ASERA
AUSTRALASIAN SCIENCE EDUCATION RESEARCH ASSOCIATION LTD

ANNUAL CONFERENCE

Massey University, Auckland Campus

Albany, New Zealand

2-5 July 2024

Photo Credit: Ollie Craig

Contents

Welcome from the Conference Organisers 3
Conference Overview..... 4
Be part of the ASERA Community..... 5
Thank you to our Sponsors, Exhibitor, and Supporters 5
A Brief Guide to Auckland 8
Sir Neil Waters Location and Layout 8
Important Information for Delegates 10
Parallel Presentation Program – Wednesday July 3.....12
Parallel Presentation Program – Thursday July 4.....14
Parallel Presentation Program – Friday July 5.....17
Abstracts.....19
- Wednesday Parallel Sessions 19
- Thursday Parallel Sessions 41
- Friday Parallel Sessions 68
- Thursday Poster Abstracts 80
- Friday Poster Abstracts 87
- Symposia Abstracts.....94

Welcome from the Conference Organisers

Kia ora koutou, nau mai, haere mai.

Welcome to Auckland, New Zealand for the 55th conference of the Australasian Science Education Research Association (ASERA). We are delighted that you have chosen to join with us, bringing researchers, educators, and practitioners together to discuss and progress science education. We look forward to the thinking, learning, and discussions that will take place over the next few days.

Excitingly, ASERA 55 is the largest ASERA conference to date. We have over 170 delegates from 15 countries attending, discussing five symposia, 24 posters, and 103 paper presentations. This conference will offer a wonderful opportunity to encourage collaboration and the exchange of ideas to shape the future of science education in Australasia and beyond.

Leading science education researchers will share their research and insights, and as you can see in the program, there is much diversity in the presentations. We encourage you to engage in considered discussion, asking thoughtful questions, and offer mana-enhancing feedback.

ASERA has a rich history of supporting early career researchers (ECRs) and higher degree by research students (HDRs). This year we are pleased to host our bi-annual ECR/HDR workshop, and we are grateful to **Professor Bronwen Cowie** and **Professor Léonie Rennie** for hosting this event. Additionally, we are grateful to **Dr Rose Hipkins** and **Professor Russell Tytler** for hosting our annual ECR/HDR Fireside Chat. Thanks also to **Associate Professor Reece Mills** and **Professor Jan van Driel** for their ongoing support for our ECR/HDR ASERA community.

We offer a sincere thank you to our conference volunteers for ASERA 55: **Michael Calarese**, **Samantha Bothe**, **Jing Zhang**, and **Melinda Dixon**. We also thank those who worked to review over 200 abstracts submitted for ASERA 55. Lastly, a massive thank you to **Tabetha Spiteri**, our ASREA Executive Officer, for her endless support for all aspects of hosting this wonderful conference.

We extend our warmest welcome to you all. We hope that you enjoy your time in Aotearoa and that you find the conference inspiring, and return home feeling engaged, informed, and energised.

Ngā mihi nui.

Dr Jared Carpendale

Dr Carrie Swanson

Dr Cathy Buntting

Conference Overview

Tuesday July 2	**HDR/ECR Workshop*** 10:00am-4:00pm **ASERA Board Meeting** 1.30pm-3.30pm **Conference Registrations** 4:00pm **Conference Welcome Reception** 5:00pm *For current HDRs/ECRs who submitted an expression of interest (EOI) to attend the workshop and have had their EOI accepted.
Wednesday July 3	**Registration Desk** Opens at 8.00am **Pōwhiri (Māori welcome)** 8:30am **Morning Tea** 9:00am **Parallel Sessions** Begin at 9:20am **Lunch** 12.00pm **Afternoon Tea** 2.50pm **ASERA Annual General Meeting** 3:15pm **HDR/ECR Fireside Chat**** 5:30pm **ASERA Board Dinner** 7:30pm **For current HDRs/ECRs who have registered to attend the Fireside Chat by completing the registration form, and have had their registration accepted via email.
Thursday July 4	**Registration Desk** Opens at 8:00am **Parallel Sessions** begin at 8:30am **Morning Tea** 10.30am **Lunch** 1.00pm **Poster Session** 3.45pm **Afternoon Tea** 4.25pm **Conference Dinner** 6:00pm (Buses depart at 5:30pm, see page 9 for bus stop location next to the SNW building)
Friday July 5	**Registration Desk** Opens at 8:00am **Parallel Sessions** begin at 8:30am **Poster Session** 9.50am **Morning Tea** 10.30am **Lunch** 12.20pm **RISE Associate Editor Meeting** 12.20pm **Conference Concludes** 1:00pm **Airport Bus Departs** approximately 1.15pm

Be part of the ASERA Community

Become an ASERA member at https://www.asera.org.au/ A special thank you to our ASERA website creators, David Geelan and Tabetha Spiteri.

Follow us on X (@ASERAeducation) and Linkedin for updates on the conference and for information on other science education research events. When posting about the conference on social media, please use the official conference hashtag (#ASERA55). Please share others' posts and please tag us in your posts.

Thank you to our Sponsors, Exhibitor, and Supporters

Platinum Sponsor

TE KUNENGA KI PŪREHUROA MASSEY UNIVERSITY UNIVERSITY OF NEW ZEALAND | TE KURA O TE MĀTAURANGA INSTITUTE OF EDUCATION

Silver Sponsor

NZCER Rangahau Mātauranga o Aotearoa

Conference Exhibitor

Springer

A Springer Exhibition booth will be located in the main area, from Wednesday to Friday.

Conference Supporters

- Quest Albany
- Ramada Suites Albany
- Sunrise Garden Apartments
- Albany Rosedale Motel
- Compass Group Catering
- Soljans Estate

Institute of Education | Te Kura o Te Mātauranga

Overview

He Kura Tāngata, He Tāngata Kura

This whakataukī expresses our valuing of scholarship and recognition of the unique talents of each member. It cherishes the importance of connecting with people to encourage collaborative partnership in the field of education.

The Institute of Education – Te Kura o Te Mātauranga is an educational environment that values equity, excellence and scholarship in teaching and learning. Our mission is to use responsive and transformative ideas, and work with people in partnership to affect all levels of education success. The Institute of Education promotes equity in education through its academic and professional programmes and research, and lifelong professional learning and development opportunities. Our teaching and research focuses on the role education plays in shaping a just, fair society for all.

We are deeply committed to being a Tiriti-led university, demonstrating authentic leadership in contemporary Aotearoa New Zealand as we uphold te Tiriti o Waitangi (the Treaty of Waitangi), the founding document of our nation, and its principles through our practice. We embrace this not just as an obligation but as a real opportunity for the nation and its people.

Research Centres

Our two research centres seek innovative solutions to contemporary issues. **Equity through Education** is an inter-professional community of educators researching issues of educational inequity. Our vision is to break down barriers to learning and promote equity in and through education via research, inquiry, supervision/mentoring and scholarship. **Centre for Research in Mathematics Education** brings experts together to work on the transformative potential of maths education in New Zealand, the Pacific and the world. A focus on equity and cultural responsiveness underwrites our projects and our developmental work with teachers, postgraduate students, and new researchers.

Study with us

The Institute of Education offers a range of opportunities for your lifelong learning journey and career pathway, with a range of professional and academic programs.

New Zealand Council for Educational Research | Rangahau Mātauranga o Aotearoa

Since its inception in 1934, NZCER has been an active researcher and supporter in the Aotearoa science education space. Our recent work has included the development of a set of science capabilities, which continue to be deployed as part of the framework for assessment of science in the national monitoring programme, and exploration of the knowledge systems approach to science curriculum design. We are thrilled to support ASERA at its 2024 conference.

A Brief Guide to Auckland

We hope that you can find some time to enjoy Auckland and New Zealand. Some highlights are offered below, and you can also browse Tourism New Zealand and Discover Auckland.

Auckland Airport

There are a range of transport options to and from Auckland airport, including taxis, car hire, rideshare, and shuttles. We recognise that the university is far from the airport, and we encourage delegates to share a ride. You can also use the public transport network in Auckland, if using this option, we recommend using the Auckland Transport website or app and you will need to buy an AT HOP card, which can be purchased at the airport. A bus has been charted at the conclusion of the conference, leaving from the university at approximately 1.15pm – the bus stop is shown on the map on the next page with a B – please see the registration desk for more information.

Getting around Auckland

Many of the conference hotels are within walking distance to the university. There is also free car parking at the university and many options for ridesharing and taxis. The bus network in Auckland is extensive and reliable, and the bus stop at the university is Stop 4214 – there are three buses services that stop there, bus 83, 861, and 917. If you plan to use public transport, we recommend using the Auckland Transport website or app. You will need an AT HOP card.

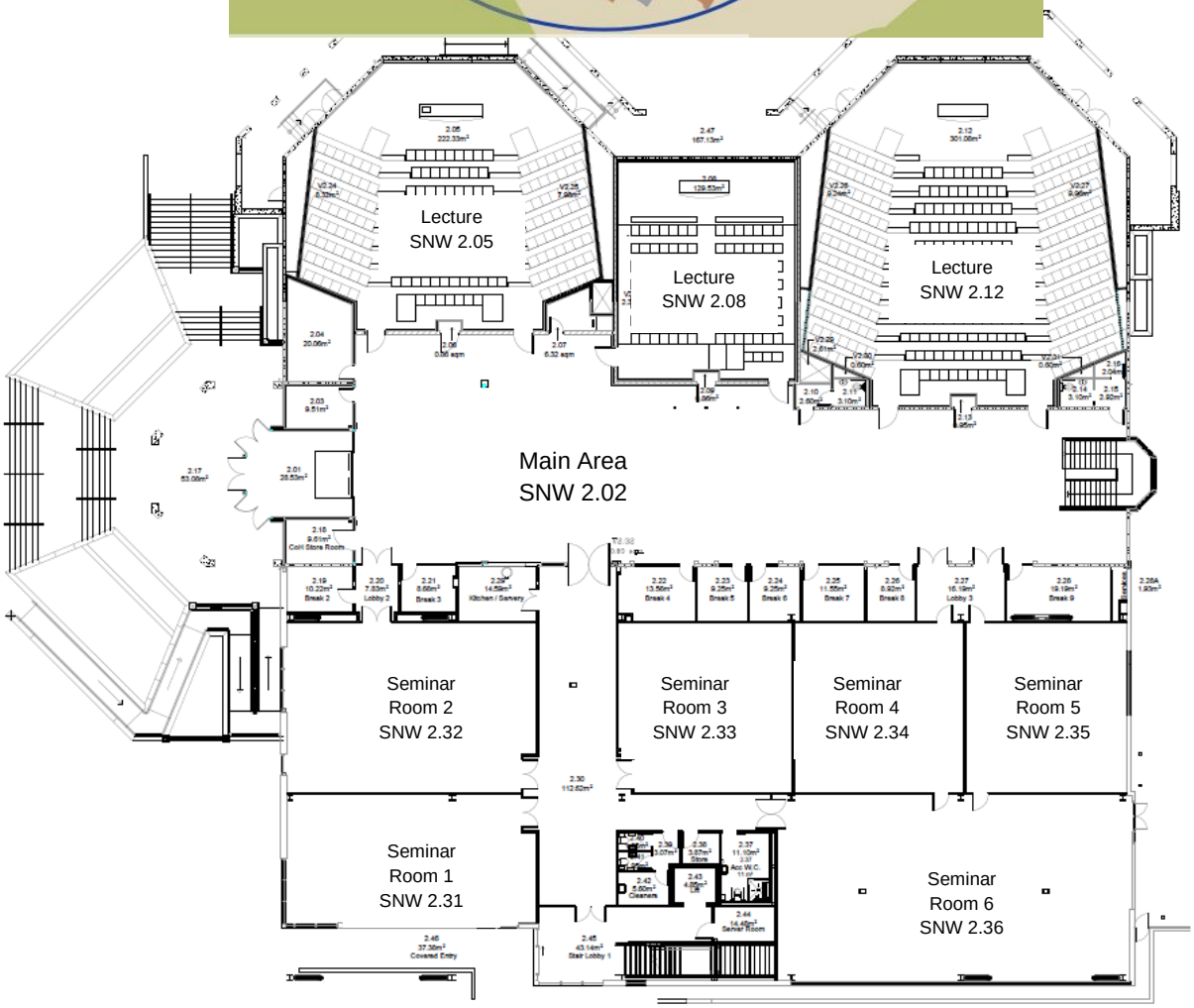
Things to do

If you have the chance before or after the conference to stay a little longer in New Zealand, here are few things you may like to explore:

- Visit the Sky Tower. At 328 meters tall, it offers wonderful panoramic views of Auckland. There is also a rotating restaurant at the top, and if you're feeling brave you can walk on the outside.
- Climb the Auckland Harbour Bridge, or if you're feeling extra brave, you can bungy jump from it.
- Visit Waiheke Island – home to around 30 boutique wineries. You will need to catch a ferry to visit Waiheke Island.
- Take a tour around Auckland harbour and see why it is often called the *city of sails.*
- Staying longer in New Zealand? Auckland Airport is our largest airport and Air New Zealand has daily flights to all cities and regions.

Photo Credit: Liam Spicer

Sir Neil Waters Location and Layout



Important Information for Delegates

Complimentary Wi-Fi
Network: MUEvents
Password: 3vent@MU24!

COVID19 Restrictions
There are currently no COVID19 restrictions in place in New Zealand. However, we ask you all to please be mindful of others. If you're not feeling well, please consider not coming to the conference. We know that this will be disappointing, but we are each responsible for helping to keep our wider communities safe. Covid19 tests can be purchased at local pharmacies, or you can ask one of our conference team for advice.

Welcome Reception
Please join us on Tuesday evening for the ASERA 55 Welcome Reception. This event will be hosted in the main area of the Sir Neil Waters building from 5.00pm, and you will be able to register from 4.00pm.

Pōwhiri
Our official welcome to ASERA 55 will take place on Wednesday at the Sir Neil Waters building, starting at 8.30am. Please arrive before that time and you will be provided with instructions and advice about the process, which will finish with morning before the parallel paper sessions begin at 9.20am.

Refreshments
Morning tea, lunch, and afternoon tea is included for all delegates, including lunch on Friday, and a water station will be available for the duration of the conference. Coffee and tea are available upon arrival each morning, except the Wednesday as we will be having the pōwhiri first, and then going into morning tea. Catering will be served in the main area of the Sir Neil Waters Building.

Name Badges
You will be issued a name badge that identifies you and your conference registration when you first check in at the registration desk. Your name badge serves as your conference pass, so please always wear it, at all conference events.

Lanyards
For sustainability reasons, we ask that all delegates bring their own lanyard to the conference - you could even swap lanyards with a new friend that you make whilst at the conference! However, we do have a few spare lanyards if required (see the Registration desk).

Mobile Phones
As a courtesy to presenters and other delegates, please ensure that your mobile phone is silent or switched off during all sessions and conference events.

AV Systems and Uploading your Presentation
All but one of the rooms has a console desktop computer and the AV set up in the room is powered by a Creston touch panel. Each computer has a unique username and password, which will be attached to the computer. The computers can stay logged in for the whole day. Seminar Room 5 (SNW 2.45) has a Promethean ActivPanel, which operates as an integrated computer, and it will also have a username and password.
Please upload your presentation to the computer that is in the room prior to your presentation – we suggest doing that during morning registration or during break times. The easiest way to upload is via USB, and there will be USBs available in each room. The conference volunteers will be able to assist.

Symposium Presentations
Symposium presentation sessions are allocated a double conference slot and may consist of three or four paper papers about a common theme, and they may also include a discussant. It is expected that half the time will be allocated to questions and discussion.

Instructions for Session Chairs
Each presentation time slot is strictly 40 minutes. It is expected that the presentation is no longer than 20 minutes, followed by questions and discussion. To ensure the program runs to schedule, please adhere strictly to the program, as provided. If a presenter does not arrive for their presentation, please do not move other presenters forward, but rather, wait until the scheduled time to begin the next presentation. Please introduce the author/s and paper title at the start of each presentation. At the end of the presentation, please thank the author/s and facilitate question time.

Instructions for Presenters
Each presentation time slot is strictly 40 minutes. It is expected that the presentation is no longer than 20 minutes, followed by questions and discussion. Please ensure that your presentation has been uploaded to the computer in the room and that you are there prior to the start of your session so the conference program runs on-time. The Session Chair will brief delegates about the format and introduce the presentations and facilitate questions and discussion.

Instructions for Poster Presenters
There are two poster presentation sessions within the program – Thursday afternoon and Friday morning. Poster presenters are expected to present their poster for questions and discussion during these times. If you wish to keep your poster, please collect it at the conclusion of the poster session on your scheduled day.

Need Help?
Please talk with our volunteers at the registration desk, or to the conference organisers. For emergency assistance, please contact Jared Carpendale (j.carpendale@massey.ac.nz or +64 21 149 6543).

