advisors, and to evaluate the quality of career advice based on literature and data from this research. The research question is: “What is the influence of career advice on shaping girls’ perceptions regarding studying physics and pursuing physics as a future career?”

A Mixed Methods Research approach is employed to collect data from students, physics teachers and career advisors. This research is part of a PhD thesis that is still in progress. Preliminary results show inconsistency in career advice given in schools. Results also reveal the complex effects of gendered stereotypes and their influence on girls’ physics identity and their subject choice.
How Recent Community College to University Transfer Students Experience Supported Science & Engineering Internships

Paper presentation

Shana L. McAlexander1, 2 (slmcalex@ncsu.edu), Katherine R. McCance1 (krmccanc@ncsu.edu), Margaret R. Blanchard1 (Student Research Advisor, Meg_Blanchard@ncsu.edu), Richard A. Venditti2 (Student Research Co-advisor, richard_venditti@ncsu.edu)

1Department of STEM Education, North Carolina State University
2Department of Forest Biomaterials, North Carolina State University

While little is known about the experience of transfer students as they engage in internships, we do know that they face academic, social, and personal challenges during the transition to a new institution (Laanan, 2001; Townsend & Wilson, 2006). At the same time, lack of funding for internships has led to participation based on economic means (Edwards & Hertel-Fernandez, 2010). Thus, in order to increase academic success and economic mobility, it is critical to understand the student experience and barriers and support at play in their career development. This narrative case study investigates the role of funded science/engineering internships for 5 transfer students as they transition from community college to four-year institutions. Data sources include interviews about student career journeys and discussions of barriers and supports, drawing from social cognitive career theory (Lent, Brown, & Hacket, 2000). This study finds that the internship experiences bolstered student career confidence, allowing them to feel on-track with their university peers. Family and program administrators were considered frequent sources of support, while transportation and lack of technical skills were most often identified as barriers or challenges. Addressing these supports and barriers in career development experiences will help advisors and academic programs in serving transfer student populations.

References

Graduate Students’ Perceptions of Participating in a
Science/Engineering and Education Interdisciplinary Collaboration: Developing Community and Navigating Boundaries

Paper presentation

Katherine R. McCance (krmccanc@ncsu.edu) and Dr. Margaret R. Blanchard (Research Advisor, Meg_Blanchard@ncsu.edu)
Department of STEM Education, North Carolina State University

Collaborating on interdisciplinary teams and integrating knowledge from different fields is believed to help us solve society’s most complex problems. Research has explored characteristics of successful interdisciplinary collaborations between STEM and Education faculty. However, graduate students’ participation in these collaborations has not been studied. Informed by Communities of Practice, this qualitative case study investigates science/engineering graduate students’ perceptions of participating in a 4-year grant-funded interdisciplinary collaboration between a STEM Education and a Science/Engineering Department, who co-developed science/engineering online courses and high school activities. Interviews and member checks with seven graduate students and the grant’s Program Manager were analyzed using constant comparative, thematic analyses and triangulated with team meeting recordings, observations, and field notes. Six key features of the interdisciplinary collaboration emerged: 1) sharing common grant goals, 2) maintaining clear objectives and structure, 3) combining diverse perspectives, 4) developing relationships, 5) communicating inclusively, and 6) negotiating to improve. The graduate students believed the collaboration resulted in department-wide impacts, enhanced team performance, and changes in their personal understanding and skills in education and science/engineering. Challenges including a lack of transparency and coordination within the team were identified and addressed with the help of a broker who spanned both disciplinary languages.

References
Measuring stuff: A big idea bridging science and mathematics education in primary school

Paper presentation

Dr Heather McMaster, University of Sydney, Email: heather.mcmaster@sydney.edu.au

Ms Leane Senzamici, University of Sydney, Email: lsen6892@uni.sydney.edu.au

Two important issues concerning the integration of mathematics and science in STEM education are the inadequate coverage of core disciplinary content and the need to focus on ‘big ideas’ across disciplines. One big idea underlying the content of mathematics and science in the primary school, is the idea that everything in our material world has both mass and volume, that these are separate attributes that can be measured. In the Australian K-6 curriculum, this idea is split between Science, which is primarily concerned with the properties of materials, and Mathematics, which is primarily concerned with the measurement of objects. In-depth task-based interviews with six 11 to 12-year old children revealed confusion between basic measurable attributes of materials and objects. In addition, the interviews revealed ambiguities in the language used to describe these attributes. Integrating measurement of the material world across science and mathematics could limit the formation of alternative conceptions and has the added advantage of enabling students to experience real world connections in their learning of mathematics.
‘We do STEM as well’: the role of Vocational Education and Training in Australia’s STEM workforce development

Victoria Millar (vmillar@unimelb.edu.au), Melbourne Graduate School of Education, University of Melbourne
Kira Clarke, (kirac@unimelb.edu.au), Melbourne Graduate School of Education, University of Melbourne
Lucy Robertson (lucy.robertson@unimelb.edu.au), Melbourne Graduate School of Education, University of Melbourne

STEM has been identified as important for knowledge economies around the world (Wong, Dillon & King, 2016). Jobs requiring STEM are projected to grow at 1.5 times the rate of non-STEM jobs (Department of Education, 2017). As such a number of Australian policy papers have highlighted the need to invest in STEM education as a way of attracting and retaining students in STEM (Office of the Chief Scientist 2016; Innovation Agenda 2015). Largely absent in such papers however is that 68% of this STEM workforce will be vocationally trained (Office of the Chief Scientist 2016) and the role of Vocational Education and Training (VET) in this.

Within this context, this paper addresses two questions. Firstly, in what way is VET participation in STEM changing in response to labour market demand for STEM skills? Secondly, how is STEM participation in VET within the senior secondary system preparing young Australians to access STEM tertiary-level VET programs? Drawing on the work of Korbel (2016) and Siekmann and Korbel (2016), an analysis of the participation trends in STEM related VET programs from 2007-2015 is presented revealing diverging participation trends between vocational STEM pathways in the senior secondary context and the post-school tertiary VET context.
Primary Specialisation in Initial Teacher Education:
Pre-service Teachers’ Lived Experiences

Paper presentation

Reece Mills (Corresponding Author)  Theresa Bourke
Faculty of Education  Faculty of Education
Queensland University of Technology  Queensland University of Technology
Email: reece.mills@qut.edu.au  Email: theresa.bourke@qut.edu.au

The positioning of teacher quality as a global problem in primary education has led to the introduction of ‘primary specialisation’ in Australian initial teacher education programs. This research explores five Master of Teaching (Primary) pre-service teachers’ experiences as they completed a new science specialisation at one metropolitan Australian university. Ball, Braun, and Maguire’s (2012) theorisations around ‘policy enactment’ and Clandinin and Connelly’s (2000) idea of a ‘narrative inquiry space’ are used to make visible pre-service teachers’ experiences of primary specialisations policy enactment along personal-social and past-present-future dimensions. In doing so we give voice to these participants as policy receivers who are rarely heard in the policy process. Findings reveal fourteen themes around the material, interpretive, and discursive facets of primary specialisation policy enactment. A number of challenges are described that contest primary specialisation in its current form and recommendations are suggested for moving the policy agenda and scholarship forward in a productive way.
The Analysis and Solutions of Steam Teacher Education Practice in Taiwan

Paper presentation

Author(s) information: MING, SHIH-YUN, National Tsing Hua University Department of Education and Learning Technology, Doctoral student, happy12517@gmail.com
Supervisor’s name: Dr. Yen, Kuo-Liang

STEAM education is one of a central issue in education all over the world in recent years. The rapid expansion of STEAM education has prompted countries to face new challenges in STEAM teacher education. This study aims to explore how the STEAM teacher education program was implemented in three different cities/counties and to investigate the program features as well as the participation experience of the STEAM teachers. Furthermore, this study analyzes and proposes feasible strategies for STEAM teacher education in the future.

The research adopted a qualitative approach with a multiple case study design. A purposive sampling method was utilized to select the STEAM teacher education programs of the three cities/counties as the cases to be studied. Data were mainly collected through in-depth interviews and document analysis, and a total of eighteen participants were interviewed from the three cities/counties.

This study came to four conclusions: 1. The case study revealed the following features of the STEAM teacher education program: the program is a curriculum design-based, field-practice-oriented teaching; the program is Short-term intensive training, workshop and the credit course planning; the role of the STEAM teacher education has discursively shifted from providing new technology support to providing STEAM teacher education programs. 2. On an individual level, the STEAM teacher education program has improved the aspiring STEAM teachers’ curriculum design capabilities, systematic thinking, and understanding of both the policies and the policy implementation process as well as the ability to use equipment and tools. 3. On a curriculum level, STEAM education is consistent with the concept of competence-oriented curriculum, but the spirit of STEAM education is difficult to implement in the subject and is usually carried out by additional activities, clubs, etc. Cross-curricular teaching is not easy, and student learning effects are limited. 4. On a school level, the STEAM teacher education programs fill the problem of insufficient STEAM teachers and provide much-needed manpower. The STEAM teacher education program is difficult to induce the teaching practice motivation of the remaining teachers' STEAM education concepts, and it is easy to go it alone.

The STEAM teacher education program has been implemented across numerous cities/counties throughout Taiwan over the last ten years. However, before this study, there have been limited domestic or foreign empirical studies that have explored this subject. The findings of this study contribute to the gap in the literature and provide a reference for countries around the world in the future planning of STEAM teacher education programs for teachers.
Enhancing Project-Based STEM Education through Student Participation and Autonomy: Implementing a STEPWISE framework.

Paper presentation

Nurul Hassan, M., El Halwany, S., Schaffer, K. & Bencze, L.

Project-based STEM courses offer an integrative approach for students to build on their math and science base and use engineering and technology to innovate creative solutions to real-world problems. Students’ active engagement and participation are central in actualizing the full potential of the course as well as developing a critical perspective toward what is learned and innovated. This study explores how implementing ‘STEPWISE’ (Science & technology education promoting wellbeing for individuals, societies & environment) (co-author-4, 2017) framework enhance students’ engagement in STEM project course; and how their active participation (if any) leads to critical thinking and problematizing the status quo. This qualitative action research included semester-long participatory observations, individual and small group semi-structured interviews, and document and artifact analysis. This research was conducted in a leading community college that offers STEM programs in Toronto, Canadian. The participants were 23 consenting students in an advanced biotechnology diploma program taught by Author-1. Findings suggest that the STEPWISE framework significantly enhanced students’ autonomy and engagement (e.g., designing and conducting additional survey research) in the course. Students took a more critical stance toward their own learning and, in the process, broadened the horizon of their understanding beyond the domains of science and technology.

Nurul Hassan Mohammad
3rd year PhD student
Curriculum Studies and Teacher Development (CTL)
Ontario Institute for Studies in Education (OISE)
University of Toronto, Canada.
Email: nurul.mohammad@mail.utoronto.ca
Research supervisor: Erminia Pedretti.
Science centres and affective teacher change – an overview of the research and implications for future studies

Paper presentation

Name: Chloë Nelson
Affiliation: The University of Melbourne
Email: chloe.nelson@unimelb.edu.au
Supervisors (PhD): Professor Jan van Driel and Dr Victoria Millar

Science centres are common around the world and are visited by millions of school children and their teachers every year. In Australia, a variety of science centres exist; from public access science centres to science centres focused on delivering education programs to school students and their teachers.

Science teachers interact with science centres in a variety of ways including alongside students on field-trips, accessing resources, and participating in formal professional development programs.

Benefits for children and adults visiting science centres have been demonstrated in the literature, with a focus on affective outcomes (Falk, Needham, Dierking, & Prendergast, 2014). However, research focused on the benefits for in-service science teachers is sparse.

The majority of the literature exploring formal science teacher professional development programs has concentrated on teachers’ cognitive changes. Affective changes for science teachers are starting to be recognised as important factors in science teachers’ ongoing professional growth. Additionally, affective changes are generally considered to influence teacher job satisfaction and retention (van Aalderen-Smeets & van der Molen, 2015).

This paper provides an overview of the literature concerning science teachers’ interactions with science centres focusing on changes to science teachers’ affective domains. The implications for future research will also be explored.
Exploring design thinking using Dewey’s theory of pragmatist inquiry and aesthetic experience

Paper Presentation

Kim Nichols, Reshma Parveen, Liz-Fynes-Clinton & Rosanne Blundell
School of Education, The University of Queensland, St Lucia, Queensland, Australia
k.nichols@uq.edu.au; r.parveen@uq.edu.au; e.fynesclinton@uq.edu.au; r.blundell1@uq.edu.au

Rylander (2009) propositioned that John Dewey’s theories of pragmatist inquiry and aesthetic experience provide a framework for a deeper theoretical understanding of design thinking and practice. This study empirically explores design thinking using Dewey’s theory of inquiry and aesthetic experience by analysing Year 6 students’ inquiry behaviours and aesthetic expression in the form of language as they participate in a design task. Six Year 6 teachers participated in professional learning around a pragmatist inquiry approach known as collaborative philosophical inquiry (CPI) and a unit of work on electricity that culminated with a design task. 159 students participated in the unit of work. The study design was a 2 x 2 pre-post intervention and comparison approach investigating students’ scientific language, representations and inquiry behaviours in the CPI and non-CPI groups through analysis of qualitative and quantitative data. Discourse analysis of design competencies and inquiry behaviours and pre- post-testing of scientific language and representations was compared. Results showed the CPI group engaged more design competencies and inquiry behaviours in their design thinking task, and while both groups showed significant improvement, the CPI group showed significantly higher accurate use of scientific language and representations. The study supports Rylander’s theoretical conception of design thinking and practice.