Parallel Presentation Program – Wednesday July 3

Time	Parallel Session #1 Seminar Room 1 (2.3.1)	Parallel Session #2 Seminar Room 2 (2.3.2)	Parallel Session #3 Seminar Room 3 (2.3.3)	Parallel Session #4 Seminar Room 4 (2.3.4)	Parallel Session #5 Seminar Room 5 (2.3.5)	Parallel Session #6 Seminar Room 6 (2.3.6)
Registration opens at 8:00am **- SNW Main Area - 2.0.2 | Pōwhiri (Māori welcome)** at 8:30am - SNW Main Area - 2.0.2						
MORNING TEA at 9:00am **| SNW Main Area - 2.0.2**						
	Session Chair: Jared Carpendale **HDR Volunteer:** Melinda Dixon	**Session Chair:** Kathy Smith **HDR Volunteer:** Melinda Dixon	**Session Chair:** John Cripps Clark **HDR Volunteer:** Samantha Bothe	**Session Chair:** Maurice M.W. Cheng **HDR Volunteer:** Jing Zhang	**Session Chair:** Cristina Guarrella **HDR Volunteer:** Jing Zhang	**Session Chair:** Carrie Swanson **HDR Volunteer:** Michael Calarese
9:20am	*Transformative pathways: Examining the development and transfer of topic-specific pedagogical content knowledge in New Zealand physics teachers through collaborative professional learning and development* Rebecca Harrop, Robin Averill, Karyn Saunders	*Reflecting on practice and professional learning through a STEM observation protocol* Emily Dare, Joshua Ellis, Christopher Irwin	*Cultivating critical thinking skills for the era of rapid information dissemination: A study on teacher training and curriculum development* Sheng Yi Hsiao, Chun Yen Chang	*The zoo: Science-rich but technologies and mathematics-poor – or is it? Reconstructing STEM ideas for future teachers through a zoo-based design thinking program* Timna Garnett, Shaileigh Rowtcliff	*Advancing a conceptual framework for fostering gender equity in early years STEM education* Lihua Xu, Jiqing Sun, Kylie Smith, Sarika Kewalramani, Linda Hobbs, Jan van Driel, Victoria Millar, George Aranda, Gerarda Richards, Lulu Hawkins, Bridgette Van Leuven, Belinda Dealy	**Symposium** *Developing an ASERA position statement on the future science education we need: Implications for policy, research, and practice.* Carol Aldous, Vaille Dawson, Tanya Doyle, Linda Hobbs, Carrie Swanson, David Treagust, Russell Tytler, Leonie Rennie
10.00am	*Development and application of an instrument to measure high school biology teachers' pedagogical content knowledge of scientific thinking* Shan Lin, Jian Wang	*Exploring problem-based learning in STEM education: Developing illustrations of practice* Kathy Smith, Jennifer Mansfield, Amanda Berry, Debbie Corrigan	*Research on secondary science teacher preparation: A review* Ron Gray, Jan van Driel	*Imagination to discovery: Science fiction convention attendees' interest in science and science fiction over a lifespan* Gina Childers, Rebecca Hite, Kania Greer	*Emotional imagination and relational expertise in STEM education: A co-teaching model for the early years* Marilyn Fleer, Aishwarya Kansakar, Monique Parkes	
10.40am	*Not all reflections are reflections – Organizing reflection-related terms using the Refined Consensus Model* Lukas Mientus, Andreas Borowski	*Developing teacher expertise in interdisciplinary science and mathematics teaching: The role of teacher epistemological beliefs in shaping practices* Wanty Widjaja, Lihua Xu, Lam Pham, Amanda Berry	*Developing pre-service teachers' capacity for cognitively demanding science teaching* Danielle Dani, Sara Salloum	*Informal science education strategies for anti-extinction education in the community: A small case study from tropical Queensland* Hilary Whitehouse	*Scientific playworlds: Young people's exploration of science ideas through drawing, model making and visualisation* Simon Taylor, Barbara Whyte	**Symposium** *International perspectives on climate change education* Peta White, Chris Eames, Yu-Chi Tseng, Rose Hipkins
11.20am	*Pedagogical content knowledge: Is it still a relevant and useful construct for science education?* Jared Carpendale, Andreas Borowski, Rebecca Cooper, Amanda Berry, Jan van Driel	*Piloting the Challenge-Based Learning (CBL) Framework in senior high school: The journey of STEM students in De La Salle University Integrated School* Leah Madrazo, Mary Geraldine Yumang, Angela Nicole Masongsong	*Reimagining primary science teacher education: A response to the challenge of online learning* John Cripps Clark, Melinda Kirk	*Teachers' learning ecologies for teaching science – contributions of learning from informal contexts and previous work experience* Mandy Gundersen, Maurice M.W. Cheng, Bronwen Cowie	*Learning progressions in early childhood science: Identifying new opportunities* Cristina Guarrella	

LUNCH at 12:00pm **| SNW Main Area - 2.0.2**						
	Session Chair: Linda Hobbs **HDR Volunteer:** Melinda Dixon	**Session Chair:** Vaille Dawson **HDR Volunteer:** Melinda Dixon	**Session Chair:** Gillian Roehrig **HDR Volunteer:** Samantha Bothe	**Session Chair:** Sabina Cleary **HDR Volunteer:** Jing Zhang	**Session Chair:** Ben Egerton **HDR Volunteer:** Jing Zhang	**Session Chair:** Chris Preston **HDR Volunteer:** Michael Calarese
12:50pm	*Entrepreneurship education and secondary STEM: Lessons from the Victorian Tech Schools* John Cripps Clark, Jennier Palisse	*Unveiling argumentation skill profiles: Using Toulmin's Argumentation Model on senior high school students' responses to general biology open-ended questions* Chelcea Mae Lagmay Darang, Sarah Meilani Fadillah, Minsu Ha	*A model for preparing pre-service science teachers in Engineering Design Integrated Science (EDIS) Teaching* Frackson Mumba		*Unveiling digital divides: Contextual factors impacting secondary teachers' ICT integration* Jing Zhang, Michael Phillips, Rebecca Cooper	*Using epistemic network analysis to investigate connections between instructional strategies and children's scientific practices in kindergartens* Ren-Cheng Zhang, Hsin-Kai Wu, Ching-Ting Hsin
1.30pm	*Positioning empathy in STEM education reform: Insights from a diverse cohort of Hong Kong STEM education leaders* Zeyu Han, Chen Chen	*Reviving post-pandemic adolescents' science interest: A mixed-methods study on the effectiveness of argument-driven inquiry and academically productive talk approaches* Kin-yi Promail Leung	*Effective engineering education for elementary multilingual learners: A conceptual framework for transformative professional learning* Jerome M. Shaw	*Investigating students' perceptions of science teachers' inquiry teaching practices, learning expectations, and learning interest in the inquiry curriculum* Shu-Fen Lin	*Unlocking the power of technology in education: A deep dive into Indonesian teachers' technological pedagogical and content knowledge with epistemic network analysis* Van Thi Hoang Ngo, Marison Sudianto Manalu, Chun-Yen Chang	*Developing a community-based program for climate change education in Korean elementary schools* Miyeon Kim, Chankook Kim
2.10pm	*STEM education ecosystems: Pathways, connections and innovations created by Victorian Tech Schools* Linda Hobbs, George Aranda	*Using socioscientific issues to improve argumentation skills in a low socioeconomic regional high school* Vaille Dawson	*Middle school students' application of science content and context into engineering design solutions* Gillian Roehrig, Muhammad Purwanto	*Moving forward: Implementing the nature of science in New Zealand secondary schools* Sabina Cleary	*Where, when, and how? Exploring models of digital technology integration in science teaching and learning* Ben Egerton	*Sci-5: Should school start with stimulating science?* Chris Preston, Helen Georgiou, Angela Fitzgerald
AFTERNOON TEA at 2:50pm **| SNW Main Area - 2.0.2**						
ASERA 2024 AGM at 3:15pm **| SNW Lecture Theatre 2.12**						
HDR/ECR FIRESIDE CHAT at 5:30pm **| SNW Seminar Room 2**						
ASERA BOARD DINNER at 7:30pm **| Orbit 360°**						

Parallel Presentation Program – Thursday July 4

Time	Parallel Session #1 Seminar Room 1 (2.3.1)	Parallel Session #2 Seminar Room 2 (2.3.2)	Parallel Session #3 Seminar Room 3 (2.3.3)	Parallel Session #4 Seminar Room 4 (2.3.4)	Parallel Session #5 Seminar Room 5 (2.3.5)	Parallel Session #6 Seminar Room 6 (2.3.6)
Registration/Tea & Coffee from 8:00am **- SNW Main Area - 2.0.2**						
8:30am	**Session Chair:** George Aranda **HDR Volunteer:** Melinda Dixon	**Session Chair:** Felicity McLure **HDR Volunteer:** Melinda Dixon	**Session Chair:** Cathy Buntting **HDR Volunteer:** Samantha Bothe	**Session Chair:** Rebecca Cooper **HDR Volunteer:** Jing Zhang	**Session Chair:** Jared Carpendale **HDR Volunteer:** Jing Zhang	**Session Chair:** Rachel Sheffield **HDR Volunteer:** Michael Calarese
	STEM student profiles George Aranda	*Primary teachers' unpredictable moments in interdisciplinary mathematics and science teaching* Gahyoung Kim, Amanda Berry, Joe Ferguson, Lihua Xu	*Secondary science teachers' conceptions and teaching practices of environmental education* Hsiao Mei Huang, Su Chi Fang	*Factors influencing the development of academic motivation of gifted students in science* Hae-Ae Seo, Yeon-Hee Kim	*Profiling scientific inquiry skills of Taiwanese high school students: A latent profile analysis* Yu-Chun Chen, Chi-Jung Sui, Chun-Yen Chang	**Symposium** *Empowering Educators for Environmental Change: Examining contextual classroom practices within South Korea and Australia focusing on environmental education through a design thinking lens* Rachel Sheffield, Rekha Koul, Michelle De Kok, Nicole Fairhurst, Ella Fitriani
9.10am	*An exploration of students' engagement with 21st-Century skills during integrated STEM activity* Muhammad Purwanto, Gillian Roehrig	*Primary school boys' and girls' awareness and interest in STEM-related activities, subjects, and careers* Michael Carey, Natalie McMaster, David Martin	*Effect of course-based research experiences in secondary advanced biological science courses: impacts on student self-efficacy, engagement, sense of belonging, identity, and overall motivation in STEM* Shawndra Fordham, Robert Talbot	*Investigating the effects of inquiry and practices course on high school students' motivation towards science learning* Yi-Hsuan Shih, Su-Chi Fang	*Predicting student success in tests using data generation and machine learning techniques* Yiu-Tin Lai, Bo-Heng Lin, Chun-Yen Chang	
9.50am	*Evaluation of an SSI-based STEAM program for scientific literacy and agency in climate change* Ha My Anna Mang, Hye-Eun Chu, Sony Martin, Michael Cavanagh	*Do Australian students still hold gendered views of suitability of STEM careers? Results from a STEM stereotypes questionnaire* Felicity McLure, Sevda Yerdelen-Damar	*Learning about photosynthesis through online scientific inquiry coupling microscopic representations: Collaborative versus individual learning?* Jyun-Sheng Syu, Ching-Ying Hsueh, Hsiao-Ching She		*Exploring Taiwanese IB science teachers' beliefs and implementation of inquiry-based teaching* Yu-An Chen, Su-Chi Fang	
MORNING TEA at 10:30am **| SNW Main Area - 2.0.2**						

	S Session Chair: Connie Cirkony **HDR Volunteer:** Melinda Dixon	**Session Chair:** Kok-Sing Tang **HDR Volunteer:** Melinda Dixon	**Session Chair:** Leonie Rennie **HDR Volunteer:** Samantha Bothe	**Session Chair:** Victoria Millar **HDR Volunteer:** Jing Zhang	**Session Chair:** Louisa Tomas Engel **HDR Volunteer:** Jing Zhang	**Session Chair:** Gillian Kidman **HDR Volunteer:** Michael Calarese
11:00am	*Māori concepts for animal ethics: Implications for the Three Rs* Georgina Tuari Stewart, Sally Birdsall	*Customized science learning: Integrating UDL in an AI chatbot development for elementary education* Hye-Eun Chu, Juyeon Lee, Sarah Hajama, Kiano Pomente, Sonya Nichole Martin	*Interactive reality - orchestrating student learning through interplays of direct and indirect experiences about plants* Maurice M. W. Cheng, Bronwen Cowie, Chloe Stantiall	*Cross-cultural insights into physics education: Unraveling the determinants of secondary students' attitudes across eight countries* Pongprapan Pongsophon	*Interlacing affect, learning, and sociocultural activity in multilingual science classrooms: Experiences of Syrian refugee youths and families* Sara Salloum, Rena Al Debs, Saouma BouJaoude, Danielle Dani	**Symposium:** *Where STEM disciplines converge: Integrating cognitive knowledge* Gillian Kidman, Hazel Tan, Roland Gesthuizen, Simone Macdonald
11.40am	*Making space for non-Eurocentric voices in the curriculum: The potential of a knowledge systems approach* Rosemary Hipkins, Bronwen Cowie, Pauline Waiti and Sara Tolbert	*Fostering hope and action for climate change: The impact of a futures-oriented teaching module with generative AI integration* Shu-Chiu Liu	*Reframing epigenetics as a tool to break free from the constraints of genetic determinism: A dynamic classroom model* Sunyoung Shin and Minsu Ha	*The atomic choir: Using interactive sound events to engage audiences in science* Alexis Weaver	*Does topic matter? Investigating students' emotions, interest and learning when writing stories about socio-scientific issues* Senka Henderson, Louisa Tomas Engel, Donna King	
12.20pm	*Reflecting on our journey towards teaching Indigenous and Western Sciences in Initial Teacher Education* Connie Cirkony, Rebecca Cooper, Jennifer Mansfield, Chris Preston, Mijung Kim	*Multimodal capabilities of generative AI: To what extent can chatgpt produce visual representations of science?* Kok-Sing Tang, Grant Cooper	*Aristotle, biodiversity, classification: An ABC of the importance of taxonomic classification for understanding biodiversity* Leonie Rennie	*Contemporary physics in the science curriculum* Victoria Millar, Maurizio Toscano	*Unraveling the role of cognitive conflict, metacognition, and working memory in scientific conceptual change: An EEG study* Chuan-Cheng Shih, Hsiao-Ching She, Li-Yu Huang, Wen-Chi Chou, Meng-Jun Chen, Tzyy-Ping Jung	
LUNCH at 1:00pm **| SNW Main Area - 2.0.2**						
	Session Chair: Richard Gunstone **HDR Volunteer:** Melinda Dixon	**Session Chair:** Russell Tytler **HDR Volunteer:** Melinda Dixon	**Session Chair:** Cathy Buntting **HDR Volunteer:** Samantha Bothe	**Session Chair:** Carrie Swanson **HDR Volunteer:** Jing Zhang	**Session Chair:** Sally Birdsall **HDR Volunteer:** Michael Calarese	
1:45pm	*What understandings of balanced and unbalanced forces do students illustrate through their diagrams and social interactions?* Sherab Tenzin, Mihye Won, David Treagust	*Documenting the integrated STEM initiative of Philippine science high school and its impact on students' motivation towards STEM learning* Mary Sheryl M. Saldon-Raznee, Cate Challen	*Exploring what iSTEM teacher leaders need to know and do* Emma Stevenson, Pauline Thompson	*Encouraging student dialogue and comprehension of enzymes by harnessing the Indigenous technology of okuyenga* Martha N Nyamakuti	*An investigation of undergraduate and postgraduate students' ideas of experimental design using primary scientific literature* Meena Kharatmal, Arnab Bhattacharya	

2.25pm	*Hands-on activities for understanding the probabilistic nature of quantum physics* Anastasia Lonshakova, David Blair, David Treagust	*The impact of a compulsory integrated STEM subject on girls' emerging STEM identities* Tabetha Spiteri, Amanda Berry, Rebecca Cooper, Jared Carpendale	*Integrated STEM in Australian Initial Teacher Education: Rationale and practice* Samantha Bothe	*The impact of Indigenous scientist biographies on Indigenous students' motivation to learn science: Self-efficacy, enjoyment, value, and daily life connection* Ming-Hsiu Mia Chen	*A study on the process-oriented assessment model to promote deep understanding of scientific concepts* Sangeui Lee, Seongjae Lee, Minsu Ha	
3.05pm	*Physics conceptual engagement in remote learning via the Monash Virtual School* Richard Gunstone, Tara McDougall, Michael Phillip	*The influence of disciplinary identity on teachers' perceptions of integrated STEM* Shefali Sharma-Wallis, Russell Tytler, Wanty Widjaja, Peta White	*Boundary objects as mediators in transdisciplinary STEM research* Cathy Buntting, Azra Moeed	*Incorporating Indigenous Ainu Knowledge into formal science education in Japan* Hideto Okuyama	*The role of education in achieving Predator Free 2050 in Aotearoa New Zealand* Sally Birdsall, Alexandra Palmer	

POSTER SESSION at 3.45pm **| SNW Main Area - 2.02**

Relating visitor personas to guest experiences in a dinosaur gallery
Rebecca Hite

Engaging students through STEM practice learning strategies in a life science course
King-Dow Su

Exploring the cumulative impact of professional learning from a regional perspective
Anthony Anning, Linda Hobbs, Lihua Xu

Ambitious science teaching: It definitely got easier with practice
Barbara Billington, Eva Nelson

Evaluation of simulators helping sixth-grade students understand "bioaccumulation of chemicals by microplastics"
Yuka Matsuyama, Tomokazu Yamamoto, Shinichi Kamiyama, Hideo Funaoi

Analysis of the educational and social meaning of the "Visiting Maker Program": Focusing on practical examples of social enterprises
Hyeonah Noh, Jaehyeok Choi

Assessment of science instructional explanation competency of pre-service science teachers
Insun Lee, Hye-Gyoung Yoon

Navigating SSI education in South Korea: Two decades of research, policy, and curriculum evolution
Hyunok Lee, Yeonjoo Ko

Exploring the multidimensional knowledge, willingness to act and climate action: Insights from a preliminary study with Taiwanese high schoolers
Rung Yu Shiu

Exploring the impact of systems thinking teaching on students' engagement in environmental issues
Ya Chun Chen

Impacts of contextual and problem-based learning on secondary students' systems thinking, scientific competency, and attitudes toward science
Ya Chun Chen

Comparison between Grade 7 students' cognitive abilities, metacognition, stress and achievement in biology learning about life in the CMEN Teaching Model and in the traditional teaching model
Suwit Uopasai, Pornpimon Phapimul

AFTERNOON TEA at 3:45pm **| SNW Main Area - 2.0.2**

CONFERENCE GALA DINNER | Soljan's Estate Winery (366 State Highway 16, Kumeū 0892, New Zealand)**

****Soljans is ~17km away from the conference venue (Massey University, Albany, New Zealand). A bus service will be provided for delegates to travel to and from the dinner (departing from the university at 5:30 pm and returning at approximately 10.15 pm)**