Moving on from getting started: mathematics and science specialist primary/middle preservice teachers’ experiences and perceptions of indigenous knowledges and practices

Paper presentation

Presenters Kathryn Paige Lisa O’Keeffe. University of South Australia, kathy.paige@unisa.edu.au lisa.o’keeffe@unisa.edu.au

The reality of many Australian preservice teacher training programmes is that the enrolled are mostly non-Indigenous. This results in many preservice teachers (PSTs) having little prior knowledge and experience of indigenous cultures and knowledges (O’Keeffe, Paige, Osborne 2018). Working with our PSTs (who are primary /middle years mathematics and science specialist) over the past five years, we have implemented a series of interventions including visiting the local indigenous art centre, lectures on culturally responsive pedagogy and ‘red’ dirt curriculum, reading aspects of Bruce Pascoe’s Dark Emu and incorporating indigenous ways of knowing in transdisciplinary units of work. Our intention guiding this work: How might a transdisciplinary, culturally responsive approach to education build knowledge and capabilities for sustainable futures with final year primary /middle preservice teachers?

Data has been collected through two key methods, firstly, through anonymous surveys at the beginning and conclusion of the course and secondly with an analysis of their submitted transdisciplinary units of work. The anonymous surveys allow us as teacher educators to identify initial understandings and learnings that have emerged in the education degree and life experiences. Questions include: How confident are final-year PSTs in their understandings of Aboriginal and Torres Strait Islander knowledges and cultures to teach mathematics and science? How confident are PSTs to teach students with an indigenous background? After the series of interventions throughout the four-month semester course, a post survey will be undertaken to determine impact and changes needed for the following year. The second element, an analysis of PSTs’ transdisciplinary units of work enables us to unpack the ways in which they have addressed a requirement to include indigenous perspectives in their final planning submissions. What examples will they feel comfortable incorporating? How do they choose to incorporate these approaches? What resources do they use, and in what ways?
How students say they choose their subjects at school and its impact on the choice of science

Paper presentation

Tracey-Ann Palmer
University of Technology Sydney

A scientifically literate citizenry is vital for the prosperity of modern society. However, low participation rates in science at school and university have led to fears that this need for scientifically educated individuals will not be met. A key decision point where students reject science is when they choose subjects for their final years of school and yet this decision process is poorly understood. Fifty Australian students from Years 10 and 11 participated in focus groups to explain how they choose subjects for their final years of school, what and who influenced them, and their opinions on choosing science. They described choosing subjects based initially on enjoyment, interest and need. If they needed additional subjects, students would then seek information and advice to fulfil their subject quota. Science was perceived as more difficult and useful only for stereotypical scientific careers and so appeared less attractive than other subjects. To address this problem, students who have not rejected science in the initial stage of their decision process may be presented with information from credible sources that counters this perception. This revaluation of science at the time subject selection is made may lead to more students choosing to continue with science.
Instructional practices facilitating argumentation in science and religious education classrooms: A case study of lower secondary teachers in England

Paper presentation

Wonyong Park, Sibel Erduran, & Liam Guilfoyle, Department of Education, University of Oxford, wonyong.park@education.ox.ac.uk

Argumentation is well recognised as a core practice of science, but the relationship between argumentation in science and that in other disciplines has not gained much attention in science education literature. For example, while much has been researched about teaching evolution and intelligent design, there is a limited understanding of how argumentation can unfold differently in science and religious education (RE) classrooms. To fill this gap, the current study investigated the teaching practices related to argumentation in lower secondary classrooms in England. Through an in-depth analysis of two pairs of science and RE teachers’ instructional practices, we illustrate how the teachers who participated in a professional development project understand and teach argumentation to their students. Data sources included questionnaires, lesson materials, classroom recordings and teacher reflections. Findings provided initial information on how argumentation can be facilitated differently in science and RE classrooms and also the teachers’ different understandings of argumentation as a disciplinary practice and an instructional objective in each subject. We discuss the implications of the findings in relation to promoting argumentation in science and RE classrooms and seeking cross-pollination between subjects, particularly when addressing topics that involve the intersections of science and religion.
Student representations - Impact of Immersive Habitat Classrooms on science learning at Taronga Zoo

Paper presentation

Christine Preston and Sally Biskupic, The University of Sydney christine.preston@sydney.edu.au; sally.biskipic@sydney.edu.au

This study at Sydney’s Taronga Zoo involved school excursions with a lesson in the new Immersive Habitat Classrooms. Three multi-sensory learning spaces were designed to inspire and educate students about critical habitat protection for animal survival. The mini ecosystems: rainforest, desert and woodland contain live animals. Untested against their goals, research into the effectiveness of such innovative learning spaces is significant. The study aimed to measure the impact of the immersive classrooms on students’ thinking about science concepts. A qualitative approach involved 15 classes (Year 7) and 5 Zoo educators. Student-generated representations before and after the lesson elicited prior knowledge and conceptual growth and participant observation verified influences on students’ ideas about classification and animal adaptions. Focus groups with zoo educators, essential to the collaborative research process, facilitated professional learning through reflective practice. Results evidenced strong positive impact of the immersive learning experience on students’ understanding of science ideas. Popular culture and stereotypical representations of animals and habits influenced students’ prior ideas. Alternative conceptions were challenged with some preconceptions remaining. Growth in student understanding comprised greater awareness of environmental features, animal and plant diversity and species-specific adaptations to the environment. Extremely high levels of student engagement were sustained throughout lessons.
A Chinese science education community’s perceptions about teaching socio-scientific issues

Paper presentation

Author name: Yujiao Qiao
Author affiliation: University of Auckland
Email addresses: y.qiao@auckland.ac.nz
Supervisors’ name: Bev France and Sally Birdsall

Teaching science through socio-scientific issues (SSIs) has been proven to be a useful way to create authentic contexts for science learning and to promote scientific literacy for citizenship. However, Chinese teachers have little experience of employing this pedagogy in their classrooms. This study explores Chinese science teachers’ beliefs and perceptions about teaching SSIs in their classes. Eleven in-service teachers, ten student teachers and four teacher educators participated in an individual interview. It involved a hypothetical lesson planning activity related to a local issue of smog and haze as well as exploring their beliefs about using the SSI pedagogy. Thematic analysis was utilised to inductively analyse data. The results indicate that most participants had basic understandings of SSI pedagogy, but they still held apolitical and/or amoral views towards science teaching. These results also generate three types of lesson plans: Science-oriented, Daily-life-oriented and Citizen-oriented. This typology shows differences in the role of SSI teaching; the general features of SSI; and the class activities proposed by these teachers. A model which consists of Beliefs of Education; Relevance; Agency; and Complexity of Activity will be advanced to theorise this typology, which reflects the elements that teachers considered necessary in the SSI pedagogy.
Factors Influencing Science Teachers’ Action Research Process in a Secondary School in Bhutan

Paper Presentation

Authors: Tshewang Rabgay, Monash University, Tshewang.Rabgay@monash.edu
Gillian Kidman, Monash University, Gillian.Kidman@monash.edu (Supervisor)
Niranjan Casinader, Monash University, Niranjan.Casinader@monash.edu (Supervisor)

Action research has gained widespread recognition in western countries such as the USA, UK, Australia and in some Asian countries such as Singapore, Philippines, Indonesia, China and Malaysia. The recent education reform in Bhutan introduced action research as a new concept for teachers to raise their teaching quality. This qualitative case study of a secondary school in Bhutan investigated the factors influencing the way science teachers conducted action research for the first time. The data were gathered using teachers’ reflective diaries, interviews and classroom observations, then analysed using the coding procedure of grounded theory. The analysis revealed that the teachers’ action research process was constrained by factors related to their school context such as, time constraints, lack of resources and the heavy science curriculum; and their personal factors such as their inadequate knowledge of action research and the lack of confidence to follow the process. The use of the internet and the researcher’s support facilitated their progress. The findings indicated that Bhutanese teachers need to be supported by creating conducive conditions within the school and providing comprehensive training on action research in order to enable them to conduct action research confidently.
A study into the impact of the changes in high syllabus in 2002 till 2018: What stayed constant over 16 years?

Paper presentation

Jules Rankin¹ and Manjula Devi Sharma¹
¹School of Physics, The University of Sydney, Camperdown, NSW 2006
Presenting Author: Jules Rankin (jran2204@uni.sydney.edu.au)
Manjula Sharma (manjula.sharma@sydney.edu.au)

High school syllabus undergo major revisions at some times in time. They then remain somewhat constant till another major revision. During the intervening period, ‘tweaks’ are made, but drastic changes to the philosophy or ethos of the syllabuses are rare. In the state of NSW, a major revision occurred in 2002 and another major revision has just occurred. This study captured data on student ‘approaches to study’ and their ‘conceptions of physics’ during the period over which the syllabus remained relatively constant. Interestingly, this is the period when phenomenal change in communications and digital technology has occurred, from collaborative writing on online platforms, mobile devices to YouTube. In this study student cohorts were sampled as they started their studies in physics at The University of Sydney. Data were collected in 2002, 2004 and in 2017 and 2018, from 2448 students. Interestingly, despite the phenomenal changes, students approaches to study and conceptions of physics stayed much the same. This points to the substantive and critical role the syllabus document plays. There is no doubt that the syllabus document is heavily contested and critiqued, often to the detriment of the learners and the learning of the discipline itself.
Understanding the Out-of-Field Teaching Experience through Positioning Theory: Perceptions of Career Research Scientists Who Became Teachers

Paper presentation

Emily Rochette, The University of Melbourne (erochette@unimelb.edu.au), Christine Redman, Supervisor, The University of Melbourne (redmanc@unimelb.edu.au), Paul Chandler, Supervisor, Australian Catholic University (paul.chandler@acu.edu.au)

According to Shulman (1986), ‘we assume that most teachers begin with some expertise in the content they teach’ (p. 8). Yet the reality is that teachers of broad multi-disciplinary subjects, like general science, may be highly accomplished in some topic areas but not others (Carlsen, 1992). Added to this complexity in the Australian state of Victoria are professional expectations that teachers incorporate digital technologies into their regular classroom practice (Victorian Curriculum and Assessment Authority [VCAA], 2016).

This paper explores the perceptions of two highly qualified science graduates who, as early career teachers, both lacked a professional history teaching with digital technologies and, like most of their international colleagues, would teach geoscience out-of-field (OOF) (King, 2008). Positioning theory (Harré & van Langenhove, 1999) is explained and presented as the overarching research methodology. The analytical tools and data from personal meaning making maps (Giardiello, Parr, McCloud, & Redman, 2014) and interviews are exemplified to show how data were methodically coded to better understand these teachers’ perceptions of their agency to teach at the science and digital technologies curricular intersection. To conclude, the paper discusses the implications of and possible steps toward supporting research scientists transitioning to the classroom.

References
Enacting the middle-ground: An approach using Indigenous sky stories

Paper presentation

Dr Nicholas Ruddell, School of Indigenous Australian Studies, Charles Sturt University, Australia, Email: nruddell@csu.edu.au
Adjunct Professor David McKinnon, Edith Cowan University, Australia, David.mckinnon1952@gmail.com

This article discusses a theoretical approach that offers researchers a culturally appropriate pathway for future research in the field of cross-cultural primary and high school science education. The middle-ground can provide the optimum conditions for place-based research, teaching and learning to emerge. Critical to the success of conducting research in this space is a guiding model that enriches the capacity building cultural competency matrix. Using data and examples from two cross-cultural school science-education projects conducted by the authors, and being mindful of confirmation bias, this article unpacks the Mutual Cultural Responsivity model as a way of showing competency in-action. The framework provides the means in which one can assess and develop a response to research involving Indigenous communities using three stages: Awareness, Becoming and Being.
Validation of the SECM (Scales of Evolutionary Conflict Measure) Instrument

Paper presentation

Gena C. Sbeglia, gena.sbeglia@stonybrook.edu, Department of Ecology and Evolution, Stony Brook University

Ross H. Nehm, ross.nehm@stonybrook.edu, Institute for STEM Education, Stony Brook University, Department of Ecology and Evolution, Stony Brook University

Although evolution is a core concept unifying the biological sciences, many students--particularly underrepresented minorities (URM)--have low acceptance levels, which negatively impact pursuit of degrees and careers in evolutionary biology. Researchers have empirically shown strong associations between personal conflict and acceptance, and have hypothesized that family and community influence acceptance. Prior work on conflict measurement (i) relied on interviews or single items, (ii) lacked robust validity evidence, and (iii) forged weak links with theory. The SECM was developed to address these limitations. Using AERA’s measurement Standards (2014), we examined content (CNV), internal structure (ISV), and convergent validity (COV) for the SECM. A literature review and experts (CNV) supported a three-scale construct (perceptions of community, family, individual conflict; 3 items/scale). Rasch was used to evaluate if responses from diverse undergraduates (N=1276) aligned with theory (ISV). Latent SECM measures were correlated with an Inclusion of Other in Self scale (COV). Items had acceptable fit (0.6-1.12), reliabilities were robust (>0.85), and three-dimensional structure was supported (X2=1938.35, p<0.01). Convergent measures were significant (r=0.50, p<0.05). Multi-group causal models indicated that perceptions of family and community conflict impacted personal conflict (β=0.15-0.63, p<0.05), and strength varied between URM and White respondents (β difference=0.17, p<0.05). Personal conflict had stronger direct impacts on acceptance (β=-0.50 to -0.66, p<0.05) than religiosity (β=-0.24-0.17, p>0.05).
Inquiry based instruction with Science Writing Heuristic (SWH) approach on pre-university students’ on understanding of stoichiometric concepts using green chemistry activities.

Paper presentation

Sheila Shamuganathan, shamsheila@yahoo.com, Environmental green chemistry, Penang Matriculation College, Penang, Malaysia

This study discusses the impact of inquiry based instruction with Science Writing Heuristic (SWH) approach on pre-university students’ on understanding of stoichiometric concepts using green chemistry activities. The instrument of SWH bridges between traditional laboratory reports and types of writing that promote meaning to learning. Two intact classes were selected for this study; one class was assigned as the treatment group, and the other class was assigned as the control group. The intervention group were presented with green chemistry activities and their report writing was developed based on SWH. Test measuring students’ conceptual understanding in the unit of stoichiometry were administered as pre-test and post test for both groups. At the end of the instruction, semi structure interviews were conducted with six students from the treatment group and six from the control group. ANCOVA results revealed that the SWH approach was superior to the traditional approach on students’ understanding of stoichiometry concepts. Interview results indicated that students in the intervention group demonstrated better scientific understanding of stoichiometry concepts compared to those in the comparison group.

Keywords: Science writing Heuristic, stoichiometry, conceptual understanding, quasi experimental research design.
Climate change: The impact of culture on students’ willingness to act on their beliefs

Paper presentation

Skamp, K., Boyes, E. & Stanisstreet, M.
Email  keith.skamp@scu.edu.au

Using a novel questionnaire, we explored the impact of countries’ cultures on students’ (n > 12,000; Grades 6-10; 11 countries) willingness to act on their beliefs about the effectiveness of voting for a government that imposed increased taxation in order to reduce global warming. The relationships between a country’s culture, characterized by its positions along three continua (autonomy-embeddedness, egalitarianism-hierarchy, and harmony-mastery) and students’ willingness to act on their beliefs suggests these cultural orientations impact on their willingness to act. Furthermore, there are interactions between students’ ages and their country’s cultural values along these three continua. These interactions, for example, suggest that students in autonomous (rather than embedded) countries, tend to be less willing to act on their beliefs. This effect appears to become more pronounced across the secondary years. Pedagogical implications are suggested. Although students’ understanding of the process of climate change affects their decisions, so do their worldviews, belief systems and consequent identity (Wals et al. 2014, Science, 334, 583-4); these are impacted by a country’s ‘cultural press’. An appreciation of the interaction of cultural dimensions and students’ environmental decision-making may influence teachers’ pedagogical reflection as they engage students with the global warming issue.
Scientists’ right to say “I do not know”: science education for contemporary Australia

Paper presentation

Dorothy Smith
La Trobe University
Dorothy.smith@latrobe.edu.au

In this paper I argue that a commitment to open-mindedness and transparency leaves scientists and their knowledge vulnerable to contestation in terms that may undercut their ability to respond to the needs and priorities of society. Although openness is widely cited as a fundamental value of science, the norms of science are being transformed by the requirement that science be done according to the dictates of neo-liberal marketisation. Science that is produced for the marketplace may be challenged on terms different from those that pertain to the academy. I consider the implications of this proposition for science education in schools and tertiary education.
The Learning Assistant Model: Supporting Faculty Teaching Transformation and Student Success

Paper Presentation

1Robert (Bud) M. Talbot III, 2Laurel Hartley, 1Hannah Huvard, 2Andrew McDevitt
1University of Colorado Denver School of Education and Human Development
2University of Colorado Denver Department of Integrative Biology
robert.talbot@ucdenver.edu
laurel.hartley@ucdenver.edu
hannah.huvard@ucdenver.edu
andrew.mcdevitt@ucdenver.edu

The transformation of undergraduate teaching and learning environments to incorporate more active learning and interactive engagement requires support resources and institutional change. Numerous STEM Intervention Programs have been developed and deployed to help drive this change. One such model for these programs is the Learning Assistant (LA) Model, which has been adopted by over 200 institutions of higher education around the world. Programs based on the LA model recruit and train undergraduate students who have been successful in their science courses to serve as near-peer Learning Assistants (LAs) for students in the supported course. The LAs learn STEM pedagogy in a specialized course, work with the lead instructors to make the courses more student centered and active, and interact with students to promote discourse around the topics under study. Extensive research on LA model adoption in Biology, Chemistry, Math, and Physics shows that LA implementation promotes student interaction, supports faculty course transformation, and increases the likelihood of student success in the course and retention to degree. In this talk, I will discuss the pillars of the LA model and present the results from research involving social network analysis, course observation, and regression modeling.
Discourse Patterns & Strategies in Science Classrooms: A Synthesis of Classroom Discourse Frameworks

Paper presentation

Associate Professor Kok-Sing Tang, School of Education, Curtin University, kok-sing.tang@curtin.edu.au

This theoretical paper presents a new way of conceptualising classroom discourse and discourse strategies in the context of science education. Defining discourse as social patterns in the use of language that shapes and is shaped by the way we think, act, and make meanings, I identify five patterns related to the following dimensions in science classroom discourse: discursive interaction, content development, lesson narrative, scientific practice and multimodal coordination. Past research in classroom discourse has mainly examined the discursive interaction and content development dimensions, focusing on how teachers elicit, guide and respond to students’ inputs in building science content knowledge. However, few have integrated the other dimensions involving: metadiscourse in organising and evaluating lesson narrative, metalanguage in describing scientific practice or genre, and the use of representations in multimodal coordination. Using classroom videos collected from a number of studies, I discuss how we can analyse these five patterns, and consequently identify a range of discourse strategies for each pattern that teachers can use to enrich classroom discourse. My central argument is that with an understanding of the underlying discourse patterns, we can transform implicit discourse strategies that science teachers unconsciously employ to a more deliberate and explicit use of discourse strategies.
Development of an Interdisciplinary STEM Classroom Observation Protocol

Paper Presentation

First Author: Toh Kai Wei, Clarence
Second Author: Tan Aik Ling

In this increasingly digitized age, STEM (Science, Technology, Engineering and Mathematics) education is gaining traction in the educational landscape. Students who enter the workforce are expected to apply their subject knowledge across various disciplines to solve real life problems and such scenarios should be simulated in classroom through STEM activities. However, despite the importance of STEM, no standardised protocol has been established to categorize and evaluate the effectiveness of STEM classrooms.

This paper aims to introduce an interdisciplinary STEM classroom observation protocol to highlight the essential features of a STEM classroom and subsequently illumine teachers and students’ patterns of discursive interactions during integrated STEM lessons. In the development of the observation protocol, Engle and Conant’s productive disciplinary engagement (PDE) framework as well as the Singapore Teaching Practice were used to distil events that were characteristic of learning in an integrated STEM classroom from various classroom videos. The refined protocol was then trialled in STEM classrooms as well as comparison classrooms by two observers. Inter-rater alignment was then compared.

With the formalisation of the observation protocol, it is hoped that a valid, reliable and consistent evaluation of STEM classrooms can be commoditized, contributing to the improvement of existing STEM curricula.

Keywords: STEM, Observation Protocol, Productive Interdisciplinary Engagement, Singapore Teaching Practice
Teaching strategies for integrative STEM education

Paper presentation

Dr. Radu Bogdan Toma\textsuperscript{1a}; Dr. Jesús Ángel Meneses Villagrá\textsuperscript{1b}
University of Burgos. Faculty of Education. Department of Specific Didactics.
\textsuperscript{a} rbtoma@ubu.es; \textsuperscript{b} meneses@ubu.es

Although much research has been conducted on the viability of STEM teaching approaches, most proposals call for the integration of only two of the four disciplines confirming the acronym, which resembles longstanding educational efforts from previous decades (e.g., S&M integration). This study aims at finding a substantiated answer to the following research question: What teaching strategies (and how) should be used for the didactic transposition of integrative STEM approaches in K-12 education? By drawing on social-constructivism learning theories, this presentation describes a pedagogical STEM framework that uses inquiry teaching, engineering design process, and computation coding and programming as the main teaching strategies for implementing integrative STEM units addressing interdisciplinary real-world projects that require the use of knowledge and skills from each of the STEM disciplines. Then, a 10-hour unit, designed using the proposed framework, will be introduced using classroom-tested examples. This pedagogical framework is the results of a three-year, Design-Based Research project, whose aim was to contribute to a coherent interpretation of the teaching and learning processes taking place when integrative STEM approaches are being implemented, and which involved the participation of 894 students from 36 state-funded schools.

Funding
This research was funded by the UBU-2017 Ph.D. Research Internship awarded to the first author of this study and partially funded by the Spanish Ministry of economy and competitiveness under the research Grant EDU2017-89405-R.
“It’s kind of like a cut and paste of the syllabus”: One Teacher’s Experience of Enacting the Queensland Earth and Environmental Science Syllabus, and Implications for Education for Sustainable Development

Paper presentation

A/Prof. Louisa Tomas, College of Arts, Education & Social Sciences, James Cook University
Louisa.Tomas@jcu.edu.au

Dr. Reece Mills, Faculty of Education, Queensland University of Technology
Reece.Mills@qut.edu.au

This case study investigated one teacher’s experience enacting Queensland’s new Earth and Environmental Science syllabus. In a previous study, a document analysis of the syllabus found that Education for Sustainable Development (ESD) is not prioritised in the intended curriculum, and the extent to which ESD is realised in schools would likely depend on teachers’ instructional decisions (Tomas, Mills, Rigano, & Sandhu, in-press). This assertion was investigated through analyses of interviews and classroom observations, garnered as a Year 11 teacher enacted Unit 1 of the syllabus for the first time in Term 1, 2019. Despite his positive attitudes towards ESD, contextual factors stemming from significant changes to senior schooling in Queensland most strongly mediated his enactment of the curriculum. In the classroom, these changes manifested in a heightened focus on assessment, and a perceived lack of teacher autonomy and time, which led to ESD ‘falling by the wayside’. These findings suggest that a teachers’ positive attitudes are not sufficient to enact ESD when it is not explicit in the intended curriculum, particularly in the context of significant curricula change. This study supports calls for a systems approach to sustainability if the transformative potential of ESD is to be realised in schools.
Characterising deep and superficial learning in science: a case study of preservice teachers’ knowledge building in an assessment task

Paper Presentation

Annette Turney aturney@uow.edu.au (Supervisor: A/Prof Wendy Nielsen)
Helen Georgiou helengeo@uow.edu.au
A/Prof Wendy Nielsen wnielsen@uow.edu.au
University of Wollongong

Calls for students to develop ‘deep subject knowledge’ are widespread. However, little empirical work exists on what this means, and in particular, how we encourage it in assessment tasks, where students don’t have the benefit of ongoing dialogue/feedback from the teacher. In this project, we consider a case study involving one assessment task in a preservice primary teachers’ science subject. The assessment task involved students creating a digital product (short video) that explained a scientific concept to a young audience. Through the close analysis of products, interviews with students and written rationales of four students, we provide a conceptual model drawing on two frameworks, Legitimation Code Theory and Systemic Functional Semiotics, that characterises the ‘deep’ and ‘superficial’ learning of scientific concepts that eventuated as the students completed this task. These findings lay the groundwork for better support for students to foster ‘deep’ understanding through more precise assessment rubrics that can be used across a range of different tasks and topics.
Exploring innovative pedagogies through interdisciplinary mathematics and science learning in the primary school

Russell Tytler, Deakin University, Melbourne, russell.tytler@deakin.edu.au
Peta White, Deakin University, Melbourne, peta.white@deakin.edu.au
Vaughan Prain, Deakin University, Geelong, vaughan.prain@deakin.edu.au
Lihua Xu, Deakin University, Geelong, lihua.xu@deakin.edu.au

This paper describes the rationale and pedagogical approach of a 3-year longitudinal study designing and evaluating interdisciplinary mathematics and science learning sequences for Grades 1 through 6 across three schools (https://imslearning.org/). Topics included measuring height, ecology, astronomy, motion, light, flight, chemical science, water, fast plants, and microbiology. The pedagogy involves students’ construction and refinement of diagrammatic and textual representations and the development of measurement and data modelling, reflecting core disciplinary processes. A four-stage pedagogical model was employed:

Material engagement/observation/measurement: a stimulus and problem opens up generative learning opportunities through establishing a need to collect, interpret and represent data and/or construct explanatory representations of the phenomenon.

Representation challenge/invention: Students are challenged to invent/construct representations that reflect their measures, interpretations, and explanations.

Comparative review/sharing/evaluation: The teacher strategically guides sharing/display and comparison/evaluation of the representations.

Review/ refinement/application to new settings: Students refine or revise their representations, or respond to new and related challenges.

The paper draws on video data and interviews to illustrate each stage, and examine the variety of ways the model is enacted by different teachers in different topics. We report on the key elements of the pedagogy that effectively support learning in both science and mathematics.
How might we enable Generalist Teachers to become confident Science and STEM Practitioners?

Paper presentation

Lynn Walker, Australian Academy of Science, Lynn.Walker@science.org.au
Nicola Dziadkiewicz, Australian Academy of Science, nicola.dziadkiewicz@science.org.au
Angela Gigliotti, Australian Academy of Science, angela.gigliotti@science.org.au

The Academy of Science is committed to working with the research community to meet the changing needs of teachers. The most recent independent evaluation of Primary Connections from University of Technology Sydney engaged with in-service and pre-service teachers from across Australia. Responding to recommendations in that evaluation and working closely with teachers, the Australian Academy of Science embarked on a digital transformation of its Primary Connections program, trialled innovative online professional learning courses, and worked in collaboration with reSolve: Maths by Inquiry to develop STEM resource packages.

Understanding and meeting the diverse needs of teachers is a priority; the Academy worked closely with design consultants to better understand the needs of teachers. This led to the development of new initiatives and approaches for working with teachers. The resulting closer collaboration with teachers, in turn led to deeper insights into teachers’ professional learning needs in Science and STEM Education. The findings from these projects will inform future work in this space. In this presentation, continuing the dialogue with researchers, the Australian Academy of Science will share findings about supporting teachers to develop, implement and reflect on, Science and STEM learning sequences and programs.
Enhancing STEM understanding for pre-service teachers

Paper presentation

Lynn Walker, Australian Academy of Science, Lynn.Walker@science.org.au
Nicola Dziadkiewicz, Australian Academy of Science, nicola.dziadkiewicz@science.org.au
Angela Gigliotti, Australian Academy of Science, angela.gigliotti@science.org.au

In response to recommendations made in a recent UTS evaluation of its Primary Connections program, and aware that Australian universities use Australian Academy of Science (AAS) education resources, the AAS sought to deepen its understanding of how those resources were used, and to identify opportunities to further collaborate with initial teacher educators.