Parallel Presentation Program – Friday July 5

Time	Parallel Session #1 Seminar Room 1 (2.3.1)	Parallel Session #2 Seminar Room 2 (2.3.2)	Parallel Session #3 Seminar Room 3 (2.3.3)	Parallel Session #4 Seminar Room 4 (2.3.4)	Parallel Session #5 Seminar Room 5 (2.3.5)	Parallel Session #6 Seminar Room 6 (2.3.6)
Registration/Tea & Coffee from 8:15am **- SNW Main Area - 2.0.2**						
8:30am	**Session Chair:** Lihua Xu **HDR Volunteer:** Melinda Dixon	**Session Chair:** Linda Hobbs **HDR Volunteer:** Melinda Dixon	**Session Chair:** Carrie Swanson **HDR Volunteer:** Samantha Bothe	**Session Chair:** Carol Aldous **HDR Volunteer:** Jing Zhang	**Session Chair:** Mihye Won **HDR Volunteer:** Jing Zhang	**Session Chair:** Russell Tytler **HDR Volunteer:** Michael Calarese
	How are teachers integrating mātauranga Māori into secondary curricula? Karen Finn	*Transforming science teachers' practice: What accounts for change in a formative intervention* Isaac Coffie	*Highlighting participants' motivations for involvement in environmental education in a local re-forestation programme.* Carrie Swanson, Jeff Silby	*Year 7 creative skill development through student-generated explanatory science diagrams to enhance conceptual understanding* Katrina Prendergast	*How to guide and facilitate student-generated visual models in an online learning platform* Jina Chang, Jisun Park, Hye-Gyoung Yoon, Joonhyeong Park, Minsu Ha	**Symposium** *Innovation in science education: Responding to climate crises* Russell Tytler, Maija Aksela, Peta White, YingShao Hsu, Chris Eames
9.10am	*A case study of Hong Kong and Taiwan accomplished secondary science teachers' pedagogical reasoning* Su-Chi Fang, Kennedy Kam Ho Chan, Lihua Xu	*Using an ecological approach to "imagineer" the professional development/education ecosystem for out-of-field teachers: A focus on science, mathematics, English and the humanities* Linda Hobbs, Seamus Delaney, Emily Ross, Connie Cirkony	*Learning by doing: Exploring the multiple learning dimensions of citizen science mosquito monitoring in schools* Larissa Braz Sousa, Chris Preston, Peter Rutledge, Yaela Golumbic, Alice Motion	*Floating boats and dropping eggs: Young children engaging creatively during an online after school Science club* Kimberly Maslin, Karen Murcia	*"I'm not good at drawing myself!" Teachers' strategies to engage students in learning through drawing science diagrams* Mihye Won	

POSTER SESSION at 9.50am **| SNW Main Area - 2.02**

Gender evolution in Korean STEM: Two decades and faculty inspiration
Hyang-yon Rhee

Investigating the implementation of education for sustainability through science in Australian secondary schools: Perspectives and practices of students and teachers
Sabira Sultana, James Deehan, Kathleen Smithers

Developing a conceptual framework for narrative science identity
Junhee Kim, Sungmin Im

The network perceptions of STEM teachers in teacher leadership programs compared to non-participants
Andrea Reeder, Cathy Cerosaletti, Joshua Reid, Gregory Rushton

Enhancing inquiry abilities: A yearlong science curriculum for junior high students
Meichun Lydia Wen, Pei-Shan Chang, Sheng-Han Lee

Science teachers' attitudes toward development and application of AI-integrated STEM education
Yongseok Jeong, Hae-Ae Seo, Yeon-Hee Kim

Unveiling the pedagogical practices in the STEM classroom: A scoping review
Mohammad Alamgir Hossain, James Deehan, Leanne Gibbs

PLC Protocol Development to Improve Pre-service Elementary Teachers' Digital Competency in Science Class
Eunyoung Jeong, Mirim Seo, Jong-Hee Kim, Kiyoung Lee, Youngsun Kwak

Teachers' existing ideas of TPACK for STEM education in Thailand
Pornchai Chinnasa, Chokchai Yuenyong

Cultivating hope and action in climate change education: Case study of a master program in Taiwan
Yu-Chi Tseng

Perceptions of pre-service science teachers on integrating AI into science education
Yeonjoo Ko

Teacher Pedagogical Content Knowledge for STEM Education: Case of a science teacher implementing the electrical circuit STEM Education
Pairoh Sohsomboon, Chokchai Yuenyong

MORNING TEA at 10.30am **| SNW Main Area - 2.0.2**						
11.00am	**Session Chair:** Wendy Nielsen and Emily Dare **HDR Volunteer:** Melinda Dixon	**Session Chair:** Jared Carpendale **HDR Volunteer:** Melinda Dixon	**Session Chair:** Carrie Swanson **HDR Volunteer:** Samantha Bothe	**Session Chair:** Jan van Driel **HDR Volunteer:** Jing Zhang	**Session Chair:** Cathy Buntting **HDR Volunteer:** Michael Calarese	
	Reviewing for RISE: A workshop to hone your skills Wendy Nielsen, Kok-Sing Tang	*Making the space for K-7 science education research in Canada: A micro level analysis* Christine D. Tippett, Todd M. Milford	*Diagnostic assessment for detecting students at risk in physics learning* Nam-Hwa Kang, Hyunju Yoon	*Science teachers' interactions with science centres: Professional development benefits and how they occur* Chloë Nelson, Jan van Driel, Victoria Millar	*Addressing bias and advancing equity in the measurement of visuospatial skills* Alvir Sangha, Jenna Tashiro, Sam Pazicni	
11.40am	*Publishing in and reviewing for the Journal of Science Teacher Education (JSTE)* Emily Dare	*Successful primary science education in New Zealand: Understanding the barriers and enablers* Jared Carpendale	*Collaborative natural language processing for automatic scoring of open-ended questions in science education* Van Thi Hoang Ngo, Chun-Yen Chang, John Jr-Hung Lin	*Science teacher Facebook groups: Productive communities of practice?* Robertson Burgess, Elena Prieto-Rodriguez, Katie Waters, Erika Spray	*Promoting the traditional use of wood ashes and salt in preserving animal skins for drum making and drumming* Angelius K. Liveve, Martha Nyamakuti, Kenneth M. Ngcoza	
LUNCH at 12.20pm **| SNW Main Area - 2.02**						
RISE ASSOCIATE EDITOR MEETING at 12.20pm | **SNW Seminar Room 1 (2.3.1)**						
CONFERENCE CONCLUDES at 1:00pm						

Abstracts

Wednesday Parallel Sessions

Wednesday 9.20am

Title
Transformative pathways: Examining the development and transfer of topic-specific pedagogical content knowledge in New Zealand physics teachers through collaborative professional learning and development

Presenters
Rebecca Harrop, Robin Averill, Karyn Saunders

Abstract
There is limited research on how physics teachers develop their topic-specific pedagogical content knowledge (PCK) in New Zealand and how this knowledge is internalised and utilised in a classroom. This presentation is part of a larger PhD study and aims to address this gap by examining the knowledge transformation of two in-field teachers of senior physics who participated in collaborative content representation framed professional learning and development (PLD). The Refined Consensus Model of PCK was used to deductively analyse the qualitative data: PLD interactions, post-PLD interviews, surveys, and observations. Preliminary findings indicate this PLD supported PCK development, however, the quality and quantity of knowledge decrease as knowledge is transferred from being collectively held to then used to inform teaching. Knowledge transfer may be influenced by disparities between existing and new knowledge schema, quality of reasoning during discussions, and participants' reflective skills. These factors may be enhanced by the facilitators' knowledge and skill. Results suggest that topic-specific PCK development can be supported by modified Communities of Learning facilitated by those with strong relevant PCK, collaborative, and facilitation skills. However, strategies are needed to identify whether teachers have the necessary content knowledge and PCK to access and implement knowledge drawn from PLD.

Title
Reflecting on practice and professional learning through a STEM observation protocol

Presenters
Emily Dare, Joshua Ellis, Christopher Irwin

Abstract
We previously developed a K-12 integrated STEM observation protocol, designed with multiple uses in mind, including for research and as a formative tool to guide and improve teacher practice. This work focused on understanding secondary science teachers' reactions to the protocol to better understand how STEM educators might use the protocol as a tool for promoting student learning,

conducting observations and self-evaluation, or curricular planning. This work used a case study design, which was bound by a sample of participants who previously attended a workshop focused on integrated STEM education. Interviews were structured in three sections; the first asked teachers to share their overall impressions of the protocol, the second probed for reactions about each of the 10 items, and the third inquired about their anticipated use of the protocol. Our thematic analysis of teachers' responses revealed three main themes: already doing, not yet including intentionally, and facing barriers. Our results shed light on how to better support teachers using the protocol as a tool for formative evaluation, improvement, and planning. When considering professional learning opportunities, it is important to first assess what the teachers are already doing, what they want to be doing, and what they believe is superfluous.

Title
Cultivating critical thinking skills for the era of rapid information dissemination: A study on teacher training and curriculum development

Presenters
Sheng Yi Hsiao, Chun Yen Chang

Abstract
We supported teachers in developing curricula focused on science criticality (SC), which combines symbiotic scientific thinking and critical thinking. The SC dispositions include open-mindedness toward scientific evidence, self-confidence in reasoning, systematicity in a complex context, and inquisitiveness toward scientific knowledge. The SC skills encompass evaluating the credibility of arguments, analyzing the relationships between evidence and variables, interpreting data, inferring the consequences, elaborating explanations based on evidence, and self-regulating while reasoning. We engaged 29 in-service and 46 pre-service Taiwanese teachers in the SC workshops aimed at prompting them to develop curricula on topics such as scientific misinformation or socio-scientific issues (SSI). Their thoughts of SC, lesson plans, and suggestions from peers were analyzed through content analyses. Results indicated: (1) a shift in focus from dispositions to skills in SC curriculum design, correlating with teaching experience; (2) pre-service teachers design courses focused on promoting open-mindedness, while in-service teachers emphasize inference and explanation; (3) both groups advocated for science criticality agencies but lacked enhancing their self-confidence. This study underscores the importance of balancing SC skills and dispositions and developing strategies to bolster self-confidence in reasoning.

Title
The zoo: Science-rich but technologies and mathematics-poor – or is it? Reconstructing STEM ideas for future teachers through a zoo-based design thinking program

Presenters
Timna Garnett, Shaileigh Rowtcliff

Abstract
The zoo is a unique science-rich learning environment and yet is rarely, if ever, used to teach future Early and Primary Years

teachers how to use the environment for planning integrated and authentic STEM learning. Initial teacher education (ITE) programs in Australia are being challenged to provide a measurable way of connecting future teachers of STEM education to real-world and authentic learning opportunities. Through our Zoo STEM Teach three-year project, we aim to contribute to the growing field of situated learning for STEM education by focusing on how the zoo environment can be used in preparing teachers to think, plan and teach STEM ideas meaningfully. The preliminary pre-post visit results (n=93) were analysed through a paired t-test and qualitative analysis of written responses highlighting that situated learning at the zoo is valued by 69% of students (pre-visit) and increased to 76% (post-visit) as a valuable way to think, plan and teach STEM education which is statically significant (pre-post) ($p = 0.017$). These findings are supported by content analysis of their written reflective statements submitted one week after the zoo visit and highlight their design thinking and connection to the experience of watching animals at the zoo.

Title
Advancing a conceptual framework for fostering gender equity in early years STEM education

Presenters
Lihua Xu, Jiqing Sun, Kylie Smith, Sarika Kewalramani, Linda Hobbs, Jan van Driel, Victoria Millar, George Aranda, Gerarda Richards, Lulu Hawkins, Bridgette Van Leuven, Belinda Dealy

Abstract
Gender equity in STEM education has been a persistent global issue for decades, particularly concerning the underrepresentation of girls in these fields. Current approaches to promote girls' participation in STEM tend to focus on school-aged girls. However, there is a growing recognition that addressing gender disparity in STEM should begin in early childhood, as gender norms and stereotypes affecting girls' engagement in STEM emerge early on. In this study, we explore factors influencing access, engagement, and participation of young children, especially girls, in early years STEM through a critical analysis of literature on the topic of gender equity in early childhood STEM education. Informed by this analysis, we propose a conceptual framework for guiding curriculum design and development that aims to foster gender equity and inclusivity in early years STEM education. Online resources guided by this framework were created and tested with focus groups of parents and educators. Insights from these focus groups will be utilised to illustrate how this framework could be applied to support both parents and educators in creating equitable opportunities for children of all genders to participate in STEM as part of their everyday practices.

Wednesday 10.00am

Title
Development and application of an instrument to measure high school biology teachers' pedagogical content knowledge of scientific thinking

Presenters
Shan Lin, Jian Wang

Abstract
Scientific thinking is an important component of scientific competencies and an essential competency for citizens to adapt to future changes in society. To cultivate students' scientific thinking, teachers first need to have the appropriate professional knowledge base, including Pedagogical Content Knowledge (PCK). Assessing teachers' PCK of scientific thinking can help develop effective curricula for their ongoing professional development. However, empirical studies on biology teachers' PCK of scientific thinking are lacking. Therefore, the purpose of the study was to develop a valid, reliable instrument to measure high school biology teachers' PCK of scientific thinking. Instrument development was performed through expert review, interviews, pilot tests and validation. The results demonstrated that the instrument has high reliability and good validity. A total of 292 in-service high school biology teachers participated in this study through an online questionnaire. The Rasch analysis showed that overall, as well as for each component, high school biology teachers' performance on PCK of scientific thinking was in the lower middle range. The performance levels of four components, knowledge of students, knowledge of instructional strategies and representations, knowledge of curriculum, and knowledge of assessment, were decreasing in order.

Title
Exploring problem-based learning in STEM education: Developing illustrations of practice

Presenters
Kathy Smith, Jennifer Mansfield, Amanda Berry, Debbie Corrigan

Abstract
Developing teacher proficiency and confidence in STEM education influences the cultivation of STEM literacies among students, such as, capacity to recognize, apply, and integrate concepts from various STEM domains to comprehend problems and devise innovative solutions. A Problem Based Learning (PBL) approach actively places students in a central role within the learning process, fostering their ability to function as self-directed, interdependent, and independent learners when tackling non-routine problems.
This paper reports on the final stages of Australian Research Council funded Linkage project (2020-2023), "Exploring Problem based learning in STEM Education". In addition to exploring the potential of PBL to enhance STEM education, another outcome of the project was the production of illustrations of teacher practice which capture the daily realities of PBL across a range of contexts. In this presentation we examine key insights drawn from teacher practices, specifically focusing on how the principles of PBL (developed in Phase 1 of the project) have prompted educators to interrogate the conditions and opportunities they create to

enhance the development of students' STEM literacies. Challenges encountered by teachers will also be explored, seeking a deeper understanding of the considerations necessary for effective implementation of PBL in STEM education.

Title
Research on secondary science teacher preparation: A review

Presenters
Ron Gray, Jan van Driel

Abstract
Here we report on a recent literature review synthesizing global theoretical and empirical research on the initial preparation of secondary science teachers, which revealed a prevalent emphasis on identifying deficits in pre-service science teachers. Our focus spans the characteristics of pre-service science teachers in diverse programs, their proficiency in science teaching practices, and the pedagogies supportive of their learning. Beyond summarizing the literature in these realms, our review offers a comprehensive perspective on the collective potential of this body of work, transcending insights gleaned from individual research endeavors. In addition to enriching the understanding of current practices, we highlight promising avenues for future research and advocate a shift in the field of secondary science teacher education. Our proposal advocates a departure from the prevalent focus on identifying deficits in pre-service science teachers. Instead, it promotes a constructive, asset-based approach, encouraging investigations that explicitly recognize and leverage the existing strengths, skills, and knowledge of pre-service teachers. This inclusive strategy is aimed at actively contributing to the development of secondary science educators. We also argue for taking a practice-based approach to science teacher education and for the development of overarching frameworks supportive of teacher learning.

Title
Imagination to discovery: Science fiction convention attendees' interest in science and science fiction over a lifespan

Presenters
Gina Childers, Rebecca Hite, Kania Greer

Abstract
Science fiction bridges humanity's imagination to scientific discoveries and is described as a source of fostering interest in science throughout a lifespan. Some science fiction enthusiasts attend science fiction conventions to connect with fandom experts, science professionals, and attendees, fostering their interest in science. Through the lens of science capital and habitus, the present study explored how science fiction convention attendees' (n=22) science experiences over a lifespan contributed to their choices in attending a science fiction convention. The interview protocol centered on their emergent interests in science and science fiction, influential individuals, availability of resources, and stories highlighting aspirations. To capture these stories, narrative inquiry along with subsequent coding approach provided the foundational means to identify critical experiences. Initial findings suggest that most interviewees (n=21, 95%) had emergent memories of science starting in childhood as 40% (n=9) attributed those memories to family science experiences (e.g., attending a museum) and 50% (n=11) classroom learning experiences such as science projects.

Furthermore, five interviewees (23%) specifically stated that their interest in science resulted from their childhood interest in science fiction media. Exposure to science fiction in childhood may provide a conduit to fostering an interest in science across the lifespan.

Title
Emotional imagination and relational expertise in STEM education: A co-teaching model for the early years

Presenters
Marilyn Fleer, Aishwarya Kansakar, Monique Parkes

Abstract
Vygotsky spoke about the Cinderella phenomenon whereby the step sisters of cognition dominate a discipline and caste aside emotions. Whilst emotions and feelings in science have in recent times gained more prominence, the psychological concept of emotional imagination has yet to be fully realised. In this presentation the concept of emotional imagination is drawn upon to understand the outcomes of an educational experiment that specifically examined how to design a co-teaching model for the early years. In our educational experiment educators (Sarah and her team) and manufacturing/robotics engineers (Ash, Jaideep) came together in our PlayLab (Marilyn, Anne, Monique and PhD community) to design and implement a Conceptual PlayWorld of the Shoe Maker and the Elves. This involved children designing a shoe factory in a childcare centre, undertaking engineering processes, and educators actively promoting girls' engagement in STEM. The study (video documentation, interviews) found 2 conceptual themes as key for designing a co-teaching model: 1) emotional imagining generated motive orientation to engineering because of the drama of the problem of the elves' shoe factory being burnt down, 2) Anne Edwards' interrelated concepts of relational expertise, relational agency, and common knowledge, were foundational for designing a co-teaching model for the early years.

Wednesday 10.40am

Title
Not all reflections are reflections – Organizing reflection-related terms using the Refined Consensus Model

Presenters
Lukas Mientus, Andreas Borowski

Abstract
Pedagogical Content Knowledge (PCK) stands as a significant indicator of teachers' professionalism during classroom practice. The implementation of the Refined Consensus Model (RCM) has facilitated the systematic research into science teachers' PCK and its enhancement. In this framework, science teachers' pedagogical reasoning during classroom activities, along with the iterative cycles of planning, teaching, and reflection, assumes a central role. Reflective thinking is highlighted as a pivotal element for professional growth within this pedagogical reasoning. However, what exactly constitutes reflection depends on various interpretations of terms. Is it merely a process, a competency, or is it more accurately viewed as an outcoming product? Is it about reflection on skills or about reflection on teaching practices? This discussion paper aims to bridge an elaborated and established German definition of reflection-related terms with the RCM within the international research context. The purpose is to organize reflection-related terminology in research that centers on the reflection-related skills of science teachers. This organization seeks to facilitate coherent communication within the science education research community and beyond.