Survey data indicates that AAS education resources are selected for use in initial teacher education because they are from a trusted source, the quality resources embody an inquiry approach modelling effective pedagogy and support the development of scientific understanding.

Analysis of survey data collected confirms that there is extensive opportunity, need, and interest for the AAS to collaborate and liaise with initial teacher educators to achieve the mutual goal of enhancing STEM understanding for pre-service teachers. With our renewed awareness of the challenges faced by initial teacher education, and considering the new developments in AAS education resources (see previous session), we will facilitate a discussion about how these new resources in development could support ITE programs. Feedback and suggestions raised in this session about opportunities to further support PSTs and their educators will inform future work at the Academy.
Effects of Metacognitive Scaffolding on Students’ Performance in Simulation-based Inquiry

Hong-Syuan Wang, Miao-Hsuan Yen, and Sufen Chen
Hong-Syuan Wang
Graduate Institute of Science Education, National Taiwan Normal University, Taipei, Taiwan
Address: No.88, Sec. 4, Tingzhou Rd. Taipei, 11677, Taiwan.
Email: hongsyuanwang@gmail.com

Miao-Hsuan Yen
Graduate Institute of Science Education, National Taiwan Normal University, Taipei, Taiwan
Address: No.88, Sec. 4, Tingzhou Rd. Taipei, 11677, Taiwan.
Email: myen@ntnu.edu.tw

Sufen Chen
Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taipei, Taiwan
Address: No.43, Keelung Rd., Sec.4, Taipei, 10607, Taiwan.
Email: sufchen@mail.ntust.edu.tw
Teaching strategies and interdisciplinary Science teaching.

Paper presentation

Bruce White (Bruce.White@unisa.edu.au) 1, Yvonne Zeegers (Yvonne.Zeegers@unisa.edu.au)1, Karen Sloan (Karen.Sloan@cesa.catholic.edu.au)2
1University of South Australia
2Catholic Education South Australia
Paper presentation

STEM has been widely promoted as one way to increase student enrolments in Science subjects (The Office of The Chief Scientist,2017). While a range of factors have been suggested as required to implement STEM in schools, one that has been clearly identified as essential is to improve teachers’ pedagogical approaches (Timms et al., 2018). What is not clear however, is what is meant by these supportive teaching approaches (Murphy et al., 2019). This presentation will draw from data collected as part of a STEM project conducted in partnership with Catholic Education South Australia schools. It will examine teacher and student perceptions of what teaching approaches were most frequently used, and teachers’ self-reported confidence to teach science and to teach interdisciplinary science during the project. While the study is relatively small, it contributes to ongoing discussions around the question “What teaching approaches can support the teaching and learning of science through interdisciplinary teaching approaches such as STEM?”.


Planning interdisciplinary maths/science learning sequences for system impact

Paper presentation

Peta White, Deakin University, peta.white@deakin.edu.au
Russell Tytler, Deakin University, tytler@deakin.edu.au

There is increasing pressure on universities to demonstrate the wider impact of their research. As a science education community, we have an established interest in our research influencing teacher practice and beliefs. How can we package our research findings to inform and influence teachers, and systems?

This paper describes long-term design research leading to an interdisciplinary primary mathematics/science learning approach based on students constructing representations, consistent with core disciplinary practices. The particular task on which we are currently focused is that of translating the research findings into effective teacher resources. The paper describes the design stages leading to our current understandings of how to support teachers to adopt the approach with some fidelity.

The stages are:
Long term development of research programs, working with dedicated teachers and tracking student learning, to generate key principles.
Widening the program to develop interdisciplinary mathematics/science learning sequences, curriculum-aligned, working across schools and teachers, year levels and topics.
Identifying key features of the pedagogy and challenges to teachers’ beliefs and practices that need to be addressed.
Codifying the approach, and sequence structures, to provide clarity on what is at stake, in ways attentive to teachers’ busy lives and competing interests.
Exploring the challenges and enablers of growing a STEM PBL program in a low SES junior secondary context.

Paper presentation

Dr Kimberley Wilson, Australian Catholic University (Brisbane), Email: Kimberley.wilson@acu.edu.au

While there are currently many hundreds of different STEM programs being implemented in education jurisdictions across Australia (Lowrie, Downes & Leonard, 2017), there is a pressing need to develop a stronger sense of what might be considered effective and appropriate STEM practices to meet the needs of diverse students. The aim of the study reported in this paper has been to fill a gap in the local research literature in terms of capturing the experience of implementing an integrated STEM Project Based Learning (PBL) program in a secondary school located within a highly diverse community experiencing socio-economic disadvantage. This qualitative study has drawn data from teacher and leadership interviews, school planning documents and an extended series of classroom observations in order to identify enablers and constraints in delivering STEM PBL in this context. Key findings of the project point towards the importance of building a school culture that is supportive of innovative pedagogical endeavours; the need to provide appropriate tools and environment to promote active and collaborative learning; and the importance of purposefully scaffolding the capabilities development of both teachers and students as they embark on a new pathway of engaging with multiple disciplinary areas in a junior secondary setting.

Reference:

Paper presentation

Mihye Won1, Dewi Ungu1, Henry Matovu1, David Treagust1, Mauro Mocerino1, Roy Tasker2 & Chin-Chung Tsai3
1 Curtin University, 2 Western Sydney University, 3 National Taiwan Normal University
Contact email: mihye.won@curtin.edu.au

Immersive virtual reality (VR) has been hailed as a new generation of visualisation that gives a realistic sense of being immersed in a virtual world, with the potential to enhance learning experiences. However, a review of VR science education research has shown that no clear educational potentials have been identified and realised. This study selected 45 empirical studies published in the last five years and examined how researchers have investigated the affordances of immersive VR in relation to addressing diverse students’ needs and meeting science learning objectives. Our analysis indicates that the majority of studies involved short, one-off activities with immersive VR (10-15 minutes), too brief an experience to expect any substantial learning. Researchers surveyed students’ overall perceptions of the VR experiences, including the feeling of presence and their motivation to use the VR for future learning. However, in-depth qualitative analysis of students’ learning or their interactions within immersive VR environments was difficult to find. There were also lack of details of affordances of immersive VR investigations in relation to pedagogical goals, immersive VR’s unique visualisation capabilities, specific design features and representations. We discuss future directions of immersive VR studies for science teaching and learning.
The viewpoints of teachers and career advisors regarding enablers and barriers in STEM for female students.

Paper Presentation

Amanda Woods-McConney, Murdoch University (Australia), a.woods-mcconney@murdoch.edu.au

While Year 11 female students studying physics were “most likely [to] possess high motivation and engagement for physics that is on par with their male counterparts” (Abraham & Barker 2015a, p. 67), female students’ continued participation in senior secondary school and university STEM enrolment is not the same. Abraham and Barker (2015b) reported that perceptions of females’ own ability predicted future secondary school physics enrolment. This study shifts the emphasis from female students and their perceptions, to what teachers and career advisors identify as barriers and enablers regarding female students’ continued participation in STEM-related subjects in senior secondary school and university. Participants were invited to interact in Two-Way Information Workshops. The two-way communication approach meant that participants responded individually and in focus groups, providing data for the study. While discussing their experiences with others in their groups participants also received information about the latest research on females in STEM. The opportunity for participants to reflect on their own experiences helped establish the relevance of current research. The findings reported here can inform science education researchers, educators and practitioners about teacher and career advisor perceptions and ways to support female students to pursue STEM subjects, degrees and careers.


Multiple representations in student learning of optics: An interdisciplinary approach

Paper presentation

Lihua Xu, Deakin University, Geelong, lihua.xu@deakin.edu.au
Christopher Speldewinde, Deakin University, Geelong, christopher.speldewinde@deakin.edu.au
Vaughan Prain, Deakin University, Geelong, vaughan.prain@deakin.edu.au

There is a growing interest in the roles of multiple representations (MRs) in teaching science and of student generated representations (e.g. drawings) in facilitating student conceptual understanding in various science topics. This study examines intertextual and contextual meaning making afforded by multiple representations constructed by primary students in an optical unit over a ten-week period. The tasks in the sequence were designed to facilitate meaningful connections between concepts in science (e.g. reflection) and in mathematics (e.g. angles). The pedagogy involves students’ construction, refinement and evaluation of representations and models to describe and explain experienced phenomena. This presentation reports the analysis of student work generated from the sequence, verbal accounts provided by the teacher and the students in interviews and video records of classroom interactions. The findings from this study demonstrate the value of this interdisciplinary approach in engaging students in core disciplinary practices in mathematics and science and in enabling them to make meaningful connections between these two curriculum areas.
Student Exploration of the Particulate Nature of Matter in a Secondary Science Classroom: A Social Semiotic Perspective

Paper presentation

Lihua Xu, Deakin University, Geelong, lihua.xu@deakin.edu.au

The particle model of matter is one of the most important ideas in science. Particularly in chemistry, it is believed to be fundamental to every topic (Harrison & Treagust, 2002). Despite its importance, many studies have found that students experienced great difficulties in understanding the ideas behind the Particulate Nature of Matter (PNM) (Driver, Guesne, & Tiberghien, 1985; Driver & Project, 1994). This paper explores the ways in which a group of secondary students attempted to make sense of the ideas associated with the Particulate Nature of Matter presented in their classroom. The study reported in this paper seeks to answer this question: how do the students construct links between their experiences and chemical representations through their classroom interactions with each other and with artefacts? Drawing on perspectives from social semiotics (Peirce, 1992; Lemke, 1998), the analysis focuses on discursive interactions between participants and their interactions with a range of representational and physical artefacts. The analysis identified similar student difficulties found in the literature, but the analysis from social semiotic perspective revealed the potential sources of student difficulties and suggests a possible way forward.
Designing Solution-centric STEM activities

Paper Presentation

First author: Ang Hao Yuan
Second author: A/P Tan Aik Ling

Integrated Science, Technology, Engineering and Mathematics (STEM) education allows students to learn through an integrative manner by solving complex inter-disciplinary real-world problems. Integrated STEM activities are hence necessary for teachers to design meaningful learning experiences for students.

This research describes the design of integrated STEM activities centred around existing products of design, where students are challenged to predict the feasibility of existing solutions, evaluate and optimize the design vis-a-vis various affordances which play significant roles in crafting the original design. Two solution-centric tasks have been designed and administered to a class of around 20 Secondary Two students. Students are assessed based on how they distil the key components of existing solutions to complex real-world problems. Their learning experiences in STEM activities will be assessed through the measurement and analysis of three areas (1) the number and types of questions asked (2) the level of argumentation and (3) their creativity.

The findings of the study serves as an indicator for the direction that future STEM classrooms should take in terms of lesson design and implementation. The richness of students learning experiences in integrated STEM lessons serves to inform curriculum designers about the affordances of different ways of designing integrated STEM lessons.

Keywords: STEM Solution-centric, Questioning, Argumentation, Creativity, Problem-solving, STEM literacy
‘It’s Very Complicated’: Expanding Students’ Views on Relationships in Socioscientific Issues

Paper presentation

Majd Zouda, Dimitris Tsoubaris, Sarah El Halwany, Minja Milanovic, Zoya Padamsi, Nadia Qureshi & John Lawrence Bencze

Addressing problems related to science and technology, particularly with increased influences from powerful groups and ideologies, requires participatory roles of citizens with critical science literacy. Hence, citizens’/youth’s collective socio-political activism through science education has been advocated. Additionally, developing critical understanding of the complexity of dynamic networks of power-relations that shape science seems essential to redirect science into more socially and environmentally ‘just’ forms. This paper reports on experiences of a high-school science teacher in the United Kingdom who adopted/implemented an activist pedagogical framework in his classrooms. It particularly examines students’ pre-instructional science-related conceptions and the teacher’s efforts to expand those by providing students with relevant critical lenses. Data analyses suggested that most students tended to have initial naïve/limited understanding regarding complexity of relationships in socioscientific issues (SSIs), particularly regarding power-relations among stakeholders, diversity of human and non-human entities (e.g. prioritizing human actors and perceiving ‘human’ as a single homogenous category), and possible relationships among social, economic and environmental factors (e.g. reductionist and unidirectional views of SSIs relationships). We argue that explicit teaching about these seemed necessary to expand students’ initial limited conceptions. We recommend that such practice would potentially support students to take more realistic and effective socio-political actions.
Poster presentations
Development of a High Quality Instrument Measuring Primary Students’ Attitudes toward Science in China

Poster presentation

Shuchen Guo¹, Enshan Liu², Dongxue Jin³

Students’ attitudes toward science is a major concern in science education and should be paid attention to since primary school. High quality instruments measuring students’ attitude towards science is needed when cultivating them. However, existing instruments show problems like unclear theoretical background, insufficient reliability and validity evidence, misinterpretation of ordinal data, etc. And most instruments are developed based on western context with not many aimed at primary students. Using existing instruments directly on primary students in other cultural context can be problematic.

This study aimed to develop a high quality instrument for measuring primary school students’ attitude toward science in Chinese context. In the study, attitude toward science was defined as consisting four constructs: enjoyment in science, self-efficacy in science, general value of science and intention for doing science. The initial item pool was reviewed by 2 experts to confirm face and content validity and then put into rounds of pilot tests which include students interview and large scale test. Factor analysis and Rasch analysis were conducted to help validate and provide evidence for psychological quality. The reliability of the final instrument is 0.87. And the evidence for validity is also satisfying. All the results indicate the instrument’s high quality.

¹ College of Life Science, Beijing Normal University, 201521200002@mail.bnu.edu.cn
² College of Life Science, Beijing Normal University, liues@bnu.edu.cn
³ College of Life Science, Beijing Normal University, jindongxue1108@163.com
The effect of colour and story on student emotion during physics practical tasks.