Title
Developing teacher expertise in interdisciplinary science and mathematics teaching: The role of teacher epistemological beliefs in shaping practices

Presenters
Wanty Widjaja, Lihua Xu, Lam Pham, Amanda Berry

Abstract
Advocacy for an interdisciplinary approach in mathematics and science teaching stems from the desire to enable students to establish connections between the two subjects and engage them in deeper learning of both. Planning for and enacting deeper connections between the two subjects requires teachers to recognise the interconnections between knowledge and practices in both disciplines, while being flexible and adaptable across the traditional disciplinary boundaries. As part of an ARC research project focusing on primary teachers' adaptive expertise, this study explores how primary teachers perceive and enact the interconnections of mathematics and science through the process of co-planning, co-teaching, and co-reflecting on a lesson sequence on the topic of heart rate. Data analysed include video recordings of the lesson sequence, teacher post-lesson and post-sequence reflections from two primary schools in Victoria. The results demonstrate variations in teachers' epistemological beliefs about: 1) the nature of mathematics and science knowledge, and their connections, 2) effective pedagogies for disciplinary and interdisciplinary teaching, and 3) how students learn in disciplinary and interdisciplinary ways. The results also show how their epistemological beliefs shape, enable and constrain their instructional practices, indicating various degrees of shift from routine to

adaptive expertise in both disciplinary and interdisciplinary teaching.

Title
Developing pre-service teachers' capacity for cognitively demanding science teaching

Presenters
Danielle Dani, Sara Salloum

Abstract
Reforms in science education call for building teaching candidates (TCs) capacity for planning and enacting cognitively demanding work that engages learners in science practices to make sense of concepts. Learning from practice supports such capacity-building, but this is often limited to TCs last student teaching semester. Consequently, the authors developed and used a model of mentoring (MM) that engaged TCs in five teaching cycles of planning, enactment, and co-reflection over an entire year. In this paper we investigate: (1) how MM supported TCs learning to plan and enact cognitively demanding science activities, and (b) the progression of TCs work with mentored planning and enactment. The study utilized a qualitative case study research design to explore the experiences of four middle-level science TCs with mentored planning and enactment. Data included: (1) initial lesson plans, final lesson plans, and lesson reflections, (2) classroom fieldnotes/video-recordings, (3) debrief discussions audio-recordings, and (4) TCs individual interviews. Albeit to different degrees, cyclical and situated mentored planning and enactment supported the four TC's capacity to plan and enact cognitively demanding activities that included various science practices. We outline how different context, mentor, and TC aspects influenced TC's planning and enactment and discuss their implications to pre-service teacher education.

Title
Informal science education strategies for anti-extinction education in the community: A small case study from tropical Queensland

Presenters
Hilary Whitehouse

Abstract
The translation of ecological knowledge to the community is vitally important in halting mammalian extinction in Australia. Extinction is a difficult and uncomfortable topic to approach in community settings. Anti-extinction work requires effective, science-led, materially beneficial, on-ground action. Informal learning takes place outside the curricula of formal educational institutions and tends to be contextual, emergent, additive, and/or transformative. This paper presents an analysis of the results of a single, insider case study of informal, anti-extinction education strategies devised by a volunteer network of ecologists, wildlife carers and educators dedicated to conserving bats, including the highly endangered Spectacled Flying Fox.
Innovations beyond community presentations, information stalls and school talks include holding regular evening batwalks, organising an Annual Bat Festival sponsored by local government, and commissioning unique learning resources such as a children's book of 'bat-tivities', posters and postcards, and a board game all communicating conservation science. The bat festival idea is promoted by the Australasian Bat Society in 2024. This study shows that convincing and novel ways of informal science

education can include affective domain learning and arts-based learning, and can be achieved with small grant funding. Limitations to this volunteer model will also be discussed. This study is based in the city of Cairns, Queensland.

Title
Scientific playworlds: Young people's exploration of science ideas through drawing, model making and visualisation

Presenters
Simon Taylor, Barbara Whyte

Abstract
This study examined the "play" of 12-13 year old students with the use of 3D models, 2D representations, gesture and talk as semiotic resources to reason about scientific concepts.
A case study of three secondary teachers and 34 students over seven weeks was undertaken, generating 42 hours of digital observations and 117 photographs of play practices. We follow a pragmatist socio- constructivist perspective, with the use of multimodal representation, and propose that scientific play entails creative reasoning enabled by both cognitive and semiotic resources. The aim was to extend current understandings of how students use drawing and 3D model construction to enact and enable scientific reasoning through interaction. We claim that this process entails students achieving both complementarity as well as coherence of meanings across modes. Because different modes do different work in meaning-making in science, we report that scientific play can be a process of transforming imaginary visual situations into scientific narratives. We draw on relevant literature and two indicative examples of student representation construction to support our presentation. In our micro-ethnographic analyses of students' collaborative reasoning on the topics of food production and photosynthesis, we interpret data from multiple video, still photography and audio capture.

Wednesday 11.20am

Title
Pedagogical content knowledge: Is it still a relevant and useful construct for science education?

Presenters
Jared Carpendale, Andreas Borowski, Rebecca Cooper, Amanda Berry, Jan van Driel

Abstract
Pedagogical content knowledge (PCK) was introduced almost four decades ago by Shulman to articulate the blending of content knowledge and pedagogy, highlighting the specialized professional knowledge of teachers. Since its introduction, many researchers particularly in science education, have taken up, utilised and further modified the PCK construct. Two international PCK research summits (2012, 2016) have sought to build conceptual clarity and develop a consensus model of PCK (the Refined Consensus Model – RCM – of PCK, published in 2019) that can drive a collective research agenda. At ASERA 49 (2018), a group of international researchers presented the RCM and explained how it can be useful as a framework for research in science education. This presentation revisits this work six years on to discuss progress in PCK research as well as critiquing the usefulness and relevance of this construct in science education. We consider the relationship between PCK and other emerging constructs such as noticing and adaptive expertise, particularly within the context of shortages of science teachers and recent technological developments in education (e.g., online teaching, availability of digital tools, and generative artificial intelligence).

Title
Piloting the Challenge-Based Learning (CBL) Framework in senior high school: The journey of STEM students in De La Salle University Integrated School

Presenters
Leah Madrazo, Mary Geraldine Yumang, Angela Nicole Masongsong

Abstract
The research delves into the transformative journey of senior high school students in De La Salle University Integrated School as they embark on a pioneering exploration of the Challenge-Based Learning (CBL) approach in the realm of Science and Mathematics education. Five sections of STEM strands were involved in the pilot project, where students experienced the essential phases (engage, investigate, and act) of CBL for 13 weeks. Through careful analysis of students' reflective essays, the research unfolds the dynamic process of the CBL framework, highlighting its positive impact on academic success, student engagement, innovation, critical thinking, and community mindfulness. Additionally, many students revealed that they developed a positive mindset and perspective towards the environment as the approach helped them become more responsible Lasallians. The research also captured the experiences, challenges, and successes of students in adapting to this innovative paradigm. Findings revealed that students have common issues when it comes to the availability and access to technology and resources needed for their project implementation and other factors related to scaling up the CBL initiatives. Overall, the evolving landscape of the CBL approach has supported holistic development that nurtures the intellectual curiosity of STEM students.

Title
Reimagining primary science teacher education: A response to the challenge of online learning

Presenters
John Cripps Clark, Melinda Kirk

Abstract
Primary school science teaching has always had as its beating heart the face-to-face interaction of teacher and students around embodied experience with physical materials and phenomenon. The move of our students and teachers to studying online has disrupted traditional techniques and patterns of instruction. In this presentation we describe a series of experiments in reimagining a pre-service teacher education course in primary science and technology education using the Activity Based Instructional Design (ABID) model based on Engeström's Cultural Historical & Activity Theory (CHAT). ABID provides a naturally modular, student centered, and theory informed template which reconceptualises the course as a series of interconnected and interrelated activities that provides the learner the set of psychological tools needed to achieve the learning objectives of the course. In this Vygotskian framework two crucial ideas emerge: it is the learning activity that is the unit of analysis; and the learning outcome of each activity provides the psychological tools used by a learner in subsequent activities. In this presentation we will use vignettes from our research to challenge the primary science education community to radically reimagine how we prepare primary teachers to effectively induct students, at the critical time for their engagement and understanding, into science.

Title
Teachers' learning ecologies for teaching science – contributions of learning from informal contexts and previous work experience

Presenters
Mandy Gundersen, Maurice M.W. Cheng, Bronwen Cowie

Abstract
Teachers' development is shaped by teacher education programmes and their classroom experiences, but the development through informal settings is under-researched. The idea of "learning ecology" highlights that people learn in a variety of contexts and connections, which include friends in other professions, ex-colleagues in prior work, community groups (e.g., language classes), leisure/ home activities, whānau, interactions with whenua and nature, published resources (e.g., magazines, books, social media). They form an "ecology" because learning in one context can inform their learning in another. In this presentation, we report our interview data from six middle to senior secondary science teachers in Aotearoa New Zealand about how their learning ecologies have informed their curriculum planning and teaching. Teachers provided diverse examples of how they drew on their learning ecologies to design engaging and relevant learning experiences for students. We will elaborate on our observations that (1) through life experiences and work experiences prior to teaching, teachers acquire a wealth of knowledge that is distinct from but complementary to that which is learnt in formal teacher training, (2) their learning from various contexts combines to create learning ecologies which are rich, unique and valuable in different ways. Policy implications will be discussed.

Title
Learning progressions in early childhood science: Identifying new opportunities

Presenters
Cristina Guarrella

Abstract
Ensuring young children are provided with developmentally appropriate learning experiences in science requires teachers to assess for understanding. This involves sourcing evidence of what children do, say, make, write, or draw to underpin evidence-informed decisions for science teaching and learning. Research suggests that Australian early childhood teachers require support to embed assessment practices in play. The use of explicit learning progressions has been recommended as one solution to this challenge (Cohrssen et al., 2023) as they support teachers in making changes in their assessment practices (Alonzo et al., 2020). Learning progressions for early childhood mathematics are well established (Clements & Sarama, 2014), however there has been less research into the learning progressions for early childhood science education. Due to the limited corpus of literature on early childhood science learning progressions, a snowballing systematic literature review (Wohlin, 2014) was used to identify existing learning progressions. Findings of this review will be presented in conjunction with a content analysis (Finfgeld-Connett, 2014) of international early childhood frameworks identifying science concepts and skills embedded within these curricula. This aims to open discussion on the current state of learning progression research in early childhood science and articulate learning progressions requiring future development.

Wednesday 12.50pm

Title
Entrepreneurship education and secondary STEM: Lessons from the Victorian Tech Schools

Presenters
John Cripps Clark, Jennier Palisse

Abstract
Entrepreneurship education is emerging in secondary schools as we reimagine how we prepare students for a future of work which is changing rapidly in difficult to predict directions. The Victorian Tech Schools (STEM resource centres providing programs and support to local schools) have been established with this specific challenge in mind and have developed a variety of programs to introduce entrepreneurship education to their students, teachers, and local community in collaboration with local industries. The relative independence of the Tech Schools has fostered the growth of a series of innovative initiatives in entrepreneurship education. We report on a survey of these initiatives based on interviews with Tech Schools directors, facilitators, and external providers. Our findings indicate that the entrepreneurship programs have been developed around STEM experiential learning models and design thinking which provide a grounding for students before they dive into idea generation, project management and pitching. Industry and startup incubators have been important as collaborators in developing programs and the Tech Schools themselves have become hubs for entrepreneurial innovation. Tech Schools have proven to be important mediators between schools and industry in the work of building a culture of entrepreneurship education in our secondary schools.

Title
Unveiling argumentation skill profiles: Using Toulmin's Argumentation Model on senior high school students' responses to general biology open-ended questions

Presenters
Chelcea Mae Lagmay Darang, Sarah Meilani Fadillah, Minsu Ha

Abstract
In the pursuit of effective scientific communication, scholars employ argumentation—an idea-anchoring process using reliable evidence. This study focuses on nurturing scientific argumentation skills among 280 high school students in the Philippines, specifically in general biology, using Toulmin's model. Participants from Bayambang National High School responded to a 15-item open-ended questionnaire; six items were used for Toulmin's analysis, categorizing responses into five levels. Using Chi-square tests, we explored associations between response distribution, grade levels, and gender differences. Results show a correlation between grade levels and argumentation proficiency, notably 12th-grade students in levels 4 to 5. No significant gender-based differences emerged, indicating fairness in argumentation skills. Emphasizing the positive impact of integrating argumentation and scientific literacy in fostering critical thinking, Toulmin's model for daily science assessments is recommended. Effective teacher questioning and dilemmatic queries stimulate diverse thinking. Educators defining criteria for a ""good"" argument and providing targeted instruction for students' proficiency are pivotal. Studying formative assessment in Philippine biology refines practices,

informs academia, and supports an inclusive education system for educators and policymakers, recognizing the dynamic nature of argumentation skills.

Title
A model for preparing pre-service science teachers in Engineering Design Integrated Science (EDIS) Teaching

Presenters
Frackson Mumba

Abstract
Current US science education reforms require teachers to integrate engineering design into K-12 science teaching. However, many science teachers have no formal preparation in engineering design and how to integrate it into science teaching. Furthermore, few models exist for preparing science teachers in engineering design and how to integrate it in science teaching. Therefore, this paper describes the model we have used for the past eight years to prepare more than 100 secondary pre-service science teachers in engineering design and how to integrate it into science instruction. Our outcomes suggest that this model can enhance pre-service science teachers' understanding of engineering design and how to integrate it into science teaching if they are engaged in intensive and authentic EDIS activities, EDIS instructional materials development, and implementation of EDIS lessons in schools. In general, this model has significantly impacted our pre-service science teachers' EDIS instructional materials development skills, as well as their instructional practice. As such, we believe the model is transferable to other institutions that are involved in preparing teachers in EDIS teaching. We will provide suggestions for implementing this model in science teacher education programs.

Title
Unveiling digital divides: Contextual factors impacting secondary teachers' ICT integration

Presenters
Jing Zhang, Michael Phillips, Rebecca Cooper

Abstract
The integration of information and communication technology (ICT) into secondary education becomes increasingly central yet under-researched, particularly regarding contextualised in-service teachers' understanding and practices. Moreover, emergence and evolution of digital divides, exacerbated by the COVID-19 global pandemic, demand further investigation. This PhD study aimed to address these gaps by identifying contextual factors contributing to digital divides experienced by secondary teachers in Northwest China and how these factors impact teachers' pedagogical reasoning and actions. Data were collected through surveys and interviews, revealing the nuanced, complex, and layered nature of digital divides. Building upon the findings presented at ASERA 54, this paper extends the examination of a biology teacher's case. A three-level contextual framework has been proposed, outlining how essential factors influence the teacher's access to and use of ICT. By enriching the understanding of digital divides in Northwest China, this framework enriches the development of contextual knowledge within the Technological Pedagogical Content Knowledge (TPACK) scholarship. By addressing the often-under-researched aspects of TPACK enactment, it

adds value to efforts aimed at supporting teachers in integrating ICT more effectively. This paper therefore provides valuable insights for pre-service education and ongoing in-service professional development of science teachers, both within and beyond this specific context.

Title
Using epistemic network analysis to investigate connections between instructional strategies and children's scientific practices in kindergartens

Presenters
Ren-Cheng Zhang, Hsin-Kai Wu, Ching-Ting Hsin

Abstract
The purpose of the study is to investigate the interplay between teachers' instructional strategies and children's scientific practices in kindergartens. Using epistemic network analysis (ENA), this study quantified the co-occurrences of instructional strategies and scientific practices and estimated the connection strength among them. Video recordings were collected from four kindergartens in Northern Taiwan—two in cities and two in Indigenous villages. Participating teachers implemented a project-based learning module to engage 98 children in scientific practices. After transcribing the video recordings, this study developed coding schemes to identify types of instructional strategies and children's scientific practices. The coded transcripts were segmented into five-minute intervals as units for ENA models. The ENA results showed that among various strategies, providing direct instruction was the most commonly used to support children's investigating practices (e.g., measuring, employing tools, recording, and doing experiments). Additionally, probing strategies were strongly connected to children's predicting and communicating practices. Other strategies, such as using diagrams, making comparisons, and demonstrating, were also associated with children's scientific practices. Furthermore, different patterns of connections were found in some practices between kindergartens in the two areas. The results could be valuable resources for kindergarten teachers to access effective teaching practices for early science learning.

Wednesday 1.30pm

Title
Positioning empathy in STEM education reform: Insights from a diverse cohort of Hong Kong STEM education leaders

Presenters
Zeyu Han, Chen Chen

Abstract
In school curricula, STEM practices are traditionally portrayed as neutral from human and societal factors. STEM educators are increasingly challenging this value-free assumption, arguing that empathy, communal values and social responsibility are ingrained in every stages of STEM innovation. As of 2024, Hong Kong (HK) Education Bureau has been going through a major overhaul—and actively seeking advice—in integrating social scientific issues in primary and secondary STEM curriculum. We interviewed twenty-four STEM education leaders in HK, ranging from university faculties, secondary and primary school science/STEM teachers, and out-of-school education agents. The key questions concern the role of empathy in HK STEM curricula. Based on qualitative analysis, two themes emerged from the transcript: 1)positioning empathy in the definition of STEM education; and 2)positioning empathy as a function in delivering STEM education. We further identified seven specific positions within the themes, each representing a conceptual model of how empathy and STEM education are integrated or compartmentalized. Overall, experts in lower grades placed empathy at the center or foundation of a STEM curriculum, whereas university experts analyze empathy critically and distinctively from STEM practices. This divide implies challenges and possibilities for STEM education reform in HK.