Poster Presentation

Arabella Crowley, Matthew Hill*
Barker College
*Corresponding author: mhill@barker.nsw.edu.au

Existing research indicates that the emotional component of the student experience in physics teaching must not be neglected. The use of colour and storytelling in physics instruction has been shown to have positive effects on student attention, retention and memory, engagement, motivation, and positive emotions towards physics. Physics laboratory materials can often be devoid of colour or storytelling, and measuring emotions can be difficult. This is currently being investigated at the tertiary level involving the validation of the Achievement Emotions Questionnaire adapted for physics practicals (AEQ-PhysicsPrac) (Bhansali & Sharma, In press).

In this study, 80 Physics students in Year 11 completed one of two modified practical tasks as part of normal instruction. One set of instruction was introduced with a background story and colour was integrated throughout, the other followed the traditional method of practical instruction with information presented simply and in black and white. Student emotions were measured with the AEQ-PhysicsPrac allowing comparisons between levels of pride, enjoyment, anger, hopelessness, boredom and anxiety.

This research is being completed by Arabella Crowley, a high school student studying the NSW Science Extension HSC course being supervised by Matthew Hill who completed his PhD in Physics Education in 2016.

Reference:
Do worksheets make a difference in the 1st year physics? A study in Thailand

Poster presentation

Arunee Eambaipreuk*, Kwan Arayathanitkul*, Narumon Emarat*, and Manjula D. Sharma

Presenting Author: Manjula D. Sharma (manjula.sharma@sydney.edu.au)
Department of Physics, Faculty of Science, Mahidol University, Thailand
School of Physics, The University of Sydney, NSW, Australia
* Corresponding author email: eam.arunee@gmail.com

Interactive lectures are important in order to engage students in large introductory class such as physics. Some research studies suggest that note taking in the lecture is related to student engagement and achievement. The worksheet is a particular technique used in various ways with the intention of helping promote note taking and achieving better student understanding. The aim of this work is to investigate the effectiveness of using worksheet in the topic of force and motion. We compared two cases; lectures using worksheet in 2017 and not using worksheet in 2018 at Mahidol University. The content was focused on drawing free-body diagrams and problem-solving using Newton’s second law. The sample groups were around 560 first-year science students. The results using pre- and post-tests revealed an increase in student’s competence in drawing force diagrams when worksheets were used in 2017 compared with no worksheet in 2018. Our results clearly show an advantage in student achievement when worksheets are used in an interactive lecture.

KEYWORDS: Worksheet, University lecture, Force and motion, and Free body diagram
Elementary preservice teachers’ game designs to promote science learning

Poster presentation

Martin Ferrer, Laura, Universitat de Vic, Spain, Laura.martin@uvic.cat  Amat Vinyoles, Arnau, Universitat de Vic, Spain, Arnau.amat@uvic.cat Espinet Blanch, Mariona, Universitat Autònoma de Barcelona, Spain, Mariona.Espinet@uab.cat

A review of gaming education by McClarty et al. (2012) outlined the many theoretical reasons why games should be effective. Morris et al. (2013) suggested that some games may promote the development of skills, attitudes, and values that are useful for scientific thinking or practice. In this research, we analyze the work performed by 21 groups of pre-service teachers in a course that is based on Abell et al. (2010) that claim a reflexive approach on pre-service teachers’ scientific practices as a way to learn science. The main purpose of this study is to describe and compare the games designed by pre-service science teachers at the beginning and at the end of the course through a qualitative content analysis approach of lesson plans written by pre-service teachers (Mayring, 2000). The preliminary results show that the main changes in their lesson plans are; a) the creation of more sophisticated games. It means that they incorporate more elements to structured and control the actions of the players; b) their games focus on the construction of scientific content following the framework of the modeling cycle (Schwarz and White 2005).
The Fire Within

Poster presentation

Tom Gordon\textsuperscript{a}, Helen Georgiou\textsuperscript{b}, (Supervisor) Manjula Sharma\textsuperscript{a}, (Supervisor)
Corresponding Author: tom.gordon@sydney.edu.au
\textsuperscript{a}Sydney University Physics Education Research (SUPER) Group, School of Physics, University of Sydney, Sydney, NSW, 2006, Australia
\textsuperscript{b}School of Education, University of Wollongong, Wollongong, NSW, 2522, Australia

KEYWORDS: Physics Education, Research, Motivation, Responsibility, Value, Relevance, Interest

The fire triangle tells us that to have a fire, we need three elements. Oxygen, Energy and Fuel. Without any one of those, there is no fire. This project will present some initial results from a project designed to investigate the link between an experiment that also has three elements 1) value, 2) relevance and 3) interest to students, with a fourth element 4) Students taking responsibility for their own learning, or The fire Within. Through literature and previous work, the project has defined what is meant by an experiment having those elements for high school physics and tertiary students in their specific contexts through well-established programs.

The preliminary results have come from validated and modified surveys from previous research and analysed in order to answer the question, “if an experiment has the three elements of relevance, value and interest for the students, does that mean that a student will take responsibility for their own learning for that experiment?” Alternatively, What impact do those three elements have on the fire within the students to learn.
Development of a High Quality Instrument Measuring Primary Students’ Attitudes toward Science in China

Poster presentation

Shuchen Guo, Enshan Liu, Dongxue Jin

Students’ attitudes toward science is a major concern in science education and should be paid attention to since primary school. High quality instruments measuring students' attitude towards science is needed when cultivating them. However, existing instruments show problems like unclear theoretical background, insufficient reliability and validity evidence, misinterpretation of ordinal data, etc. And most instruments are developed based on western context with not many aimed at primary students. Using existing instruments directly on primary students in other cultural context can be problematic.

This study aimed to develop a high quality instrument for measuring primary school students’ attitude toward science in Chinese context. In the study, attitude toward science was defined as consisting four constructs: enjoyment in science, self-efficacy in science, general value of science and intention for doing science. The initial item pool was reviewed by 2 experts to confirm face and content validity and then put into rounds of pilot tests which include students interview and large scale test. Factor analysis and Rasch analysis were conducted to help validate and provide evidence for psychological quality. The reliability of the final instrument is 0.87. And the evidence for validity is also satisfying. All the results indicate the instrument’s high quality.
Research into girls’ Lived Experiences of STEM Education as they Transition from Primary to Secondary School

Poster Presentation

Tabetha Spiteri (Tabetha.Spiteri@monash.edu), Author’s Affiliation: PhD Candidate, Monash University, Research Supervisors: Prof. Amanda Berry, (Amanda.Berry@monash.edu), Dr. Rebecca Cooper (Rebecca.Cooper@monash.edu), Dr. Jared Carpendale (Jared.Carpendale@monash.edu)

Despite the many initiatives focused on developing girls’ STEM aspirations, certain senior secondary STEM subjects continue to display a gender bias towards males (eg: Computing, Physics and Specialist Mathematics). Girls’ STEM interest starts to decrease between the ages of 10-14 years (Corrigan & Aikins, 2020), preceding the decline in female enrolments in senior secondary STEM subjects, and coinciding with the transition from primary to secondary school. This PhD study (in progress) aims to explore girls’ “lived experiences” (van Manen, 1997, p. 9) of their STEM education as they transition from primary to secondary school, and to determine how these experiences influence their STEM attitudes and aspirations. This study will use a hermeneutical phenomenological approach with 18 girls from three Victorian P-12 state schools as participants. Participants will be from different socio-economic and cultural backgrounds. Data collection will take place in terms 2 and 4 of 2021-2022, when participants are in years 6-7. During each data collection point, participants will be asked to draw an image of a recent salient STEM education experience and explain the contents of their drawing in an in-depth focus group interview. Thematic analysis will be used to extract common themes within students’ interviews and drawings.
Integrating technology with model-based inquiry to improve student engagement in physics laboratories

Poster presentation

Srividya Durga Kota and Manjula Sharma

School of Physics, The University of Sydney, Camperdown, NSW 2006

Srividya Durga Kota (skot2539@uni.sydney.edu.au)

Manjula Sharma (manjula.sharma@sydney.edu.au)

Waves is a standard topic in first-year undergraduate physics courses with laboratory experiments used to aid student understanding of waves. Here, we present how technology and inquiry was integrated when designing an experiment for modelling waves on a rope. Furthermore, we investigated how do students engage with the new experiment? The experiment was designed using design-based research (DBR) methodology. It had three features: qualitative description and kinesthetic feel of waves being created on ropes, taking measurements using video analysis software, and comparison of experimental and theoretical values using a pre-designed EXCEL spreadsheet. The experiment was trialled in tutor training sessions to obtain feedback but also to familiarise them with the notion of modelling in this experiment. The sample includes 501 students. Data were collected via observational notes, survey responses from 206 students in the Regular unit and 200 students in the Fundamentals unit, logbooks & interviews. Preliminary results indicate that the experiment fostered teamwork, video analysis was interesting and required appropriate investment of mental effort demonstrating that the experiment did engage students in a meaningful manner. The integration of technologies and inquiry resulted in higher levels of engagement with the experiment and good engagement with the content.


Multifaceted effects of self-efficacy on Taiwanese high school students’ learning engagement

Poster presentation

Tzung-Jin Lin
Program of Learning Sciences/ Institute for Research Excellence in Learning Sciences, National Taiwan Normal University, Taiwan
tzungjinlin@ntnu.edu.tw

In the past, most studies were concerned with the relations between certain types of learning engagement and one single scale of self-efficacy, without a more comprehensive examination. By analyzing 280 Taiwanese high school students’ responses on the two survey instruments, the Science Learning Self-Efficacy (SLSE) instrument and the newly-developed Science Learning Engagement Instrument (SLEI), this study aims to differentiate the predictive powers of multi-faceted science learning self-efficacy on assorted forms of science learning engagement. The main results indicated that, for Behavioral engagement and Agentic engagement, the SLSE dimensions of Higher-order Cognitive Skills and Practical Work are the positive predictors. Next, the two SLSE dimensions of Everyday Application and Conceptual Understanding can positively predict Cognitive engagement. Similarly, in addition to the SLSE dimensions of Everyday Application and Conceptual Understanding, the SLSE dimension of Science Communication can also positively predict Emotional engagement. Finally, for Social engagement, three SLSE dimensions, Science Communication, Practical Work, and Conceptual Understanding, are the positive predictors. The findings of this study could be informative for science educators and practitioners to adequately engage students in various aspects of science learning.
Exploring the Transformative Agency of Youth Activists for Climate Change in Korea

Poster presentation

Hyeonjeong Shin1*, Da Yeon Kang1, Sung-Eun Lim1, Sonya N. Martin1**
1Seoul National University, Republic of Korea.
* masic12@snu.ac.kr

In September 2019, about two million students around the world skipped school on Fridays in an effort to urge adults to take responsibility for climate change. This movement also inspired many students in Korea who organized and attended an Action for Climate Change event. The purpose of this study is to apply the concept of transformative agency to explore societal structures that supported and limited students to join the school strike movement for climate change in Korea. We interviewed 14 youth activists (ages 14-18) who participated in at least one school strikes event. All interviews were transcribed and analyzed using a phenomenological approach to explore the meaning of self-experience and perception about student participation in climate change action. Using this data, we explore students’ transformative agency related to climate change issues. The goal of this analysis is to identify what topics may serve as a foundation for fostering students’ competencies for responding to climate change in an effort to develop curricula developed around socio-scientific issues (SSI) that science teachers could engage as part of a school-based climate change education program that could develop more students’ awareness and competencies for becoming climate activists.

Keywords: youth climate action, transformative agency, climate change education, socio-scientific issues.

** Sonya N. Martin(Supervisor): sm655@snu.ac.kr
Call on me! Undergraduates’ perceptions of voluntarily asking questions in front of large-enrollment science classes

Poster presentation

Erika M. Nadile1, Emilie Alfonso2, Briana Barreiros2, William D. Bevan-Thomas2, Megan Chin2, Isabella Ferreira2, Sariah Ford-Myles2, Logan E. Gin1, Jomaries O. Gomez-Rosado2, George Gooding2, Alyssa Heiden2, Airyn Hutt2, Meagan L. King2, Shannon G. Perez2, Yasiel I. Rivera Camacho2, Flor Salcedo2, Christopher F. Sellas2, Krystian A. Sinda2, Katherine Stahlhut2, Michelle D. Stephens3, Nicholas J. Wiesenthal2, Keonti Williams2, Sara E. Brownell1, Katelyn M. Cooper4

1 The Biology Education Research Lab, Research for Inclusive STEM Education Center, School of Life Sciences, Arizona State University, Tempe, AZ, USA

2 BSC 4932: Undergraduate Biology Education Research Class, Department of Biology, University of Central Florida, Orlando, FL, USA

3 Translational Genomics Research Institute, Phoenix, AZ 85004, USA

4 The Department of Biology, University of Central Florida, Orlando, FL, USA

^Corresponding author. Email: Katelyn.Cooper@ucf.edu

Short title: Perceptions of asking and answering questions

Key words: participation, asking questions, answering questions, gender, race/ethnicity

Research advisor: Sara Brownell

Static poster abstract

A common way to engage students in college courses is to encourage them to ask questions, yet few studies have explored student perceptions of this. We conducted semi-structured interviews with 50 undergraduate students who had been in large-enrollment science courses (which we defined as more than 50 students). Interviews were transcribed and constant comparison method was used to identify themes. We conducted the next part of the study as part of a course-based undergraduate research experience (CURE). Using themes we identified, the students in the CURE developed a closed-ended survey that probed student perceptions of asking questions. We surveyed 417 students at an R1 institution to understand to what extent students perceive asking questions to be helpful and to what extent students engage. Over 90% of students reported that they find it helpful. However, 47.7% of students reported never asking questions. The most frequently selected factor discouraging students from asking questions to the instructor in front of large-enrollment science courses is anxiety (67.1%). Our findings highlight that although students rarely report asking questions, they do perceive benefits from hearing other students. These inequities in reported participation may need to be attended to if student participation helps improve student engagement.
Designing a role-play school science lesson including programming activities for pre-service teachers: Focusing on the concept of electric current

Poster presentation

Hayashi NAKAYAMA, University of Miyazaki, e04502u@cc.miyazaki-u.ac.jp
Tomokazu YAMAMOTO, Hyogo University of Teacher Education, ttyamamo@hyogo-u.ac.jp

According to Japan’s new curriculum, the 6th grade unit on ‘use of electricity’ should include programming activities such as developing iPad programs that turn lights on/off automatically using a sensor. This requires a new teaching model for Japanese educators. However, we explored the difficulties that children face in scientifically understanding ‘electric current’ though programming activities. We researched which type of lesson design is most effective in teaching electricity through programming activities and improved the ‘design principles’ of the science lesson. The key points were (1) compose questions related to programmed functions from everyday life activities, and (2) set learning goals to explain programmed functions using scientific words and concepts. These were tested in a science classroom role-play situation with college students acting as ‘teachers’ and ‘school children’. Fifty-five pre-service teachers were grouped into five teams. One team, role-playing as teachers, conducted a science lesson including programming activities, while others played the role of primary school children. During the lesson, the ‘children’ filled out a worksheet. On the worksheet, 28 out of 40 ‘children’ mentioned ‘electric current’ and ‘electric circuit’ while providing explanations. Consequently, we concluded that our design principle is effective for children’s learning of electricity through programming activities.