Title
Reviving post-pandemic adolescents' science interest: A mixed-methods study on the effectiveness of argument-driven inquiry and academically productive talk approaches

Presenters
Kin-yi Promail Leung

Abstract
Studies indicate that students' interest in science often declines during adolescence, a trend potentially exacerbated by the COVID-19 pandemic. This research aims to investigate the effectiveness of employing the Argument-Driven Inquiry (ADI) and Academically Productive Talk (APT) approaches in enhancing students' motivation for science learning. Using a quasi-experimental, mixed-methods design, this study included 158 eighth-graders from two Hong Kong schools over eight weeks. A control group used traditional teaching methods (CON), while experimental groups experienced the ADI model, with one integrating the APT approach for a dialogic classroom environment (ADIAPT). Data collection involved validated instruments, Students' Motivation Towards Science Learning (SMTSL) questionnaires, and additional student group interviews. The SMTSL questionnaire results indicated that the ADIAPT group significantly outperformed both the CON and ADI groups, as demonstrated by a two-way mixed-model (3x2) factorial ANOVA and Bonferroni t-tests. Student interviews revealed that the ADI instructional model facilitated a positive shift in learning motivation toward science and reinforced the importance of scientific knowledge and its acquisition.

Furthermore, the ADIAPT approaches enhanced engagement with the learning environment (curriculum design and teacher-student interactions), promoted problem-solving proficiency and encouraged peer learning. This study contributes to the existing body of knowledge and teacher educators' practice.

Title
Effective engineering education for elementary multilingual learners: A conceptual framework for transformative professional learning

Presenters
Jerome M. Shaw

Abstract
The Next Generation Science Standards call for educators to incorporate the teaching of engineering with science instruction in K-12 classrooms in the United States. A sizable portion of students in those classrooms come from backgrounds in which English is not the first or native language; i.e., English Learners (ELs) – more positively known as Multilingual Learners or MLs. However, studies have documented (a) the lack of engineering teaching occurring in elementary classrooms, (b) elementary teachers' expressed lack of preparation for teaching engineering, and (c) elementary teachers' expressed lack of preparation for teaching MLs. To address these inequities, our four-year project is developing a model of teacher professional learning whose goal is to enhance elementary teachers' understanding of and capacity to effectively engage in (1) the teaching of engineering, (2) teaching multilingual learners in general, and (3) teaching engineering to multilingual learners in particular. To guide this work, we have written a conceptual framework (CF) that contains a literature-based synthesis of key understandings on those three topics as well as on state-of-the-art teacher professional learning. A living document during the course of our project, this paper presents the current CF in the interest of engendering discussions that may inform future versions.

Title
Investigating students' perceptions of science teachers' inquiry teaching practices, learning expectations, and learning interest in the inquiry curriculum

Presenters
Shu-Fen Lin

Abstract
The "inquiry and practices" course became compulsory in senior high schools in contemporary Taiwanese science curriculum reform. Understanding of students' perceptions and expectations of the course would redirect curriculum design and professional development. The purposes of the study were to investigate students' perception of science teachers' inquiry teaching practices and learning interest, and to compare students' and teachers' learning expectation of inquiry curriculum. The stratified sampling method was used to recruit 657 students and 202 science teachers from 55 schools including 7 promoters in the survey. A validated questionnaire of Student Perceptions of Teacher Inquiry Teaching (SPTIT), the scale of Public Emotional Perceptions of Leaning Science (PEPLS)(Lin & Lin, 2016), and some open-ended and structured questions were used. The results indicated that

students' perceptions of promoters' and teachers' inquiry teaching practices were significantly different on the two scales of views of nature of science and effective teaching. Students expected to learn more scientific knowledge, but teachers ignored them. The top four characteristics which could improve students' learning interest in inquiry curriculum were interesting or novel topics, hands-on, life relevance, and improvement of subject knowledge. Students' PEPLS scores influenced their learning interest of the course, rather than their school achievement level.

Title
Unlocking the power of technology in education: A deep dive into Indonesian teachers' technological pedagogical and content knowledge with epistemic network analysis

Presenters
Van Thi Hoang Ngo, Marison Sudianto Manalu, Chun-Yen Chang

Abstract
This study presents the significance of TPACK training for science teachers by employing a groundbreaking method, the Epistemic Network Analysis (ENA) approach, to show the intricate dynamics of knowledge interaction among Indonesian science teachers within the Technological Pedagogical and Content Knowledge (TPACK) framework. The investigation integrates dynamic network models from coded data, triangulated with a comprehensive analysis of teachers' lesson plans and in-depth semi-structured interviews. Central to our exploration are the seven core elements of TPACK: TK, CK, PK, PCK, TCK, TPK, and the overarching TPACK. The findings from TPACK training using the DECODER (Demonstrations, co-train, co-teach, co-design, debrief, and real classroom implementation) model with CCR highlights teachers' use of PK, TK, and TPK. Experienced teachers primarily engage with PK-TPK, focusing on pedagogical strategies, while novice teachers often combine PK-TK and TK-TPK, emphasizing technological integration. This study contributes to the broader discourse on how technology can be harnessed to foster more dynamic and effective science teaching by identifying the gap of the science teacher TPACK.

Title
Developing a community-based program for climate change education in Korean elementary schools

Presenters
Miyeon Kim, Chankook Kim

Abstract
The purpose of this action research was to develop a community-based program on climate change, where teachers and learners collaboratively construct the learning processes in their local context. For that, two (2) teachers and 51 students were invited from two 5th-grade classes in Korea. The researcher, an elementary teacher, designed and implemented the lessons on climate change, conducting participant observations and interviews to investigate meanings of the community-based program. The results are as follows: Firstly, with two iterations of climate lessons, the designed program was aligned with the discourses on climate change education in Korea, incorporating the climate data from local agencies into learners' daily lives in local contexts. Secondly,

the participating students recognized climate phenomena in their community, sympathized with the issues of climate injustice, and showed their support for responding to climate change. The elementary students were engaged in climate action that they planned, and their fears towards climate change became eased. Thirdly, this study elaborated on the meanings of the program. Participating in community projects, the elementary students could increase their self-efficacy and alleviate negative emotions towards climate change. The students also expressed their commitment to the local community beyond the school boundaries.

Wednesday 2.10pm

Title
STEM education ecosystems: Pathways, connections and innovations created by Victorian Tech Schools

Presenters
Linda Hobbs, George Aranda

Abstract
As a critical part of the broad STEM education ecosystem, Victorian Tech Schools resource local teachers and students with technology-rich learning experiences and aim to equip young people with STEM skills for future employment in industry growth sectors. This paper uses Bronfenbrenner's ecological perspectives to examine how Tech Schools develop and deliver diverse programs, establish partnerships with schools, industry and the community, and work closely with their host institutions. Using ecological systems theory, we draw on data generated as part of an evaluation of the Tech Schools Initiative involving key stakeholders who comprise the STEM education ecosystem of each Tech School. With students at the centre of the STEM education ecosystem, we show how the parts of the ecosystem (microsystem, mesosystem, exosystem, macrosystem and chronosystem) influence students through: interactions that lead to innovation in program design and student and teacher experience; interactions that lead to pathways opportunities; and connections created between schools, industry, community, and hosts. Data shows that Tech Schools are revolutionising current understanding of pathways in their local context. They are also shifting the traditional pathway of school-to-university/TAFE-to-industry and the world of work by bringing STEM industries and work into the consciousness of young people while in schools.

Title
Using socioscientific issues to improve argumentation skills in a low socioeconomic regional high school

Presenters
Vaille Dawson

Abstract
The Australian school science curriculum is intended to enable students to understand science and inquiry processes. However, students also need to develop the skills to make evidence-based decisions about science-based issues. The aim of this research was to examine whether Year 7 science students located in regional Western Australia could improve their argumentation skills following instruction in the context of water based socioscientific issues (SSI). An experienced science teacher and her two classes of Year 7 students (n=39) participated in the research. Using an interpretive paradigm and a case study method, quantitative (pre- and post-questionnaire) and qualitative (classroom observations, work samples and teacher interview) data were collected. After two explicit lessons on argumentation, students' argumentation skills improved significantly. Teacher strategies that may have contributed to the improvement included (1) creating a safe environment for students to take risks with their thinking; (2) providing multiple opportunities for students to practice argumentation; (3) differentiating instruction to cater for varying abilities: (4) and encouraging students to write down their arguments. It is concluded that, with support, the students were able to understand the

components of an argument and construct an argument.

Title
Middle school students application of science content and context into engineering design solutions

Presenters
Gillian Roehrig, Muhammad Purwanto

Abstract
Research argues that the integration of engineering design tasks into K-12 science instruction provides a motivating context for students to apply scientific knowledge in the development of design solutions. Small group engineering activities offer opportunities to examine how students make sense of both context and content in proposing and developing design solutions. This study examined the different approaches of four small groups of middle school students to their design work. Two groups relied heavily on the criteria and constraints associated with the engineering design context, drawing on the user experience to make design decisions. Whereas the other two groups focused solely on the technical design, without consideration of the client's specific needs. Two groups explicitly drew on their science knowledge to make design decisions; however, the other two groups used the equipment to tinker in the development of their designs without drawing at all on knowledge of science. This study informs the field about the use of engineering design activities to enhance learning in middle school science classrooms and provides implications for the design of engineering design activities that support students' incorporation of context and application of science knowledge into their design thinking.

Title
Moving forward: Implementing the nature of science in New Zealand secondary schools

Presenters
Sabina Cleary

Abstract
Both science, and the role that science plays in societies has changed significantly over the past decades and will continue to evolve in the future. This poses challenges for teachers as they are required to develop a deeper understanding of the nature of science (NOS) in order to support their students to use their science knowledge and engage with science-related issues. This study sought to explore the experiences of nine secondary science teachers in New Zealand as they changed their practice to include NOS in their teaching. Narratives provided by the teachers were analysed using thematic analysis in order to make meaning of their stories and generate themes that might provide insights for other teachers. The narratives illustrated a sense of urgency felt by the teachers to change their practice to a focus on NOS and revealed glimpses into how they achieved this in their settings, and which aspects they focused on. They and their students experienced positive outcomes as a result of challenges to their beliefs and practice that resulted in new ways of approaching science teaching and learning.

Title
Where, when, and how? Exploring models of digital technology integration in science teaching and learning

Presenters
Ben Egerton

Abstract
As is the case with school curricula in many other countries, the New Zealand Curriculum (2017) tasks teachers – including science curriculum specialists – to implement and provide contexts for digital technologies (DT) learning. Yet, research internationally reveals that teachers have conflicting understandings of, and purposes for, where and why to integrate DT into their curriculum areas – not least worries about their own DT competency, or erosion of curriculum learning time. As part of our three-year New Zealand-focused empirical study investigating affordances of online citizen science (OCS) for supporting science teaching and learning, we were interested in how primary and secondary science teachers embedded DT learning within their science teaching. In this paper, drawing on data from our study, I report on our findings; proposing models for how DT teaching and learning might not only be integrated and structured within science teaching, but done so in such a way that DT learning is in service of, and used to amplify and communicate, science learning and understanding.

Title
Sci-5: Should school start with stimulating science?

Presenters
Chris Preston, Helen Georgiou, Angela Fitzgerald

Abstract
This paper presents the title as a provocation – should science be taught from the very beginning of school? What form should science instruction take for early years learners? What kind of activities are appropriate? How can teachers be supported to help children transition from play-based to guided inquiry? Why do we advocate a constructivist, hands-on, minds-on, view of learning that draws on 25 years of research in science education (Skamp & Preston, 2021) and 20 years of practical experience teaching kindergarten. How is research into developing and implementing the Sci-5 program in Australian schools providing insights into the specific professional learning needs of early years teachers? What strategies can support teacher understanding of early years science and practical inquiry, interactive discourse with children, and formative assessment? How can we as experienced science educators support teachers to harness children' curiosity and desire to actively explore, play and wonder about their world? What are we learning about how to leverage the strengths of classroom teachers to implement exemplary science teaching practice? This paper invites you to consider how science can be positioned as an engaging and creative discipline from the start of school.

Thursday 8.30am

Title
STEM student profiles

Presenters
George Aranda

Abstract
There is growing concern about student participation and attitudes towards STEM disciplines, particularly given the needs of contemporary society for STEM workers and for STEM literate citizenry. It is recognised that secondary students focus on studying STEM disciplines for a range of reasons, including, a current personal interest or aspirations for working in a STEM career – or they may have no interest in a STEM career. Student orientation to STEM reflects in part their motivation to pursue a career in a STEM pathway and their interest in what STEM offers them personally. Schools are not set up for incorporating sophisticated STEM activities into the curriculum and the Tech School Initiative was designed as a response to this by providing engaging STEM activities through a suite of programs that may be aligned to the school curriculum. This paper will draw on data from a 4-year evaluation and explore student responses to their experiences of participating in the Tech School programs in terms of career and study aspirations. Four orientations to STEM in this Tech School context were evident in the data: STEM motivated, STEM inspired, STEM playful and STEM disinterested. Teacher perceptions of student aspirations will also be explored. This study will examine whether student experiences of their participation in the Tech School programs influenced their attitudes and orientation to STEM disciplines and their career or study aspirations. The outcomes of this research will focus on what teachers and STEM centers like Tech Schools can do to foster positive student associations with STEM disciplines and to support students who might already have developing aspirations for future STEM study and/or careers.

Title
Primary teachers' unpredictable moments in interdisciplinary mathematics and science teaching

Presenters
Gahyoung Kim, Amanda Berry, Joe Ferguson, Lihua Xu

Abstract
Various factors, such as diverse learners, educational reforms, and technological advancements, are adding to the challenges for science teachers. This is particularly true for interdisciplinary mathematics and science teaching, which emphasises open-ended questions, inquiry approaches, and student-centred learning. Therefore, teachers are facing more frequently unpredictable moments in interdisciplinary mathematics and science teaching and require expertise to adapt flexibly and effectively to these moments. This study is part of an ARC research project that explores primary teachers' adaptive expertise in interdisciplinary mathematics and science teaching. Our case study aims to explore the situations and responses of two primary teachers during

their first experiences of teaching an interdisciplinary lesson sequence, 'Journey through Space.' The findings suggest that teachers encounter unpredictable moments involving interdisciplinary connections, misunderstandings between teachers and students, unforeseen questions, diverse learners, time management challenges, and environmental factors. Their responses appear to fall into the following categories: improvisational, delayed, or reflective. This study contributes to understanding the difficulties primary teachers face and provides a basis for exploring the development of primary teachers' adaptive expertise in interdisciplinary mathematics and science teaching.

Title
Secondary science teachers' conceptions and teaching practices of environmental education

Presenters
Hsiao Mei Huang, Su Chi Fang

Abstract
The PISA 2025 Science Framework extends the scope of science education to encompass sustainable development and environmental education, with a particular emphasis on students' environmental science capabilities. The new framework underscores the pivotal role of science education in cultivating environmental literacy and the interconnectedness of these two domains. To understand how science teachers implement environmental education in Taiwan, this study employed a qualitative research approach to explore secondary science teachers' conceptions and their teaching practices of environmental education. Ten enthusiastic senior and junior high school science teachers who have implemented environmental education in their school curriculum were invited to participate in the study and interviewed. The teachers' conceptions were analyzed based on the 15 currents of environmental education proposed by Sauvé (2005) while teaching practices were categorized by the types of teaching methods. The findings show that eco-education and conservationism emerged as the predominant environmental currents cited by the teachers. Those teachers subscribing to scientific and problem-solving currents tended to integrate scientific knowledge into their environmental education practices. The majority of teachers employed multiple teaching methods when implementing environmental education. Notably, the teachers who embraced a spectrum of conceptions of environmental education displayed a broader array of teaching methods.

Title
Factors influencing the development of academic motivation of gifted students in science

Presenters
Hae-Ae Seo, Yeon-Hee Kim

Abstract
Academic motivation is important in determining students' task persistence, academic performance, future career choice, and even life goals. This study aimed to find out factors influencing on academic motivation from the perspective of gifted students in science. The research method employed in the study was in-depth semi-structured interview with fourteen students from three science gifted academies. Qualitative data collected were analyzed through the procedures of inductive data analysis with coding,

categorizing and interpreting. Findings indicated that students often attributed their academic interest and motivation to active interaction with peers who share similar research interests and career goals. They exhibited accelerated motivation when peers recognized academic knowledge and asked to teach them. In addition, several factors relating to family support, teacher feedback, extracurricular activity programs after schools, and the value of studying were found to have positive influences on the development of academic motivation. Moreover, it was analyzed that some students' academic motivation was low due to competition caused by the relative evaluation of school-based GPA. The findings are expected to be used by schools and teachers to provide the best support for developing academic motivation among gifted students in science and to provide meaningful implications for general students as well.

Title
Profiling scientific inquiry skills of Taiwanese high school students: A latent profile analysis

Presenters
Yu-Chun Chen, Chi-Jung Sui, Chun-Yen Chang

Abstract
In this research, our objective was to investigate the scientific inquiry skills of high school students in Taiwan and to delineate distinct profiles based on their inquiry skills. Through the animation-based activity (ABA), we engaged students in a scientific inquiry focused on the atmospheric chemistry of climate change. During the inquiry, students implemented tasks involving data analytics (DA), control of variables (COV), and scientific reasoning (SR) – three fundamental skills identified as imperative for fostering students' active participation in the learning process. Data was gathered from 667 high school students aged 15-16 over a span of two consecutive years in Taiwan. Employing latent profile analysis (LPA), we sought to identify potential subgroups based on students' inquiry skills. Our analysis revealed three distinct subgroups of inquiry skill profiles: “Reasoner”, “Analyst”, and “Novice”, characterized by their proficiency in DA, COV, and SR. The Reasoner subgroup exhibited strong performance across all three abilities, the Analyst subgroup excelled primarily in DA, while the Novice subgroup demonstrated deficiencies in all three skills. The findings echoed the previous study that modeled inquiry skill profiles among Chinese high school students. In summary, this study contributes to generalized students’ inquiry profiles while engaging in learning through ABA.

Thursday 9.10am

Title
An exploration of students' engagement with 21st-Century skills during integrated STEM activity

Presenters
Muhammad Purwanto, Gillian Roehrig

Abstract
The popularity of integrated Science, Technology, Engineering, and Mathematics (STEM) education, particularly engineering incorporation into K-12 science classrooms, is growing globally. One of the arguments for integrated STEM is promoting 21st-century skills (creativity, critical thinking, communication, and collaboration) deemed important for future participation in STEM. Thus, this research focuses on understanding how integrated STEM facilitates students' 21st-century skills development. Through a single embedded case study involving four sixth-grade students, the research explores their engagement in 21st-century skills during an engineering design process (EDP) within an integrated STEM unit. The students worked collaboratively to design a laser security system to prevent thieves from stealing valuable artifacts from museums. Video and audio of their interactions were analyzed using a coding protocol adopted from the National Education Association (NEA) (2010). Our findings suggest that communication and collaboration were the most frequently observed skills. Creativity and critical thinking were prominent during the brainstorming stage. However, during the testing phase, despite encountering some challenges, the students' experiences did not lead to significant learning or innovation in the design. Findings suggest that students engage in a wide range of 21st-century skills during an EDP. This study demonstrates that EDP can promote students' 21st-century skills.

Title
Primary school boys' and girls' awareness and interest in STEM-related activities, subjects, and careers

Presenters
Michael Carey, Natalie McMaster, David Martin

Abstract
Internationally, there is an under-supply of intellectual capital to provide for STEM-related employment. One factor is the low number of female students selecting STEM school subjects and careers. Despite the literature recommending students engage in STEM activities earlier, many initiatives are not implemented until high school. Our project named MindSET-do, provides students with early positive STEM experiences to raise awareness of, interest in, and aspirations for STEM-related subjects and careers. This presentation discusses the development and validation of the survey instrument and project results with n = 107 Year 6 boys' and girls' interests, ability beliefs and expectations in STEM school subjects and careers. Students' awareness and interest in STEM-related subjects and careers increased significantly following experiences with inquiry-based STEM activities, $\chi 2(1, n=107) = 4.57$ to 63.67, $p < .05$. Expectancy for success in mathematics was significantly higher for males than for females ($U=1125$, $p=.044$, $r=.2$). Expectancy for success in science was slightly lower for the female group, but $p>.05$. Logistic regression found females were 24 percent less likely to have a positive view of mathematics than males ($p=.003$). Gender differences in STEM

ability versus ability beliefs and expectancies for success and development of survey instruments for younger participants are discussed.

Title
Effect of course-based research experiences in secondary advanced biological science courses: impacts on student self-efficacy, engagement, sense of belonging, identity, and overall motivation in STEM

Presenters
Shawndra Fordham, Robert Talbot

Abstract
Integrating Course-based Research Experiences (CREs) into introductory STEM courses at the university level has been recognized as important in increasing persistence in STEM. A significant area of attrition from the STEM pathway, however, occurs during secondary school when student interest in STEM rapidly declines. In this study, I investigated the impact of integrating CREs in secondary advanced bioscience courses on student self-efficacy, engagement, identity and motivation in STEM. Using a mixed-methods approach, students in advanced bioscience courses, with and without CREs, were administered the Self-determination, Purpose, Identity, and Engagement in Science (SPIRES) survey using a pre-post study design followed by semi-structured student interviews. Students with a first experience in a bioscience course with a CRE had a significant increase in self-efficacy, engagement, sense of belonging, and motivation in STEM. In addition, students with a second experience in a bioscience course with a CRE not only maintained the high starting levels of self-efficacy, identity, sense of belonging, and motivation in STEM, their engagement in STEM increased significantly. Student interviews confirmed the importance of CREs in influencing these results. This study contributes to the growing body of literature around CREs in general and integrating them into secondary school STEM courses.

Title
Investigating the effects of inquiry and practices course on high school students' motivation towards science learning

Presenters
Yi-Hsuan Shih, Su-Chi Fang

Abstract
According to the newly implemented Taiwan 108 Curriculum Guidelines, the "Inquiry and Practice" course is a required course at senior high levels to foster students' development of inquiry practices through practical experiences. Researching the impact of the "Inquiry and Practice" course on students' motivation towards science learning is of considerable significance in improving inquiry-based teaching and learning.
The study used mixed methods to investigate the effects of Inquiry and Practice Course on high school students' motivation towards science learning. Quantitatively, the ""Science Motivation Towards Science Learning Questionnaire (SMTSL) (Tuan et al., 2005), including six constructs: self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment incentives, was used to measure students' motivation towards science learning before and after the

course. A latent profile analysis was employed to identify the before- and after-motivational profiles based on the six dimensions of motivation. Teacher and student interviews were conducted to explore potential reasons underlying the change/unchanged of students' motivation profiles. The preliminary analysis identified four motivational profiles showing distinct dimensional characteristics: active & achievement-driven, active & performance-driven, evenly motivated, and low science self-efficacy science learners. The changing/unchanged profiles will be analysed further and underlying reasons will be discussed.

Title
Predicting student success in tests using data generation and machine learning techniques

Presenters
Yiu-Tin Lai, Bo-Heng Lin, Chun-Yen Chang

Abstract
This study presents a simplified validation method focusing on predicting student success rates on tests and early identification of students needing support. Unlike traditional approaches requiring extensive testing and varied data, this method utilizes existing scores to create predictive models with customizable success criteria, applicable to any test. The purpose of this study was to investigate the application of data generation and machine learning techniques to predict success in other assessing scientific inquiry ability (SIA). Using a dataset of 366 high school students, with 70% for training and 30% for testing. Various data generation and machine learning techniques were attempted for choosing the best model. Synthesized Minority Oversampling Technique was employed to augment the training dataset. The Linear Discriminant Analysis model was trained on these variables, utilizing a conditional probability threshold ($P(Y|X \geq 0.57)$). The model successfully predicted ISTAR score groups for 75% of the tested students, accurately identifying 73% of the low-scoring group, i.e. the lower quartile. This research presents an empirical case by using a self-developed SIA test to predict student success in another SIA assessment. Although this study utilizes tests to predict outcomes of tests, this method is also applicable to various data types for high-risk test prediction.

Thursday 9.50am

Title
Evaluation of an SSI-based STEAM program for scientific literacy and agency in climate change

Presenters
Ha My Anna Mang, Hye-Eun Chu, Sony Martin, Michael Cavanagh

Abstract
As science education shifts the focus towards nurturing students to become scientifically literate individuals who can act as active global citizens and agents of change, science education needs to be reframed through integrated socio-scientific approaches for Science, Technology, Engineering, Arts and Mathematics (SSI-based STEAM). This study employs a design-based research methodology to evaluate the effectiveness of an SSI-based STEAM program in enhancing student scientific literacy and agency. The program was evaluated using the SSI-based STEAM Teacher Evaluation and Design (SSTEPD) rubric by 16 final year pre-service teachers, who had completed introductory SSI-based STEAM and 6E inquiry lessons in their education courses. The rubric consists of 37 SSI-based STEAM items in 7 evaluation categories related to learning outcomes and the 6E inquiry model. Preliminary findings indicate high agreement among pre-service teachers about the program's effectiveness in enhancing student scientific literacy and agency, as well as the usefulness of the rubric. This research has significant implications for supporting teachers use of program evaluation tools to guide their evaluation and design of SSI-based STEAM programs and reflect on their teaching practices. Furthermore, this research provides teachers with an innovative approach that effectively fosters scientific literacy and student agency.

Title
Do Australian students still hold gendered views of suitability of STEM careers? Results from a STEM stereotypes questionnaire

Presenters
Felicity McLure, Sevda Yerdelen-Damar

Abstract
One of the barriers to females participating equally with males in STEM careers has been beliefs that STEM careers are more appropriate for males than females. In order to measure whether students' still hold stereotypical views of careers in the fields of science, technology, engineering and mathematics, a STEM stereotypes questionnaire was designed and validated, and then used to compare the views of male and female Grade 8 and 9 students in three schools (N=272). The items in the questionnaire were found to load onto four scales describing each of the fields: general beliefs, beliefs about female participation, beliefs about male participation, and beliefs about socio-economic aspects of participation. Comparison of students' perceptions about the suitability of STEM careers for males versus for females showed significant differences in both male and female students' beliefs about STEM careers in each domain (science, mathematics, technology and engineering): namely that they are more appropriate for males than females. Paired t-test comparisons of the difference between responses to items related to suitability of careers for males and suitability of the same careers for females revealed that, in all cases except engineering, females hold a significantly

less gendered view of suitability of careers than males.

Title
Learning about photosynthesis through online scientific inquiry coupling microscopic representations: Collaborative versus individual learning?

Presenters
Jyun-Sheng Syu, Ching-Ying Hsueh, Hsiao-Ching She

Abstract
Photosynthesis is considered one of the most challenging concepts for students because of the microscopic levels' understanding of dark and light reactions involved. Thus, five online photosynthesis lessons were created combining scientific inquiry activities with microscopic representations. We recruited 112 7th grade students from four intact classes from the same school and assigned them randomly to collaborative and individual learning groups. All students were administered scientific concept, scientific inquiry and mental model tests before and after learning. They each have an iPad equipped with online learning programs to work individually or collaboratively. Collaboration involves students sitting with their partners and discussing face-to-face, while using their own iPads. The results indicated that both groups made significant improvements in their scientific concept and scientific inquiry performance. Additionally, the collaborative learning group outperformed the individual learning group on the mental model test. During online science learning, collaborative groups outperformed individual groups in the process of drawing experimental conclusions, macro-micro integration questions, and overall online inquiry scores. Using the online scientific inquiry with microscopic representations learning content, we conclude that collaborative learning is more effective than individual learning approach in helping students construct mental models, construct micro-macro concepts, and conduct scientific inquiry processes.

Title
Exploring Taiwanese IB science teachers' beliefs and implementation of inquiry-based teaching

Presenters
Yu-An Chen, Su-Chi Fang

Abstract
The International Baccalaureate (IB) is known for its emphasis on inquiry-based teaching in the global education system. IB has therefore become a reference for science education reforms in many countries, including Taiwan. However, limited research exists on IB science teachers and their practices in IB schools. This study addresses this gap by investigating the beliefs and inquiry-based teaching approaches of IB science teachers in IB science classrooms.
This study utilized a case study approach to explore three IB science teachers' beliefs, backgrounds, experiences, classroom environments, and inquiry instructional designs through in-depth interviews. Classroom observations and field notes were used to investigate teachers' inquiry teaching practices. The researcher utilized the Secondary Science Teaching Analysis Matrix (STAM; Brown, 2002) to analyze teacher beliefs and inquiry-based teaching. The results indicate that the three IB science teachers' beliefs

generally align with student-centered characteristics. The teachers employed diverse teaching strategies concerning the nature of the learning unit, demonstrating their student-centered beliefs in inquiry teaching practices. The educational background, teaching experience, and teaching context had varying degrees of influence on the formation of their beliefs. The distinctive features of inquiry-based teaching and assessment in the IB education system deeply impacted teachers' choices of teaching strategies.

Thursday 11.00am

Title
Māori concepts for animal ethics: Implications for the Three Rs

Presenters
Georgina Tuari Stewart, Sally Birdsall

Abstract
Māori knowledge (or Mātauranga Māori) is a system of knowledge about the natural world that overlaps with Western science in some ways, and differs markedly in other ways. Mātauranga Māori is holistic - it makes no separation between 'facts' and 'values' so philosophical Māori concepts can be both facts and values at the same time.
This project explores Māori concepts relating to animals, and the implications for using animals in research and teaching. The Three Rs are strategies for more humane methods of using animals: Replacement (avoiding animal use); Reduction (reducing number of animals used) and Refinement (decreasing severity of procedures).
Our strands of data collection included:
(1) re-reading archives on Māori knowledge of animals through a Kaupapa Māori lens;
(2) conducting interviews with six Māori experts working with animals in various domains.
We find that the central concepts of Māori philosophy give rise to Māori concepts of Respect and Relate, which underpin those of the Three Rs, expanding Western science by enacting the Three Rs as part of being a "good citizen of the natural world".
We are creating classroom resources on animal ethics based on this research and reflecting our aspirations for the responsible inclusion of Mātauranga Māori in science education:
1. Year 7-10: Māori Knowledge of Animals;
2. Year 11-13/tertiary: Māori Concepts for Animal Ethics and the Three Rs;
3. Six profiles of Māori experts;
4. Te Reo Māori resource: Extracted from above, translated, desktop published, pdf online.

Title
Customized science learning: Integrating UDL in an AI chatbot development for elementary education

Presenters
Hye-Eun Chu, Juyeon Lee, Sarah Hajama, Kiano Pomente, Sonya Nichole Martin

Abstract
Elementary science students exhibit diverse levels of learning, with some facing barriers in accessing traditional materials due to special education needs, second language acquisition challenges, and socioeconomic disparities. This study introduces an AI Chatbot to enhance engagement and accessibility in elementary science education, fostering inclusive learning environments and bridging educational gaps. This AI Chatbot targets a Grade 6 Light and Optics unit, as this unit poses misconception-related challenges. Informed by Universal Design for Learning (UDL) principles, the chatbot offers level-specific and self-directed learning

features. Pre-tests were conducted to categorise students into three levels. Depending on the student's level, materials were organized by applying the principles of UDL. Additionally, the 5 steps of the self-directed learning model were applied to guide student autonomy. The chatbot's content validity is verified by six experts by employing an AI Chatbot Evaluation Checklist. Future research will assess and apply the AI chatbot to 6th grade students, exploring its impact on students' cognitive and affective factors. The insights gained will inform future development and utilization of AI chatbots, ensuring alignment with UDL principles and addressing learners' diverse needs. This study advances inclusive educational practices by integrating AI technology with UDL principles to support elementary science education.

Title
Interactive reality - orchestrating student learning through interplays of direct and indirect experiences about plants

Presenters
Maurice M. W. Cheng, Bronwen Cowie, Chloe Stantiall

Abstract
This paper contributes to understandings of multiple representations by creating/identifying extended potentials of observable objects/phenomena in tackling 'plant blindness'. Our participatory research study involves a Year 5/6 class in Aotearoa New Zealand that spent a week studying kōwhai trees. In each of the following activities that were co-constructed by the researchers and teacher-researcher, students had multiple opportunities to interact with kōwhai and to learn about various botanical aspects. Student learning involved (i) identifying then searching for and collecting kōwhai seeds from the school grounds, then planting seeds in the classroom, (ii) observing the arrangement of leaflets then creating annotated drawings of the leaflets based on observations and samples they brought to the classroom, (iii) constructing a representation for the development from a fertilised flower to a seedpod based on real specimen collection, (iv) working on i-naturalist charting kōwhai trees on and around the school campus. We created vignettes based on class observations, and collected/analysed students' work, including infographics that reflected their knowledge about kōwhai. In the paper we highlight the affordances of multitude of aspects of the 'real' and their interactions for student learning that we believe to be readily translatable to other plants and school year levels.

Title
Cross-cultural insights into physics education: Unraveling the determinants of secondary students' attitudes across eight countries

Presenters
Pongprapan Pongsophon

Abstract
Understanding the determinants of attitudes toward physics is crucial for improving academic achievement in the subject. This study addresses the gap in identifying significant predictors of these attitudes. Utilizing the Trends in International Mathematics and Science Study (TIMSS) Advanced 2015 data from the USA, Italy, Lebanon, Norway, Portugal, Russia, Slovenia, and Sweden, this research conducts descriptive statistics to calculate weighted means and standard deviations, followed by multiple regression analyses to examine the influence of predictive variables on students' attitudes towards physics. The findings reveal significant

cross-cultural variations. Gender appears as a significant factor influencing attitudes toward physics, with female students showing a less favorable attitude as compared to male counterparts across all countries involved in the study. Time spent on physics homework correlates positively in the majority of the countries, suggesting the importance of out-of-class engagement. Interestingly, the perception of engaging teaching and the value students place on physics emerge as strong, positive determinants of students' attitudes, underscoring the role of instructional quality and relevance of the subject matter. These results provide a nuanced understanding of how various factors contribute to students' attitudes towards physics and offer a foundation for targeted educational interventions.

Title

Interlacing affect, learning, and sociocultural activity in multilingual science classrooms: Experiences of Syrian refugee youths and families

Presenters

Sara Salloum, Rena Al Debs, Saouma BouJaoude, Danielle Dani

Abstract

The entanglement of linguistic, classed and racialized power dynamics with science education manifests in inequitable classroom practices that can elicit a range of affect and emotions for diverse multilingual learners. Our study explores the affective and emotional responses of a group of middle school Syrian refugee students, their teacher, and parents, after engaging in a linguistically responsive life science curriculum, and their general perceptions and challenges navigating Lebanon's multilingual educational system. The hybrid and dialogic curriculum was designed as a space for refugee multilingual learners to develop science knowledge and discourse through active inquiry, purposeful translanguaging, and home connection activities. We utilized 'Collective Memory Work' as a qualitative research approach for participants to recollect their experiences during the science unit and contextualize them within other teaching and learning experiences and the wider social and institutional structures. Multi-layered data analysis included identifying explicit and direct expressions of emotional lived experiences (e.g. anxiety, etc.) and discerning pedagogical practices and interactions connected to explicit expression of emotional experiences. 'Activity system' representations were constructed accordingly to show dialectical interconnections among affect and science learning as a historical and socio-cultural 'activity.' Results are discussed through cultural-historical activity theory (CHAT) and a 'rightful presence' perspective.

Thursday 11.40am

Title
Making space for non-Eurocentric voices in the curriculum: The potential of a knowledge systems approach

Presenters
Rosemary Hipkins, Bronwen Cowie, Pauline Waiti and Sara Tolbert

Abstract
'Mana ōrite', broadly translated, conveys the aspiration that mātauranga Māori–the knowledge of the people indigenous to Aotearoa New Zealand—should be given equal status to the Eurocentric knowledge typically taught and assessed in schools. The mana ōrite imperative was first introduced as part of the reform of NCEA, the senior secondary qualifications system, and then adapted for the 'refresh' of the national curriculum framework. It quickly became apparent that translating the aspiration into the updating science curriculum and NCEA assessments would be easier said than done. This talk will outline a 'knowledge systems' approach developed by a small group of science educators, commissioned by New Zealand's MOE to design a high-level strategy for aligning the separate curriculum and assessment reforms. Avoiding binary thinking (which 'others' indigenous knowledge in comparison to science) and being very clear about why the change is being considered, and who is expected to benefit, are just two of the challenges we have faced in our ongoing explorations. Adopting phenomenon-based pedagogy offers promise for addressing these challenges, while also highlighting the importance of contextual choices, and of making learning space for young people's knowledge and lived experiences of the natural world.

Title
Fostering hope and action for climate change: The impact of a futures-oriented teaching module with generative AI integration

Presenters
Shu-Chiu Liu

Abstract
The study examines the development and impact of a futures-oriented teaching module designed to cultivate foresight and engagement with climate change actions. The module was based on a scaffolding model that guides undergraduate students through exploring possible future scenarios, identifying their underlying factors and drivers, and envisioning the desirable, sustainable future with a connection to their present lives. Building on an earlier version, the current version incorporates generative Artificial Intelligence (AI) to facilitate students' envisioning of sustainable future scenarios. Through pre- and post-test design (N = 58), we assessed the effects of this module on students' hope and self-perceived action competence regarding climate change. Additional post-instructional reflections on futures-oriented learning and AI were included in the analysis. From the results, it is evident that students' sense of hope and self-perceived competence in fighting climate change has significantly increased. They felt more aware of their own role as well as the implications of climate change after exploring future possibilities. The novel use of generative AI in this approach offers students a dynamic and engaging way to reflect on their present and future in the context of climate change.