We would like to thank Editage (www.editage.com) for English language editing.
Exploring the current education design of socio-scientific issues in zoo exhibitions

Poster presentation

Shiho Miyake
School of Human Sciences, Kobe College, Japan
miyake@mail.kobe-c.ac.jp

Zoos are education facilities that inform people about animals and the relationships between animals and humans. Today, international biodiversity conservation initiatives and the Sustainable Development Goals [SDGs], focused on socio-scientific issues about the natural environment, expect zoos to promote public understanding of the environment. The author visited ten zoos in seven countries: Australia (2), the Czech Republic (1), Japan (3), Austria (1), Ireland (1), Sweden (1), and the USA (1), and explored how their exhibitions to approach these expectations. The authors took photographs as research materials and found that zoos provide three kinds of socio-scientific perspectives: biological and ecological knowledge, biodiversity conservation, and environmental ethics. Biological and ecological knowledge includes animal habitats, food, life cycles, and the physical characteristics of their bodies. Biodiversity conservation includes the IUCN Red List Ranking, populations, and problems in habitats such as human-wildlife conflicts. Environmental ethics include enrichment information (zoo innovations to make animals’ living environment more conformable), animal welfare (health care), and environmental measures—how to recycle plastic, pet bottles, and paper to save the land and water. This study suggests that the current meaning of ‘visiting the zoo’ is to learn, even unconsciously, about global environmental issues.
The study describes a Socio-Scientific Issue (SSI) based teaching program infusing a STEAM (arts-integrated STEM) approach to improve students’ climate-change literacy. The lessons in this STEAM program incorporate aspects of learning and action/behavioral changes that are important components in the SSI education approach. The purposes of this study are (1) to develop SSI-STEAM program, (2) to examine the impacts of the program on students' knowledge, perception, and action about climate change, and (3) to analyse students’ productions during class activities. One class in Korea and another in Australia each participated in the lessons designed to encourage students to examine current problems and issues related to climate change. However, only the findings from 31 Korean Year 8 students’ data are presented at this stage. A total of 48 items focusing on Knowledge, Perception and Action scales were devised and implemented as a pre-/post-survey. In addition, interviews and videos were collected to identify students’ responsible decision-making regarding action that may affect climate change. The findings will be discussed, as well as the challenges/benefits of a SSI education program incorporating STEAM lessons as a means of focused climate-change education that can equip future citizens with climate literacy.

Keywords: SSI, STEAM, climate change, knowledge, perception, action, class activities.
Designing a Coherence- and Concept-Based Modular Course to Facilitate Students’ Understanding of Crosscutting Concepts

Poster presentation

Dongxue Jin. College of Life Sciences, Beijing Normal University, Beijing, China. jindongxue1108@163.com
Enshan Liu. College of Life Sciences, Beijing Normal University, Beijing, China. liues@bnu.edu.cn
Shuchen Guo. College of Life Sciences, Beijing Normal University, Beijing, China. 201521200002@mail.bnu.edu.cn

Crosscutting concepts is an important conceptual knowledge known as “key ideas” in the Australian science curriculum standards and needs to be conveyed in the basic education to promote students’ understanding of disciplinary concepts, scientific practices and the nature of science. Crosscutting concepts is superordinate in the scientific concept system, and common across disciplines, and very abstract. These characteristics, with the addition of incoherence in curriculum arrangement challenge its instruction. Therefore, this research intends to explore an effective way to teach crosscutting concepts and then help teachers mastering its instruction and promoting students' understanding. A modular course was designed based on coherence of crosscutting concepts and combination of “concept-based instruction” and “5E instructional model” —both strategies point to conceptual understanding. The course was implemented in a senior high school twice, along with a teacher-training workshop. Data was collected through pre- and post-tests and semi-structured interviews to assess participants' understanding. The results showed that the target audience’s understanding of crosscutting concepts had been significantly improved, which supported the effectiveness of setting course structure with coherence as well as organizing instruction based on conceptual understanding. The way of designing the modular course can provide a reference for science teachers or curriculum designers.
Identification of Climate Change Action Competence Through Exploring Youth Environment Activists in Korea

Poster presentation

Da Yeon Kang¹*, Hyeonjeong Shin ¹, Sung-Eun Lim¹* and Chan-Jong Kim¹**
¹ Seoul National University, Seoul, Republic of Korea, chajokim@snu.ac.kr

Currently, science education research aims to engage students in understanding complex and controversial features of science and making their own decision and action about socio-scientific issues (SSI). As global environmental threats due to climate change have emerged, it became important for science educators to foster students’ activism against climate change. However, few studies have explored how the education system can support students to carry on socio-political actions on global-scale environmental issues. Thus, this study aims to identify students’ climate change action competence to set up clearer goals for SSI education.

In this presentation, we will share findings from interviews with 14 youth environment activists who were members of a Korean youth-led organisation for climate change. This organisation led the school strike for climate change in Korea. We conducted semi-structured interviews in terms of their knowledge, perceptions, and experiences. Interview data were analysed based on the literature review (a priori codes) and researchers found emerging themes (inductive codes) while reading and discussing data. We found the components of climate change action competence, for example, desire to change conditions and belongingness in the group. We expect this can benefit other researchers in other countries to foster students’ climate change action competence.

Keywords: action competence, climate change, socio-scientific issues (SSI), youth climate action
Educational Practices of Sommerfeld School and Its Implications: What is a Good Science Education?

Poster

Chulkyu Park, Hun-Gi Hong*
Seoul National University, Department of Chemistry Education, Seoul, Korea
hghong@snu.ac.kr

In this study, we tried to answer a question ‘What is a good science education?’ by analyzing educational practices of Sommerfeld school, which can be regarded as a historical success in science education. Sommerfeld who was a professor of theoretical physics at the University of Munich cultivated many outstanding scientists such as Heisenberg, Pauli, and Debye. Moreover, the educational practices of Sommerfeld school were highly appreciated by many people including Einstein, Born, and Pauling. We used literature of Sommerfeld, disciples, colleagues, and historians for the analysis. The educational practices of Sommerfeld school consist of seminar, colloquium, seminary, and out-of-class education. Although these practices are different in the aspect of formality, there are four features in common: i) pleasant relationship between teacher and students, ii) specific and challenging problem-centered learning, iii) intellectual coherence between various themes, and iv) shared opinion on problems. We discussed the implications of the features of the educational practices in science education.
Student Confidence, Riddles and Reflections

Poster presentation

Petr Lebedeva, Christine Lindstrømb, and Manjula Sharmaa
a School of Physics, The University of Sydney, Camperdown, NSW 2006
b School of Physics, The University of New South Wales, Kensington, NSW 2058

Petr Lebedev (petr.lebedev@sydney.edu.au)
Manjula Sharma (manjula.sharma@sydney.edu.au)
Incorporating Both-Ways Thinking about Time into the Science Curriculum

Poster presentation

Michael Michie, Batchelor Institute of Indigenous Tertiary Education, michael.michie@batchelor.edu.au
Joël Rioux, Batchelor Institute of Indigenous Tertiary Education, joel.rioux@batchelor.edu.au
Michelle Hogue, University of Lethbridge, michelle.hogue@uleth.ca

The two interpretations of time, linear time and cyclical time, can be used in both Western and Indigenous science and can complement each other. Time in the Australian Curriculum: Science is examined and seen to be primarily associated with Western science knowledge traditions but could be more inclusive. A model of time based on the slinky is proposed and analysed. The inclusion of Indigenous cultural cross-curriculum priorities in science can be achieved in three ways, as Indigenous perspectives, Both-Ways approach, and Both-Ways approach with epistemic insight. Examples of ways of inclusion of seasons and cycles in the Australian Curriculum: Science are suggested.
Examining the Physical Science Misconceptions of Middle Primary Students

Poster presentation

Kristy C Osborne, Australian Council for Educational Research, Kristy.Osborne@acer.org

Abstract: With technological advances impacting future work prospects, and issues such as climate change and environmental protection affecting our quality of life and resources, it is imperative to help children (and thus future adults) improve their scientific literacy. There is a large body of research into the common misconceptions held by children about the physical sciences. However, much of the current misconception literature has been focused on the upper primary and secondary years. This project adds to the current misconception literature by studying the student responses of over 8,000 middle primary aged students. The instrument used in this study is a multiple choice assessment delivered both on paper and online. Since this data is sourced from the middle primary cohort, this work may be particularly useful for those teaching and preparing science resources for primary students.
Exploration of a Science Teacher's Personal Practical Knowledge of Socio-scientific Issues in the SSI-STEAM Class Context

Poster presentation

A-Rang Won¹, Su-Yeon Choi¹, Hye-Eun Chu², Hyun-Jung Cha³, Chan-Jong Kim*¹
¹Seoul National University
²Macquarie University
³chajokim@snu.ac.kr

Successful modernisation, based on science and technology, has been accompanied by various social conflicts and environmental problems, besides enabling more affluent lifestyles. Socio-scientific issues (SSI) focus on controversial social issues which relate to or arise from science. Because of its complexity and uncertainty, SSI education aims to cultivate good citizenship as well as scientific knowledge and inquiry ability. However, teachers often aren’t well prepared to teach SSI and simply present solutions to problems. This study explores a science teacher’s personal practical knowledge (PPK) in teaching climate change, using the SSI-STEAM approach as a teaching method for professional development. The guiding research questions were: 1) what is the teacher’s PPK in the SSI-STEAM class?, 2) what are the difficulties encountered in conducting SSI-STEAM classes, and 3) what are the characteristics of PPK the teacher uses? The participant teaching seven sessions of climate change classes was a science teacher in a middle school in Seoul, Korea. The data were collected from semi-structured interviews, video-recordings of the classes, and the researcher’s observation logs. They are being analysed qualitatively using Elbaz’s five categories of teacher’s PPK. The findings, as well as the challenges encountered by the teacher when teaching SSI, will be discussed.

Keywords: SSI, socio-scientific issues, STEAM, practical knowledge, science teacher

A-Rang Won, Seoul National University, Seoul, Korea arang89@gmail.com
Su-Yeon Choi, Seoul National University, Seoul, Korea csys222@snu.ac.kr
Hye-Eun Chu, Macquarie University, Sydney, Australia hye-eun.chu@mq.edu.au
Hyun-Jung Cha, Seoul National University, Seoul, Korea todd0906@snu.ac.kr
Chan-Jong Kim, Seoul National University, Seoul, Korea chajokim@snu.ac.kr

Email of corresponding author: chajokim@snu.ac.kr
Explicit teaching of “problem solving” using worksheets in lectures and tutorials

Poster presentation

Vicky Tzioumis\(^a\), Arunee Eambaipreuk\(^b\)*, Manjula D. Sharma\(^a\), Narumon Emarat\(^b\), and Kwan Arayathanitkul\(^b\)

Presenting Author: Vicky Tzioumis (vicky.tzioumis@sydney.edu.au)
\(^a\)School of Physics, The University of Sydney, NSW, Australia
\(^b\)Department of Physics, Faculty of Science, Mahidol University, Thailand
* Corresponding author email: arunee.eambaipreuk@sydney.edu.au

Worksheets have been shown to be an effective tool that helps engage students in their lecture. The worksheet used in this study was developed in Thailand and implemented in a large lecture class with first-year science students. The results showed that the worksheets effectively enhanced students learning and their problem-solving skills. We then adapted them for the University of Sydney. The topics were extended to include thermodynamics and waves. The worksheets were deployed in both lectures and tutorials. The sample groups were about 500 students from Fundamental, Regular, and Advanced classes in 2019. The worksheet was structured into three columns, (a) clarifying a situation, (b) identifying variables, and (c) drawing a diagram. The results showed that the worksheet affected student behaviours in the classes. The efficiency of this work is shown by using the average score and SOLO taxonomy which refers to the levels of student’s understanding.