Title
Reframing epigenetics as a tool to break free from the constraints of genetic determinism: A dynamic classroom model

Presenters
Sunyoung Shin and Minsu Ha

Abstract
Understanding complex subjects like genetics is often hindered by fragmented information and biases. This study introduces a teaching model aiming to cultivate broader perspectives in genetics education, challenging cognitive biases such as genetic determinism. Genetics is a useful tool for finding explanations for human behavior or traits, but it is important to understand the complex interactions between the environment and genes. The proposed teaching model explores examples from epigenetics, facilitating a challenging perspective on genetic determinism. Choosing fruit flies as model organisms is justified by their short reproductive cycles and diverse genetic variations, enabling students to experience and comprehend genetic principles firsthand. Additionally, by presenting cases from epigenetics, we aim to provide insights into the interaction between the environment and genes, assisting students in breaking away from simplistic genetic determinism and forming new perspectives.This teaching model is expected to enhance students' ability to comprehend the limitations of genetic determinism and consider various influencing factors on human traits. Moreover, it provides opportunities for enhancing scientific and critical thinking, as well as fostering creativity and inclusivity. Future assessments involving expert validation and pilot testing will evaluate how effectively this teaching model improves students' learning and perceptions.

Title
The atomic choir: Using interactive sound events to engage audiences in science

Presenters
Alexis Weaver

Abstract
Combining interactive auditory experiences with novelty and humour has the potential to engage new audiences in science. This presentation will introduce the idea of the Atomic Choir: an interactive speech- and sound-based event that aims to teach its audience about scientific concepts in a way that promotes engagement and memorability. Drawing on multiple iterations of the event, including one staged at the Sydney Observatory for World Pride 2023, I will discuss how this framework exploits the unique characteristics of sound-based events for science communication and learning. I will also discuss potential improvements to future events and propose ways that this framework can be used by communicators and teachers. Of particular focus will be the role of spontaneity and play, participant agency and non-hierarchical interactivity as effective tools for engagement and learning. If numbers permit, the presentation will begin with a short interactive example of the Atomic Choir.

Title
Does topic matter? Investigating students' emotions, interest and learning when writing stories about socio-scientific issues

Presenters
Senka Henderson, Louisa Tomas Engel, Donna King

Abstract
This case study of a Year 8 science class in South-East Queensland investigated the affective and cognitive experiences of engaging students a science-writing project. Students wrote a series of short stories across two school terms about the socio-scientific issues (SSIs) of coal seam gas (CSG) mining and skin grafting. Data were collected through an emotion diary, thinking prompts (designed to elicit students' evolving understanding of each SSI) and semi-structured student interviews. We identified trends in students' interest and emotions and analyse their relation to classroom activities. Three assertions emerged from data analysis: (1) Students' self-reported interest was statically higher in relation to skin grafting compared to CSG; (2) Students reported positive emotions in relation to the topic of skin grafting, while positive emotions in the CSG unit were related mostly to instructional approaches; and (3) Students could explain the social, moral and ethical dimensions of each SSI and an evidence-informed position at the end of both units. These assertions support our thesis that topic does matter when engaging students with SSIs. At the same time, while these results confirm the learning affordances of SSIs, they suggest that a teacher's pedagogical decisions also matter when students are less interested in a topic.

Thursday 12.20pm

Title
Reflecting on our journey towards teaching Indigenous and Western Sciences in Initial Teacher Education

Presenters
Connie Cirkony, Rebecca Cooper, Jennifer Mansfield, Chris Preston, Mijung Kim

Abstract
Science educators are seeking ways to bring Indigenous perspectives into their classrooms to enhance learners' understanding of the diverse ways in which people make sense of the natural world through culturally responsive approaches. With most educators trained exclusively from a Western science perspective, and from non-Indigenous backgrounds, this work presents important considerations. As a starting point, an international group of non-Indigenous science educators from Australia, Canada and New Zealand have formed a Community of Practice aiming to decolonise and Indigenise science education in Initial Teacher Education (ITE) programmes. Informed by the principles of Two-Eyed Seeing, where both Indigenous and Western scientific ways of knowing are valuable, achievable, and can inform how we live in the world, this presentation highlights our personal and professional learning journeys. Drawing on a thematic analysis of our reflexive journals framed through a lens of Van Lankveld et al.'s (2017) model for teacher identity for the higher education context, we report on the following themes: approaches to Indigenous perspective in science education, supports and constraints, and ethical considerations.

Title
Multimodal capabilities of generative AI: To what extent can chatgpt produce visual representations of science?

Presenters
Kok-Sing Tang, Grant Cooper

Abstract
Current generative artificial intelligence (GenAI) tools exhibit multimodal capabilities, enabling them to transform information across formats, including text, audio, images and videos. However, limited research has explored the potential and limitations of multimodal GenAI in enabling science teaching and learning through the use of multiple representations. This study aims to assess the feasibility of images produced by GPT-4 (with built-in DALL-E3) in terms of their relevance, accuracy and alignment with secondary science curriculum. It specifically investigates the question: To what extent can GPT-4 produce images to support science learning? Drawing from the theory of social semiotics, the study analyses and compares the images produced by GPT-4 against the photographs and diagrams from Pearson Science Australia textbooks for Year 7-10. The findings reveal a stark contrast between AI-generated images from two different genres: information report and scientific explanation. In information reports, AI-generated images closely resemble the realistic photographs used to depict natural phenomena. In scientific explanations, while AI-generated images do not match the textbooks' explanatory diagrams designed to illustrate technical processes and relationships, they nevertheless feature visual motifs commonly found in explanations, such as the use of arrows, sequential images, and invisible particles. Implications from these findings will be further discussed.

Title
Aristotle, biodiversity, classification: An ABC of the importance of taxonomic classification for understanding biodiversity

Presenters
Leonie Rennie

Abstract
Biodiversity and the interconnectedness of life" is Unit 1 of the Australian Biology Curriculum. Learning outcomes include "understand how classification helps to organise, analyse and communicate data about biodiversity", and matching statements relevant to understanding biodiversity appear in the strands of Science Inquiry Skills, Science as a Human Endeavour, and Science Understanding. This paper demonstrates how, beginning with Aristotle, naturalists and scientists have built the systems for classifying and naming organisms that we use today. It will demonstrate how the system of taxonomy, either a binomial, hierarchical taxonomy, or according to evolutionary phylogenetic nomenclature, is fundamental to understanding diversity. Unnamed species cannot be counted, diversity cannot be monitored, species that are threatened cannot be identified, and decisions cannot be made about maintaining ecosystems. Helping students to understand and work with classification processes is important, not only as students of biology, but as thoughtful citizens beyond their schooling. Connecting taxonomy to conservation efforts to protect endangered species helps students to appreciate their role in helping to preserve biodiversity. The presentation also touches on the relative poverty of phylogenics compared to hands-on, descriptive taxonomy in terms of understanding and finding ways to preserve biodiversity.

Title
Contemporary physics in the science curriculum

Presenters
Victoria Millar, Maurizio Toscano

Abstract
The science education literature in recent decades has included many and varied discussions about what should be included within the science curriculum. Within this context, this paper takes up the discussion about greater inclusion of contemporary science ideas in the science curriculum with a focus on contemporary physics in the curriculum.
This paper will examine reasons for including contemporary physics in the physics curriculum alongside the tensions that arise from history and epistemology of physics curricula that hinder the introduction of contemporary physics. It does so through a critical examination of how the physics curriculum emerged, how current curriculum documents reveal convergent/divergent interpretations of physics curricula internationally, the role of aesthetics and how the incorporation of contemporary physics can be imagined and enacted.
This paper seeks to answer the following questions:
1. What are the epistemological and historical arguments for the physics curriculum that have made it difficult to include contemporary physics?
2. What are the aesthetic arguments for including contemporary physics in the curriculum?

3. How can these epistemological, historical and aesthetic arguments for contemporary physics in the physics curriculum be reconciled?

Title
Unraveling the role of cognitive conflict, metacognition, and working memory in scientific conceptual change: An EEG study

Presenters
Chuan-Cheng Shih, Hsiao-Ching She, Li-Yu Huang, Wen-Chi Chou, Meng-Jun Chen, Tzyy-Ping Jung

Abstract
Over a thousand articles have been published on scientific conceptual change in an attempt to change students' misconceptions since the 1970s, and some have linked conceptual change to cognitive conflict, metacognition, or working memory. The factors leading to conceptual change remain unclear, thus we designed 40 computer-based weak and radical conceptual change tasks. Each task consisted of question and prediction, confidence rating, experiment video watching, conflict rating, and thinking and explaining stages. An example of conceptual change question: "What candle (long or short) will extinguish first in a beaker after burning for a short time?" Electroencephalography technology was used to study 58 science-major students' brain mechanisms associated with conceptual change, including frontal midline theta and central parietal alpha activations. Results indicated that students achieved significantly better conceptual change success with weak tasks than with radical tasks. Compared to weak tasks, radical tasks resulted in longer reaction and thinking times, lower confidence, and higher cognitive conflict. When successful conceptual change was achieved, frontal midline theta power was significantly higher with radical tasks than with weak tasks. These findings suggest that successful conceptual change is not primarily driven by cognitive conflict or metacognition, but rather by activating and maintaining working memory processes.

Thursday 1.45pm

Title
What understandings of balanced and unbalanced forces do students illustrate through their diagrams and social interactions?

Presenters
Sherab Tenzin, Mihye Won, David Treagust

Abstract
In teaching for conceptual understanding, it is important to identify students' prior knowledge. This study investigated what students' diagrams and social interactions reveal as their understanding of balanced and unbalanced forces. Sixty-one Year 7 students and three teachers from a high school in Australia participated in the study. In the context of three lessons involving rice and pencil, parachute, and magnet and paperclip experiments, 20 students' diagrams and interactions were analysed. The analysis showed that students have varying misconceptions about the forces involved in friction, gravity, and magnetism. The type of errors and misunderstandings related to the concept of balanced and unbalanced forces were dependent on the context. It is essential to note that most of the misunderstandings and misconceptions were detected through the diagrams rather than the verbal explanations. Understanding the context associated with students' understanding will help teachers and educators to prepare and support students. This study illustrates how diagrams can be used as a tool to identify students' misconceptions about scientific concepts.

Title
Documenting the integrated STEM initiative of Philippine science high school and its impact on students' motivation towards STEM learning

Presenters
Mary Sheryl M. Saldon-Raznee, Cate Challen

Abstract
In 2018, Philippine Science High School (PSHS) launched its integrated STEM initiative called Science Research Summit (SRS), a platform for grade 11 and 12 students to showcase their STEM research work. Although research class is mandatory for all students in the PSHS curriculum, the SRS is a co-curricular event for select students from the 16 PSHS campuses. Students either independently or in groups of two or three, submit at least one research paper which is subject to screening for poster and paper presentations. This study aims to document and determine the impact of the SRS as an integrated STEM initiative on students' motivation towards STEM education by addressing two questions: (1) What are the students' views of the SRS and (2) How does the integrated STEM initiative affect their motivation towards STEM learning? This mixed methods study will include quantitative data from the Science Motivation Questionnaire-II and qualitative data from the student interviews in the 2024 SRS. Consequently, collected data will be analyzed using descriptive statistics whereas a thematic analysis will be used to analyze the interview. Results of the study will be used to improve the SRS program to increase students' motivation towards STEM learning.

Title
Exploring what iSTEM teacher leaders need to know and do

Presenters
Emma Stevenson, Pauline Thompson

Abstract
Internationally, science, technology, engineering, mathematics (STEM) education continues to flourish in schools, with many now embracing the combined disciplinary assumption suggested by its acronym; integrated STEM (iSTEM) education. Advocated for its potential to increase student interest and achievement in STEM subjects, courses and careers, leadership in iSTEM education is beneficial for promoting its success in schools. However, there is limited understanding of the characteristics of effective iSTEM teacher leaders. Seeking to provide greater insight into iSTEM teacher leadership, this qualitative study explored the perceptions of five iSTEM teacher leaders to address the question: What are the characteristics of iSTEM teacher leaders? Data analysis of semi-structured interviews identified what iSTEM teacher leaders need to know and do, including disciplinary knowledge, collection and creation of teaching materials, and promotion of iSTEM with the school community. This paper will discuss the identified characteristics, their importance in progressing iSTEM education in schools and implications for iSTEM teacher leader development.

Title
Encouraging student dialogue and comprehension of enzymes by harnessing the Indigenous technology of okuyenga

Presenters
Martha N Nyamakuti

Abstract
In southern Africa, there is a growing discussion on decolonizing and indigenizing science, challenging the dominant perspective that overlooks indigenous knowledge. Namibia's curriculum policies seem insufficient in addressing equity and social injustice in schools. A study in Namibia explored how using indigenous technology for oil extraction from marula nuts and melon seeds, known as okuyenga, impacts Grade 10 Biology learners' understanding of enzymes. Embracing indigenous research paradigms, which prioritize participants' experiences and values, the study incorporated the Ubuntu perspective of respect and togetherness. Data collection involved participatory observation and journal reflections, followed by thematic analysis. The findings showed that presentations by community members on indigenous oil extraction significantly influenced learners' comprehension of enzymes and related concepts. The study suggests teachers collaborate with community members to integrate local indigenous knowledge into science teaching, promoting a more inclusive understanding of science and appreciation for diverse knowledge systems.

Title
An investigation of undergraduate and postgraduate students' ideas of experimental design using primary scientific literature

Presenters
Meena Kharatmal, Arnab Bhattacharya

Abstract
Studies have highlighted that undergraduates and postgraduates experience problems understanding experimentation, including generating hypotheses, recording observations, and analyzing data. In this preliminary study, we investigated undergraduate and postgraduate biology students' ideas of experimental design using primary scientific literature of an experiment on olfaction in fruit flies. Students were asked to read the literature and interpret the experimental design using text and drawing in open-ended questionnaires. Responses were analyzed for depiction of key parameters of experimentation. A qualitative data analysis indicates that most undergraduates missed depiction of placement of larvae (71%), placing of odorants (65%), movement of larvae (71%). Although only a few postgraduates missed depiction of placement of larvae (35%), most postgraduates missed placement of odorants (88%), movement of larvae (76%). Further, repeatability was missed by 71% undergraduates, 88% postgraduates, measurement was missed by 41% undergraduates, 53% postgraduates. This reflects a worrying disconnect between course work on research methodology and acquiring useful scientific literacy skills. Our study demonstrates the potential of using critical discussions of primary scientific literature as a teaching intervention to effectively enhance understanding of experimentation for acquiring scientific literacy skills.

Thursday 2.25pm

Title
Hands-on activities for understanding the probabilistic nature of quantum physics

Presenters
Anastasia Lonshakova, David Blair, David Treagust

Abstract
A foundational concept in quantum physics is probability. However, in science education, this concept is widely misunderstood. The Einstein-First project addresses this situation with the development of a sequence of hands-on activities and games for understanding the intrinsic probabilistic nature of the Universe. Simple experiments using laser pointers, CD covers, hanging mirrors and partial reflections in windows are underpinned by Max Planck's and Einstein's discoveries of photons. The activities link the physics of photons to coin tossing experiments and to a science probability tool called the phasor wheel, which assists students in estimating the probability of photon arrival in quantum optics experiments. Our learning instruments were developed in classroom trials with students aged 8-14 years. Students took a pre-test and after eight hours of learning, completed a post-test comprising the same 10 questions. T-tests were used for the statistical analysis of the test results. Students demonstrated substantial engagement, and impressive knowledge gains in post-test results in which students could explain random processes (100%), provide reasonable interpretations of interference patterns in terms of photon arrival probabilities (82%), and demonstrate understanding of the N 1/2 standard deviation rule for random processes (76%).

Title
The impact of a compulsory integrated STEM subject on girls' emerging STEM identities

Presenters
Tabetha Spiteri, Amanda Berry, Rebecca Cooper, Jared Carpendale

Abstract
Integrated STEM education (iSTEM) reportedly fosters STEM engagement and the development of a positive STEM identity, particularly for girls. However, there have been calls for more research into STEM engagement and identity development within a dedicated iSTEM subject. My PhD study sought to investigate girls' experiences in a compulsory iSTEM subject, and understand how these experiences influenced their emerging STEM identities whilst they were undertaking the subject, as well as one year after they completed the subject. Participants included nine girls from one Melbourne co-educational secondary school who undertook a compulsory year seven iSTEM subject. Whilst undertaking this subject, the girls were asked to photograph their iSTEM experiences and discuss these experiences in two photo-elicited focus groups. One year later, they were asked to reflect on their experiences in a one-on-one semi-structured interview. Thematic analysis of the data revealed insights into the girls' perceptions of their iSTEM experiences in relation to (1) the value of the real-world context for their learning, (2) how they worked and interacted with peers, (3) the processes of learning and receiving feedback on their learning, and, (4) learning and applying the skills and practices of STEM. These insights helped gain an understanding of the factors that facilitated/hindered the emergence of

positive STEM identities for these girls.

Title
Integrated STEM in Australian Initial Teacher Education: Rationale and practice

Presenters
Samantha Bothe

Abstract
Integrated STEM units in Australia's Bachelor of Education (Primary) programs vary, potentially leading to variations in the quality of integrated STEM learning in schools. Extensive studies highlight the complexities of what integrated STEM entails and the multitude of approaches to its implementation in schools. There has been less commentary on how integrated STEM is designed and implemented in Initial Teacher Education (ITE), indicating that this area warrants further research. This PhD study aims to investigate the different approaches to integrated STEM education adopted by Australian universities through the perspectives of teacher educators and curriculum design. The study will also examine the rationale behind each institution's approach and how teacher educators' expertise shapes curriculum design and implementation. The multiple case study will use the Practice Architectures and Curriculum (PAC) framework, which is based on the theory of practice architectures and curriculum theories. This framework will help identify the conditions that influence the rationale for integrated STEM in ITE and how these conditions shape curriculum design and implementation. This presentation will outline how the PAC framework supports the examination of the conditions that shape the curriculum design and implementation of integrated STEM in ITE.