**KEYWORDS:** Worksheet, Lectures and tutorials, SOLO taxonomy
Development of inquiry-based courses about biomedical technology in general education classroom

Poster presentation

Chih-Hui Yang1, Sheng-Chang Chen2, Keng-Shiang Huang3

1 Department of Biological Science & Technology, I-Shou University, Taiwan
2 Institute of Education, National Chiao-Tung University, Taiwan
3 The school of chinese medicine of post baccalaureate, I-Shou University, Taiwan
Email addresses: 1 chyang@isu.edu.tw, 2 sengechen@nctu.edu.tw, 3 huangks@isu.edu.tw

Carbohydrates play an important role in directly influence human health and diseases. On the surface of viruses or cancer cells, there are special structures of carbohydrates, called glycans, which can be used as special marks in biomedicine. In recent years, glycan array and glycan-based vaccines have developed from biomedical technology to screen viruses or treat cancer to diagnose and predict the carbohydrate-mediated diseases. However, these knowledge and technology are little understood by the public including college students because of their owning abstract concepts and lacking an appropriate course. Besides, there are relatively little inquiry-based courses at colleges although they have been widely implemented in K-12 education. Consequently, the research aimed to design the inquiry-based courses in general education to improve college students’ comprehending of glycan array and glycan-based vaccines, as well as the related concepts and mechanisms about them, for example, antigens and antibodies. The building blocks with an Arduino device were used to simulate the mechanism of glycan array and glycan-based vaccines and further provided college students with an inquiring tool about producing an immune response. The results are believed that inquiry-based courses can foster college students’ science learning and understanding of biomedical technology.
How does visual representation construction facilitate learning in science classroom? Affordances of teacher-centered and students-centered visual representation construction

Poster presentation

Hye-Gyoung Yoon (Chuncheon National University of Education, yoonhk@cnue.ac.kr)
Eun Ah Lee (The University of Texas at Dallas, eunahj47@gmail.com)
Mijung Kim (The University of Alberta, mijung@ualberta.ca)

Recently, there has been increasing research interests in visual representation in science education. This study employed a case study to understand the affordances of visual representation construction in collective levels. By looking into cases of visual representation construction during classroom talk in two elementary science classrooms, this study examines how visualization helps students’ reasoning, meaning-making and social interactions. The case analysis of this study shows that teachers naturally engage visual representations as part of their instructional strategies. We selected two cases that include the emergence of teacher’s and students’ drawing and analyzed each case with a focus on what interaction occurs during the construction of visual representations and how this interaction promotes scientific reasoning and meaning-making. Three researchers watched the video cases repeatedly and developed in-depth discussion to draw possible themes. The findings are a) there are common grounds of visual representation that make collective reasoning possible b) constructing visual representation collectively invites students to connect prior experiences and new knowledge and to see the development of knowledge connection in the shared space, and c) visual representations in classroom talk are constructed by either teachers or students, expands one’s knowledge and reasoning from individual to collective and further social interactions.
Symposia
Schools are increasingly expected to provide opportunities for learners that foster and nurture their 21st century capabilities. Amongst these capabilities, creative and critical thinking are being afforded a great deal of prominence for their potential contribution to aspects of personal development (e.g. independence, ability to interpret and respond to with new situations) as well as to the economy and culture. Given increasing focus on the development of creative and critical thinking as a significant outcome of school education, what is known about how STEM education contributes to these capabilities? And, what might STEM education contribute to the development of these capabilities (in ways that are not yet being realized)? Further, how can the development of these capabilities contribute to STEM? The six presentations in this Symposium are the result of a collaborative project bringing together educators and researchers from across the informal and formal education sectors, to address these questions. Drawing on the ideas from this Symposium’s presentations, a final discussant will outline key insights from the collaboration between the Symposium’s presenters and others.

1. Thinking about critical and creative thinking in STEM Education (Peter Ellerton)
Critical and creative thinking are stated outcomes of most state and national curricula around the world. They are also among the most ill-defined and difficult to operationalise aspects of teaching, at least in terms of a consistency of understanding and implementation. Understanding what we mean by critical and creative thinking is an important step along the path to designing the kinds of learning experiences that foster these capabilities in our students. Since different conceptualisations of critical and creative thinking imply different approaches, getting this right pays a significant pedagogical dividend.

2. Fluency in STEM conversations (Cathy Buntting)
Drawing on a case study of teacher James and his class of 12-13 year olds, this presentation explores what ‘fluency’ might look like in STEM learning conversations, where fluency is interpreted as the ability to move seamlessly between the scientific, mathematical, technological, and everyday contexts. James’ expertise as a teacher in navigating these multiple discourses with students across a hydraulics STEM module provides insights into some of the knowledge and skills needed to effectively scaffold students’ STEM learning.

3. Using Out-of-School Activities to Enhance STEM Curricula (Léonie Rennie)
This presentation demonstrates how taking students outside of the classroom and providing them with learning activities that require interaction with local community issues enables them to develop their creativity and critical thinking in a STEM context. Three research-based examples of integrated STEM learning are analysed to illustrate how guiding students to interact with local, place-based, and/or community issues enabled them to develop and practice the skills of creativity and critical thinking, and began to develop a sense of ecological and social justice. These experiences benefited not only their creativity and critical thinking, but enhanced their skills of communication and collaboration. These are exactly the kinds of learning activities and outcomes that build confidence and create self-directed learners.

4. How the weak makerspace could be the future for STEM education (Micheal Tan)
In school systems increasingly gripped by the desire for accountability, technologies and ‘things’ are seen as means by which we can secure student engagement, and therefore, their learning and performance in standardised assessments. If we were to consider alternative goals for schooling,
such as increasing the innovative capabilities of our students, a conclusion that we might arrive at is that teachers need to embrace the risk arising from the essentially unforeseeable nature of nurturing creativity (Biesta, 2016). Thus, the notion of the weakness of STEM education is suggested: teachers need to approach STEM in a manner that is open to the possibilities of the interaction between teacher and student, a process that should not be scripted, even for the best intentions of student ‘success’. This presentation will consider how such a ‘weak makerspace’ can happen, and some challenges to its existence and success.

5. When failure means success: Accounts of the role of failure in the development of new knowledge in the separate STEM disciplines (Jennifer Mansfield & Richard Gunstone)

Failure is an integral aspect of knowledge development in the disciplines of Science, technology, Engineering and Maths (STEM). Yet the important role of failure within each discipline is often not portrayed accurately and openly to those outside the disciplines. This can lead to inaccurate perceptions about the role of failure, which in turn has implications for how failure in these disciplines is then valued and articulated in school STEM education. This chapter considers how failure is integral to advancement of each of the STEM disciplines, such as the value of ‘testing to failure’ in engineering or learning through failure to guide future inquiry in science. This discussion will highlight the valuable role failure plays for knowledge and skill development, and how this is often in contrast to how failure is used and valued (including by students) in each of the disciplines with school contexts.

Discussant: So how might we understand critical and creative thinking in relation to STEM?

Amanda Berry

Drawing on the ideas from this Symposium’s presentations, this final segment outlines key insights that came out of a collaboration between the Symposium’s presenters and others. There will also be room for discussion.
Surveying the primary science education landscape: What is happening in initial teacher education across Australia?

Symposium

Angela Fitzgerald, University of Southern Queensland, angela.fitzgerald@usq.edu.au
Kimberley Pressick-Kilborn, University of Technology Sydney, kimberley.pressick-kilborn@uts.edu.au
Reece Mills, Queensland University of Technology, reece.mills@qut.edu.au

There has been recent rapid change in primary school science education, as well as in teacher education. Anecdotally, we know that every institution develops and delivers a different science education experience for pre-service teachers, but there is little - perhaps no - research in Australia which captures what this actually looks like. This project endeavoured to connect with each Australian Initial Teacher Education (ITE) provider, with the aim of understanding approaches to primary science education and what drives decision making. The overarching research question is, What is happening in primary science teacher education in Australia and where to next? An exploratory study was conducted with teacher education academics and included an online survey to scope the big picture (n=29) and semi-structured interviews (n=13) to better understand the nuance and detail. Initial analysis indicates some of the tensions emerging from this research include accreditation (time, content and structure); links with professional experience; primary specialisms; casualisation of academic staff; and most broadly, the purpose of primary science education in itself. The evidence gathered through this project identifies similarities and differences in primary science ITE programs, and has the potential to shape the future of primary science education in Australia.
Workshops
Science Games Nights Workshop

Workshop Presentation

Dr George Aranda, Deakin University, george.aranda@deakin.edu.au
Dr John Cripps Clark, Deakin University, john.crippsclark@deakin.edu.au
Dr Peta White, Deakin University, peta.white@deakin.edu.au
Dr Joseph Ferguson, Deakin University, joe.ferguson@deakin.edu.au

Board games have been steadily growing in popularity over the last few decades. This has been in part due to the increased number of co-operative games that allow players to work together (e.g. solving a problem or saving the world). This workshop presents work conducted as part of National Science Week, where families were invited to attend science games nights around Victoria. A range of science board games of varying complexity were provided at these events, which examined different science topics that families could explore together and with other attendees. Playing these board games as a social group offered opportunities for attendees to share science ideas and socially co-construct understanding of the board games and related science content and skills. Challenges for organisers and attendees included: having too many board games available, difficulty in selecting appropriate games for younger children, and insufficient time available for meaningfully engagement with sophisticated games. Suggestions will be provided as to how educators can effectively run their own science games nights. This presentation will showcase two games (Organ Attack! and Go Extinct!) that were highlighted as part of these science games nights. Participants will have the opportunity to play these games and examine the affordances they provide for engaging with science concepts and skills.
## Corresponding Author Contacts

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arunee Eambaipreuk</td>
<td><a href="mailto:eam.arunee@gmail.com">eam.arunee@gmail.com</a></td>
</tr>
<tr>
<td>Adam Masri</td>
<td><a href="mailto:jonesad@deakin.edu.au">jonesad@deakin.edu.au</a></td>
</tr>
<tr>
<td>Aesha Bhansali</td>
<td><a href="mailto:bhansali.aesha@gmail.com">bhansali.aesha@gmail.com</a></td>
</tr>
<tr>
<td>Amanda Berry</td>
<td><a href="mailto:amanda.berry@monash.edu">amanda.berry@monash.edu</a></td>
</tr>
<tr>
<td>Amanda Woods-McConney</td>
<td><a href="mailto:a.woods-mcconney@murdoch.edu.au">a.woods-mcconney@murdoch.edu.au</a></td>
</tr>
<tr>
<td>Andrew Tzung-Jin Lin</td>
<td><a href="mailto:Tzungjinlin@ntnu.edu.tw">Tzungjinlin@ntnu.edu.tw</a></td>
</tr>
<tr>
<td>Ang Hao Yuan</td>
<td><a href="mailto:NIE18ANGH350@e.ntu.edu.sg">NIE18ANGH350@e.ntu.edu.sg</a></td>
</tr>
<tr>
<td>Angela Fitzgerald</td>
<td><a href="mailto:angela.fitzgerald@usq.edu.au">angela.fitzgerald@usq.edu.au</a></td>
</tr>
<tr>
<td>Annette Turney</td>
<td><a href="mailto:a.turney@uow.edu.au">a.turney@uow.edu.au</a></td>
</tr>
<tr>
<td>A-Rang Won</td>
<td><a href="mailto:arang89@gmail.com">arang89@gmail.com</a></td>
</tr>
<tr>
<td>Bev France</td>
<td><a href="mailto:b.france@auckland.ac.nz">b.france@auckland.ac.nz</a></td>
</tr>
<tr>
<td>Brady Michael Jack</td>
<td><a href="mailto:bradyjack@gmail.com">bradyjack@gmail.com</a></td>
</tr>
<tr>
<td>Bruce White</td>
<td><a href="mailto:Bruce.White@unisa.edu.au">Bruce.White@unisa.edu.au</a></td>
</tr>
<tr>
<td>Bud Talbot</td>
<td><a href="mailto:robert.talbot@ucdenver.edu">robert.talbot@ucdenver.edu</a></td>
</tr>
<tr>
<td>Carol Aldous</td>
<td><a href="mailto:carol.aldo@flinders.edu.au">carol.aldo@flinders.edu.au</a></td>
</tr>
<tr>
<td>Ching-Sui Hung</td>
<td><a href="mailto:sui20120401@gmail.com">sui20120401@gmail.com</a></td>
</tr>
<tr>
<td>Ching-Ting Hsin</td>
<td><a href="mailto:cthsin@gapp.nthu.edu.tw">cthsin@gapp.nthu.edu.tw</a></td>
</tr>
<tr>
<td>Chloë Nelson</td>
<td><a href="mailto:chloe.nelson@unimelb.edu.au">chloe.nelson@unimelb.edu.au</a></td>
</tr>
<tr>
<td>Christine Lindstrom</td>
<td><a href="mailto:c.lindstrom@unsw.edu.au">c.lindstrom@unsw.edu.au</a></td>
</tr>
<tr>
<td>Christine Preston</td>
<td><a href="mailto:christine.preston@sydney.edu.au">christine.preston@sydney.edu.au</a></td>
</tr>
<tr>
<td>Christopher Banks</td>
<td><a href="mailto:christopher.banks@csiro.au">christopher.banks@csiro.au</a></td>
</tr>
<tr>
<td>Chulkyu Park</td>
<td><a href="mailto:hghong@snu.ac.kr">hghong@snu.ac.kr</a></td>
</tr>
<tr>
<td>Clarence Toh Kai Wei</td>
<td><a href="mailto:NIE18TOHK9537@e.ntu.edu.sg">NIE18TOHK9537@e.ntu.edu.sg</a></td>
</tr>
<tr>
<td>Da Yeon Kang</td>
<td><a href="mailto:chajokim@snu.ac.kr">chajokim@snu.ac.kr</a></td>
</tr>
<tr>
<td>David Geelan</td>
<td><a href="mailto:d.geelan@griffith.edu.au">d.geelan@griffith.edu.au</a></td>
</tr>
<tr>
<td>Davis Jean-Baptiste</td>
<td><a href="mailto:Davis.L.JnBaptiste@student.uts.edu.au">Davis.L.JnBaptiste@student.uts.edu.au</a></td>
</tr>
<tr>
<td>Dongxue Jin</td>
<td><a href="mailto:jindongxue1108@163.com">jindongxue1108@163.com</a></td>
</tr>
<tr>
<td>Efrat Eilam</td>
<td><a href="mailto:Efrat.Eilam@vu.edu.au">Efrat.Eilam@vu.edu.au</a></td>
</tr>
<tr>
<td>Emily Rochette</td>
<td><a href="mailto:erochette@unimelb.edu.au">erochette@unimelb.edu.au</a></td>
</tr>
<tr>
<td>Erika Nadile</td>
<td><a href="mailto:Erika_Nadile@student.uml.edu">Erika_Nadile@student.uml.edu</a></td>
</tr>
<tr>
<td>Garry D. Galvez</td>
<td><a href="mailto:gg48@students.waikato.ac.nz">gg48@students.waikato.ac.nz</a></td>
</tr>
<tr>
<td>Gena C. Sbeglia</td>
<td><a href="mailto:gena.sbeglia@stonybrook.edu">gena.sbeglia@stonybrook.edu</a></td>
</tr>
<tr>
<td>George Aranda</td>
<td><a href="mailto:george.aranda@deakin.edu.au">george.aranda@deakin.edu.au</a></td>
</tr>
<tr>
<td>Gillian Kidman</td>
<td><a href="mailto:gillian.kidman@monash.edu">gillian.kidman@monash.edu</a></td>
</tr>
<tr>
<td>Hayashi Nakayama</td>
<td><a href="mailto:e04502u@cc.miyazaki-u.ac.jp">e04502u@cc.miyazaki-u.ac.jp</a></td>
</tr>
<tr>
<td>Heather McMaster</td>
<td><a href="mailto:heather.mcmaster@sydney.edu.au">heather.mcmaster@sydney.edu.au</a></td>
</tr>
<tr>
<td>Helen Georgiou</td>
<td><a href="mailto:helengeo@uow.edu.au">helengeo@uow.edu.au</a></td>
</tr>
<tr>
<td>Hong-Syuan Wang</td>
<td><a href="mailto:hongsyuanwang@gmail.com">hongsyuanwang@gmail.com</a></td>
</tr>
<tr>
<td>Hye-Gyoung Yoon</td>
<td><a href="mailto:yoonhk@cnue.ac.kr">yoonhk@cnue.ac.kr</a></td>
</tr>
<tr>
<td>Name</td>
<td>Email</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Hyeonjeong Shin</td>
<td><a href="mailto:masic12@snu.ac.kr">masic12@snu.ac.kr</a></td>
</tr>
<tr>
<td>Hyun-Jung Cha</td>
<td><a href="mailto:hyunjungcha00@gmail.com">hyunjungcha00@gmail.com</a></td>
</tr>
<tr>
<td>James Davis</td>
<td><a href="mailto:jp.davis@qut.edu.au">jp.davis@qut.edu.au</a></td>
</tr>
<tr>
<td>James Deehan</td>
<td><a href="mailto:jdeehan@csu.edu.au">jdeehan@csu.edu.au</a></td>
</tr>
<tr>
<td>Jules Rankin</td>
<td><a href="mailto:jran2204@uni.sydney.edu.au">jran2204@uni.sydney.edu.au</a></td>
</tr>
<tr>
<td>Kai Ming Kiang</td>
<td><a href="mailto:kaimingkiang@cuhk.edu.hk">kaimingkiang@cuhk.edu.hk</a></td>
</tr>
<tr>
<td>Karen Goodnough</td>
<td><a href="mailto:kareng@mun.ca">kareng@mun.ca</a></td>
</tr>
<tr>
<td>Katherine R. McCance</td>
<td><a href="mailto:krmccanc@ncsu.edu">krmccanc@ncsu.edu</a></td>
</tr>
<tr>
<td>Kathryn Paige</td>
<td><a href="mailto:kathy.paige@unisa.edu.au">kathy.paige@unisa.edu.au</a></td>
</tr>
<tr>
<td>Keith Skamp</td>
<td><a href="mailto:keith.skamp@scu.edu.au">keith.skamp@scu.edu.au</a></td>
</tr>
<tr>
<td>Kennedy Kam Ho Chan</td>
<td><a href="mailto:kennedyckh@hku.hk">kennedyckh@hku.hk</a></td>
</tr>
<tr>
<td>Kim Nichols</td>
<td><a href="mailto:k.nichols@uq.edu.au">k.nichols@uq.edu.au</a></td>
</tr>
<tr>
<td>Kimberley Wilson</td>
<td><a href="mailto:Kimberley.Wilson@acu.edu.au">Kimberley.Wilson@acu.edu.au</a></td>
</tr>
<tr>
<td>Kok-Sing Tang</td>
<td><a href="mailto:kok-sing.tang@curtin.edu.au">kok-sing.tang@curtin.edu.au</a></td>
</tr>
<tr>
<td>Kristy Osborne</td>
<td><a href="mailto:Kristy.Osborne@acer.org">Kristy.Osborne@acer.org</a></td>
</tr>
<tr>
<td>Larry Bencze</td>
<td><a href="mailto:larry.bencze@utoronto.ca">larry.bencze@utoronto.ca</a></td>
</tr>
<tr>
<td>Laura Martin Ferrer</td>
<td><a href="mailto:laura.martin@uvic.cat">laura.martin@uvic.cat</a></td>
</tr>
<tr>
<td>Liam Guilfoyle</td>
<td><a href="mailto:liam.guilfoyle@education.ox.ac.uk">liam.guilfoyle@education.ox.ac.uk</a></td>
</tr>
<tr>
<td>Lihua Xu</td>
<td><a href="mailto:lihua.xu@deakin.edu.au">lihua.xu@deakin.edu.au</a></td>
</tr>
<tr>
<td>Linda Hobbs</td>
<td><a href="mailto:l.hobbs@deakin.edu.au">l.hobbs@deakin.edu.au</a></td>
</tr>
<tr>
<td>Louisa Tomas</td>
<td><a href="mailto:louisa.tomas@jcu.edu.au">louisa.tomas@jcu.edu.au</a></td>
</tr>
<tr>
<td>Lynn Walker</td>
<td><a href="mailto:lynn.walker@science.org.au">lynn.walker@science.org.au</a></td>
</tr>
<tr>
<td>Majd Zouda</td>
<td><a href="mailto:majd.zouda@mail.utoronto.ca">majd.zouda@mail.utoronto.ca</a></td>
</tr>
<tr>
<td>Margaret R. Blanchard</td>
<td><a href="mailto:Meg_Blanchard@ncsu.edu">Meg_Blanchard@ncsu.edu</a></td>
</tr>
<tr>
<td>Matthew Hill</td>
<td><a href="mailto:mhill@barker.nsw.edu.au">mhill@barker.nsw.edu.au</a></td>
</tr>
<tr>
<td>Michael Fitzgerald</td>
<td><a href="mailto:m.fitzgerald@ecu.edu.au">m.fitzgerald@ecu.edu.au</a></td>
</tr>
<tr>
<td>Michael Michie</td>
<td><a href="mailto:michael.michie@batchelor.edu.au">michael.michie@batchelor.edu.au</a></td>
</tr>
<tr>
<td>Nicholas Ruddell</td>
<td><a href="mailto:nruddell@csu.edu.au">nruddell@csu.edu.au</a></td>
</tr>
<tr>
<td>Nurul Hassan Mohammad</td>
<td><a href="mailto:nurul.mohammad@mail.utoronto.ca">nurul.mohammad@mail.utoronto.ca</a></td>
</tr>
<tr>
<td>Olga Ioannidou</td>
<td><a href="mailto:olga.ioannidou@education.ox.ac.uk">olga.ioannidou@education.ox.ac.uk</a></td>
</tr>
<tr>
<td>Peta White</td>
<td><a href="mailto:peta.white@deakin.edu.au">peta.white@deakin.edu.au</a></td>
</tr>
<tr>
<td>Petr Lebedev</td>
<td><a href="mailto:petr.lebedev@sydney.edu.au">petr.lebedev@sydney.edu.au</a></td>
</tr>
<tr>
<td>Radu Bogdan Toma</td>
<td><a href="mailto:rbtoma@ubu.es">rbtoma@ubu.es</a></td>
</tr>
<tr>
<td>Reece Mills</td>
<td><a href="mailto:reece.mills@qut.edu.au">reece.mills@qut.edu.au</a></td>
</tr>
<tr>
<td>Rekha Koul</td>
<td><a href="mailto:r.koul@curtin.edu.au">r.koul@curtin.edu.au</a></td>
</tr>
<tr>
<td>Roxanne Shu Xin Lau</td>
<td><a href="mailto:NIE184289@e.ntu.edu.sg">NIE184289@e.ntu.edu.sg</a></td>
</tr>
<tr>
<td>Russell Tytler</td>
<td><a href="mailto:russell.tytler@deakin.edu.au">russell.tytler@deakin.edu.au</a></td>
</tr>
<tr>
<td>Ruth Fentie</td>
<td><a href="mailto:Ruth.A.Fentie@student.uts.edu.au">Ruth.A.Fentie@student.uts.edu.au</a></td>
</tr>
<tr>
<td>Sally Gutierez</td>
<td><a href="mailto:sbgutierez@up.edu.ph">sbgutierez@up.edu.ph</a></td>
</tr>
<tr>
<td>Sarah Halwany</td>
<td><a href="mailto:sarah.elhalwany@mail.utoronto.ca">sarah.elhalwany@mail.utoronto.ca</a></td>
</tr>
<tr>
<td>Sarika Kewalramani</td>
<td><a href="mailto:sarika.kewalramani@monash.edu">sarika.kewalramani@monash.edu</a></td>
</tr>
<tr>
<td>Name</td>
<td>Email</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Senka Henderson</td>
<td><a href="mailto:s10.henderson@qut.edu.au">s10.henderson@qut.edu.au</a></td>
</tr>
<tr>
<td>Seok-Hyun Ga</td>
<td><a href="mailto:shga89@naver.com">shga89@naver.com</a></td>
</tr>
<tr>
<td>Shana McAlexander</td>
<td><a href="mailto:slmcalex@ncsu.edu">slmcalex@ncsu.edu</a></td>
</tr>
<tr>
<td>Sheila Shamuganathan</td>
<td><a href="mailto:shamsheila@yahoo.com">shamsheila@yahoo.com</a></td>
</tr>
<tr>
<td>Sheng-Chang Chen</td>
<td><a href="mailto:sengechen@nctu.edu.tw">sengechen@nctu.edu.tw</a></td>
</tr>
<tr>
<td>Shiho Miyake</td>
<td><a href="mailto:miyake@mail.kobe-c.ac.jp">miyake@mail.kobe-c.ac.jp</a></td>
</tr>
<tr>
<td>Shih-Yun Ming</td>
<td><a href="mailto:happy12517@gmail.com">happy12517@gmail.com</a></td>
</tr>
<tr>
<td>Shuchen Guo</td>
<td><a href="mailto:201521200002@mail.bnu.edu.cn">201521200002@mail.bnu.edu.cn</a></td>
</tr>
<tr>
<td>Sibel Erduran</td>
<td><a href="mailto:sibel.erduran@education.ox.ac.uk">sibel.erduran@education.ox.ac.uk</a></td>
</tr>
<tr>
<td>Srivdya Durga Kota</td>
<td><a href="mailto:skot2539@uni.sydney.edu.au">skot2539@uni.sydney.edu.au</a></td>
</tr>
<tr>
<td>Su-Fen Chuang</td>
<td><a href="mailto:t1160407@gmail.com">t1160407@gmail.com</a></td>
</tr>
<tr>
<td>Su-Yeon Choi</td>
<td><a href="mailto:csy222@snu.ac.kr">csy222@snu.ac.kr</a></td>
</tr>
<tr>
<td>Tabetha Spiteri</td>
<td><a href="mailto:tabetha.spiteri@monash.edu">tabetha.spiteri@monash.edu</a></td>
</tr>
<tr>
<td>Tom Gordon</td>
<td><a href="mailto:tom.gordon@sydney.edu.au">tom.gordon@sydney.edu.au</a></td>
</tr>
<tr>
<td>Tracey-Ann Palmer</td>
<td><a href="mailto:Tracey-Ann.Palmer@uts.edu.au">Tracey-Ann.Palmer@uts.edu.au</a></td>
</tr>
<tr>
<td>Tshewang Rabgay</td>
<td><a href="mailto:Tshewang.Rabgay@monash.edu">Tshewang.Rabgay@monash.edu</a></td>
</tr>
<tr>
<td>Vaille Dawson</td>
<td><a href="mailto:vaille.dawson@uwa.edu.au">vaille.dawson@uwa.edu.au</a></td>
</tr>
<tr>
<td>Vicky Tzioumis</td>
<td><a href="mailto:vicky.tzioumis@sydney.edu.au">vicky.tzioumis@sydney.edu.au</a></td>
</tr>
<tr>
<td>Victoria Millar</td>
<td><a href="mailto:vmillar@unimelb.edu.au">vmillar@unimelb.edu.au</a></td>
</tr>
<tr>
<td>Wonyong Park</td>
<td><a href="mailto:wonyong.park@education.ox.ac.uk">wonyong.park@education.ox.ac.uk</a></td>
</tr>
<tr>
<td>Yaela Golumbic</td>
<td><a href="mailto:yaela.golumbic@sydney.edu.au">yaela.golumbic@sydney.edu.au</a></td>
</tr>
<tr>
<td>Yujiao Qiao</td>
<td><a href="mailto:y.qiao@auckland.ac.nz">y.qiao@auckland.ac.nz</a></td>
</tr>
<tr>
<td>Yvonne Yi-Fen Yeh</td>
<td><a href="mailto:yyf521@ntnu.edu.tw">yyf521@ntnu.edu.tw</a></td>
</tr>
</tbody>
</table>
ASERA 2020 online conference
In lieu of the face to face conference planned to be held at North Wollongong University
Hosted by the University of Wollongong
Contact: wnielsen@uow.edu.au