Title
The impact of Indigenous scientist biographies on Indigenous students' motivation to learn science: Self-efficacy, enjoyment, value, and daily life connection

Presenters
Ming-Hsiu Mia Chen

Abstract
This research aimed to explore the impact of Indigenous scientist biographies on indigenous Taiwanese primary students' motivation to engage with science learning. The investigation was conducted in five schools located within remote Indigenous areas, involving 114 fourth to sixth graders as participants. This study employed a quasi-experimental design, where the experimental group was taught using biographies of Indigenous scientists, and the control group was instructed using biographies of mainstream Han Chinese scientists. The motivation to learn science questionnaire, adapted from Barak and colleagues' (2011) instrument designed for elementary school students, was utilized. The questionnaire examined four dimensions: self-efficacy, interest and enjoyment, connection to daily life, and importance to the students. Pre- and post-tests were administered at the beginning and end of the school year, before and after the students were exposed to scientist biographies. Results indicated that teaching with Indigenous scientist biographies positively affected Indigenous students' self-efficacy and perceived relevance of science to their daily lives.

Title
A study on the process-oriented assessment model to promote deep understanding of scientific concepts

Presenters
Sangeui Lee, Seongjae Lee, Minsu Ha

Abstract
The Understanding by Design educational framework encourages learners to grasp core concepts and apply the knowledge or skills they have learned in new contexts. Through such processes, students transform their knowledge into something they can practically use. This approach to learning, known as deep learning, is recognized as a crucial objective in science education. To facilitate and verify deep understanding of scientific concepts, a specialized assessment model is required. This study has developed a process-oriented assessment model that promotes and identifies deep understanding. The developed model selects key questions based on science achievement standards within the curriculum and chooses familiar materials related to natural phenomena covered in textbooks to create assessment items. The prompts define scientific theories or concepts and introduce related natural phenomena. The assessment begins at the lower-dimensional level of explanation and progresses through stages of interpretation, application, perspective, insight, and reflection, allowing for the evaluation of higher-level competencies. The items are developed in a process-oriented manner, where each item aids in understanding and solving subsequent items. Utilizing the assessment model developed in this study can promote a deep understanding of scientific concepts and assess students' higher-order thinking skills.

Thursday 3.05pm

Title
Physics conceptual engagement in remote learning via the Monash Virtual School

Presenters
Richard Gunstone, Tara McDougall, Michael Phillips

Abstract
The Monash Virtual School, established with a mission to challenge educational inequities amid the remote learning requirements of COVID-19 lockdowns, has rapidly evolved from its initial focus on supporting pre-service teachers and school students in the Australian state of Victoria to broader ambitions of global educational reform. Today it engages students and others from many countries, including deliberate focus on some conflict areas (Afghanistan, Myanmar, Ukraine).
The school expands its innovative focus on equity in 2024 by initiating the STEM Event Series (STEMES), a globally unique initiative designed to revolutionise STEM education through online events with experienced engaging thought leaders. STEMES aims to address the urgent need for educational practices that empower youth to tackle contemporary global challenges. It not only questions traditional pedagogies but also seeks to redefine possibilities within STEM education. STEMES aims to be an exemplary model of educational innovation in the face of ongoing global crises.
Two early sessions in the STEMES program, to be conducted well before ASERA, will focus on fostering physics conceptual engagement (each session standalone via remote learning and informed by extensive learning research). We will report the specific consequences of these sessions

Title
The influence of disciplinary identity on teachers' perceptions of integrated STEM

Presenters
Shefali Sharma-Wallis, Russell Tytler, Wanty Widjaja, Peta White

Abstract
The effectiveness of STEM education is ultimately driven by the quality of teaching occurring within the classroom. A teacher's motivation, commitment, and satisfaction- all of which contribute to teacher efficacy- can be influenced by their teacher identity. Within the world of Australian integrated STEM teachers, this indirect relationship between teacher identity and teacher efficacy is particularly interesting given that, 1) there is an absence of mandatory STEM teacher qualifications; 2) teachers often specialise in specific disciplines and either request to or are asked to teach integrated STEM, and 3) teachers have the freedom to choose their STEM curriculum. This PhD project adopts a qualitative, phenomenological methodology to explore how the discipline-specific identity of teachers influences their practices and perceptions of integrated STEM. Australian integrated STEM teachers from varied STEM-related disciplines were interviewed to gain insights into their teaching history, motivations, challenges, etc. A timeline of their journey was created and used as a plane for plotting two fortune lines. The presentation will highlight preliminary findings, which are suggesting that teachers' STEM positioning could be influenced by a complex relationship between their disciplinary-

specific and general teacher identities. This has implications for how we think about teacher roles and professional learning trajectories.

Title
Boundary objects as mediators in transdisciplinary STEM research

Presenters
Cathy Buntting, Azra Moeed

Abstract
In a recent three-year research project, a transdisciplinary community of practice (CoP) investigated the affordances of online citizen science (OCS) projects for supporting engagement and learning in primary and secondary school science.* The CoP included science education researchers, technology education researchers, information systems researchers, generalist primary teachers and science secondary teachers. This presentation will consider the place of boundary objects (Akkerman & Bakker, 2011) to facilitate the development of shared understanding throughout the planning, delivery and evaluation of the teaching interventions that were at the core of the project. The findings have implications for research that involves transdisciplinary teams. Drawing on participants' questionnaire responses about being involved in the project, we will also argue that such transdisciplinary teams are important for pushing the boundaries of contemporary science education research.

*The project – On2Science: Multiple affordances for learning through participating in online citizen science – was funded by New Zealand's Teaching and Learning Research Initiative.

Title
Incorporating Indigenous Ainu Knowledge into formal science education in Japan

Presenters
Hideto Okuyama

Abstract
The Ainu Policy Promotion Act, which came into effect in 2019, clearly stated for the first time in law that the Ainu people are an indigenous people. In response to this, MEXT's curriculum guidelines, which were transferred sequentially from elementary school to high school beginning in FY2020, offered more opportunities to learn about matters related to the Ainu people. Ainu culture has been included in textbooks not only in the subjects listed in the guidelines such as Social Studies, but also in a wide range of subjects, including Japanese Language, Music, and Ethics. Formal science education in Japan is unique in that students learn both 'Western science' and 'knowledge native to Japan.' However, 'indigenous Ainu knowledge' is not mentioned in any science textbooks. Some schools in Hokkaido are enthusiastic about learning about Ainu culture as part of their community studies, and there are opportunities for students to learn about the 'indigenous Ainu knowledge.' These educational practices could serve as a reference for incorporating the 'indigenous Ainu knowledge' into formal science education in Japan. This paper reports on the current situation of indigenous knowledge in formal science education in Japan, as revealed by these literature reviews and

observations of educational practices.

Title
The role of education in achieving Predator Free 2050 in Aotearoa New Zealand

Presenters
Sally Birdsall, Alexandra Palmer

Abstract
Aotearoa-New Zealand has a rich and unique biodiversity. Unfortunately, many of its unique plants and animals are threatened with extinction, largely due to humans introducing exotic animal species. Predator Free 2050 has been established to enable New Zealanders to protect ecosystems through the elimination of predator mammals. But this elimination requires nation-wide active community support and involvement and sustained social licence. To achieve this goal, encouraging the next generation to support and continue predator control is needed. Some schools currently teach students about predator control. However, this teaching has been criticised. Critics believe that students are not developing their own opinions and assert that encouraging participation in predator control leads to children becoming desensitised to violence, resulting in a reduction in empathy for animals and then for humans. Responding to these criticisms, twelve interviews were held with key informants where they shared their ideas for teaching predator control. They agreed that predator control education should: encourage respect for all animals; enable students to develop their own opinions and choose whether to participate in trapping and; be tailored for specific contexts, e.g., an urban or rural setting. There were disagreements about the age at which students should begin trapping, and the degree of student agency allowed when making decisions. However, these data are a snapshot of opinions and further research is needed to ascertain effective pedagogical approaches for this contentious issue.

Friday 8.30am

Title
How are teachers integrating mātauranga Māori into secondary curricula?

Presenters
Karen Finn

Abstract
Equal status for mātauranga Māori, which features in the NCEA review, is a step forward in honouring Te Tiriti o Waitangi. But what does equal status for mātauranga Māori mean for teacher practice? This presentation outlines my PhD research into how Aotearoa New Zealand secondary school geography teachers are integrating mātauranga Māori and decolonising geography. This research bricolage uses critical and decolonising methodologies in a sequential explanatory approach. Using survey data, I discuss how teachers decolonise and indigenise curricula and pedagogies, and the need for further partnership with Māori, learning of mātauranga Māori, and self-reflexivity. The presentation offers applications for science teachers, who are also experiencing educational change. The research aims to support teachers to reconsider their curricula through the lenses of decolonisation and mātauranga Māori. It aims to help teachers who are non-indigenous, like me, to share responsibility for incorporating mātauranga Māori into school curricula. It offers implications for teachers' praxis, initial teacher education, and educational policy. The presentation adds to international and localised discussions of decolonising and indigenising curricula, and questions how non-indigenous teachers can safely engage with indigenous knowledges alongside indigenous peoples.

Title
Transforming science teachers' practice: What accounts for change in a formative intervention

Presenters
Isaac Coffie

Abstract
This study aimed to facilitate science teachers' professional learning, transforming their practice in line with changing curriculum requirements that required a more student-centred approach in Ghana. The study used an interventionist approach based on Cultural Historical Activity Theory, called the Change Laboratory to help science teachers from six schools learn and develop their practice in light of these expectations of change. A change laboratory is an interventional approach where participants work collaboratively to identify challenges in their workplace and design solutions to address them. Over three months, six Change Laboratory workshops were conducted, plus two interviews with each teacher, six focus groups with students and 18 lesson observations. Teachers' practices changed in four key areas that strengthened the student-centred approach: use of questions, assessment, teaching beyond the classroom, and designing a range of activities. This presentation will draw on Sannino's Model of Transformative Agency by Double Stimulation (TADS), to identify the kedge anchors and associated actions that enabled the

teachers to transform their teaching practice amid the challenges they faced. The metaphor of kedge anchoring illustrates how change can be collectively achieved in the midst of difficulties, helping in the understanding of collective transformative agency.

Title
Highlighting participants' motivations for involvement in environmental education in a local re-forestation programme

Presenters
Carrie Swanson, Jeff Silby

Abstract
Climate change is a complex, intergenerational, political and ecological problem, primarily caused by human activities. Transformation change is required to manage and mitigate the effects of climate change in Aotearoa New Zealand. One way of reducing emissions is through reforestation and enhancing native forest coverage. Another is through educating our children about climate change. Concerningly, mitigating the effects of climate change does not appear to be an "educational priority" in Aotearoa New Zealand (Bolstad, 2020, p.2). This study is one component of a transdisciplinary study to mitigate the loss of ecological diversity and climate change on retired agrarian land in the Hauraki gulf. This interpretive qualitative study research is centred on the educational programme connected to the sites, where students explore the re-forestation of the area with native trees. The presentation will outline preliminary data from semi-structured interviews undertaken with local iwi, scientists, educators, teachers who visit the site and programme funders. The data will highlight the differences and commonalities of the participants' motivations for supporting environmental education for tamariki (children) and rangitahi (young people), and why they consider learning in an 'open air' classroom can support the development of their knowledge about biodiversity in their local environment.

Title
Year 7 creative skill development through student-generated explanatory science diagrams to enhance conceptual understanding

Presenters
Katrina Prendergast

Abstract
How to progress students from descriptive recall to analysing and applying concepts should be considered during teacher programming. ACARA (2012) has linked creative skill development as one possible way to progress student concept development from concrete to abstract. In this study I have undertaken a case study of a Year 7 science class involving a series of lessons aimed at both developing creative skills and increasing depth of student understanding. Eight lessons were developed using Glăveanu's 5A framework, to promote a creative learning environment and encourage creative skill development through student-generated explanatory science diagrams. Four lessons in term two were based on soluble and insoluble substances and four lessons in term three on balanced and unbalanced forces. Lessons involved observations of a phenomena followed by group and class discussions. Students then used imagination to create diagrammatic representations in an attempt to explain the observed phenomena. This study has indicated that most students developed deeper understanding through these lessons. When challenged with application questions, students would attempt to explain how processes worked rather than describing their

observations. This research will demonstrate how and to what extent drawing explanatory self-generated diagrams contributed to student understanding of some Year 7 physical science concepts.

Title
How to guide and facilitate student-generated visual models in an online learning platform

Presenters
Jina Chang, Jisun Park, Hye-Gyoung Yoon, Joonhyeong Park, Minsu Ha

Abstract
This study aims to explore the guidance of student-generated visual models on an online learning platform. To this end, we designed online-based learning activities to facilitate the construction of students' visual models and applied them to 123 students. The designed learning activities in this study involve three phenomena related to light and shadow, each requiring students to construct two visual models following three steps: (1) Observing a phenomenon in a video and constructing the first visual model to explain the phenomenon; (2) evaluating two different sample visual models drawn by the researchers; (3) observing another similar phenomenon and constructing the second visual model. A total of 738 student-generated visual models across three phenomena were collected and analysed in terms of the levels of using elaborate symbols and conceptual understanding shown in each model, respectively. Consequently, in visualising how light travels through the use of symbols, students were reported to employ increasingly elaborate symbols throughout the activities. In terms of conceptual understanding, the students' visual models showcased conceptual development in explaining the first two phenomena, which are relatively simple. However, when faced with a more complex phenomenon, which is the third, the conceptual development of their models was limited. Based on the results, we discuss educational implications in terms of the pedagogical affordances of online learning platforms for facilitating the elaboration of student-generated visual models.

Friday 9.10am

Title
A case study of Hong Kong and Taiwan accomplished secondary science teachers' pedagogical reasoning

Presenters
Su-Chi Fang, Kennedy Kam Ho Chan, Lihua Xu

Abstract
Pedagogical reasoning, the thinking underpinning teachers' knowledgeable practices, is a core mechanism for teacher professional growth. The scholarly investigation of pedagogical reasoning can illuminate teachers' professional expertise in teaching. This presentation is part of a 3-year international project across Australia, Hong Kong and Taiwan, utilising a multiple case study approach to investigate accomplished science teachers' pedagogical reasoning underlying their planning and implementation of practical work lessons. It illuminates insights into high-quality science teaching.
This presentation reports on preliminary findings from one Hong Kong and one Taiwanese classroom. Data includes classroom videos on the unit of Matter and pre/post-lesson teacher interviews. The analysis shows that during planning, both teachers, though emphasising varying aspects, uniformly incorporated considerations of the science curriculum, student learning, assessment practices, and instructional strategies into developing the instructional sequences. Despite curricular and time constraints, both lessons incorporated laboratory work affording students opportunities to cultivate scientific practices. Both teachers' reflections on practical lessons accentuated students' scientific practices and procedural knowledge and demonstrated varied degrees of attentiveness and responsiveness to student thinking of science content, student action, and student engagement. Some episodes featuring the teachers' characteristic teaching practices were selected to elucidate the pedagogical insights inherent in high-quality science instruction.

Title
Using an ecological approach to "imagineer" the professional development/education ecosystem for out-of-field teachers: A focus on science, mathematics, English and the humanities

Presenters
Linda Hobbs, Seamus Delaney, Emily Ross, Connie Cirkony

Abstract
The long-term teacher shortage facing schools has reached crisis point. Whilst increasing teacher supply is paramount, developing an adaptable teaching workforce is critical for quality education but hampered by cultural norms that undervalue re-specialisation of out-of-field (OOF) teachers through professional education (PE) for the core teaching subjects. Using an ecological approach (Bronfenbrenner, 1994), this project integrates multiple perspectives from across the PE ecosystem (principals, teachers, PE providers, subject associations, education system governing bodies, policy makers, universities, and other organisations). Ecological systems theory enables: examination of the culture surrounding PE and OOF teaching; a focus on the enduring forms of interaction that lead to teacher capacity building; and representation of the varying perspectives from across the PE ecosystem.

This presentation will outline the theoretical rationale for the project and theoretical framework to be used represent the current and "imagineered" professional education ecosystems. The theoretical lens shifts the analysis on OOF teaching towards understanding the underlying culture around teaching quality and specialisation, teacher learning, government imperatives, contestations at the levels of subject and broader education, and societal attitudes towards the teaching profession. The project intends to challenge policy settings that create the need for and perpetuate a reliance on OOF teaching to fill the shortfall in specialist teachers.

Title
Learning by doing: Exploring the multiple learning dimensions of citizen science mosquito monitoring in schools

Presenters
Larissa Braz Sousa, Chris Preston, Peter Rutledge, Yaela Golumbic, Alice Motion

Abstract
The Learning by Doing (LBD) research project, funded by the New South Wales Department of Education and conducted by the University of Sydney researchers, explores citizen science integration in schools. Despite the potential benefits of citizen science in schools, such as real research experience and hands-on learning, LBD findings reveal that lack of curriculum alignment poses a significant barrier for teachers. This presentation details the creation of adaptable resources for incorporating a national mosquito monitoring program into the Australian curriculum. Using the Framework for Articulating and Measuring Individual Learning Outcomes from Participation in Citizen Science, the project developed curriculum-aligned resources for Mozzie Monitors, focusing on six learning outcomes. Lesson plans, centred on Years 5 and 7 science descriptors, engage students in mosquito identification, iNaturalist participation, and exploring mosquito-borne diseases. The plans align with Years 5 and 7 Achievement Standards, requiring students to design a species inventory list and assess its correlation with the risk of local disease outbreaks. The presentation delves into the nuances of aligning lesson plans with both Australian and NSW curricula, aiming to provide educators with insights and strategies for seamlessly integrating citizen science into their classrooms.

Title
Floating boats and dropping eggs: Young children engaging creatively during an online after school Science club

Presenters
Kimberly Maslin, Karen Murcia

Abstract
Fostering young children's creativity is a desired outcome of contemporary science learning experiences. While research has informed understanding and practices for fostering creativity in a physical setting, less is known about an online learning context. This study addresses this gap by proposing pedagogical principles that support young children's science learning in online environments. The multiple case study approach involved three six-year-olds who reside in regional Western Australia. As part of the study, they participated in four afterschool sessions delivered synchronously by facilitators from Scitech, Western Australia's leading Science Discovery Centre. They were introduced to four engineering design challenges, each offering opportunities to draw upon their scientific knowledge and creative problem-solving skills. Data included multimodal video analysis of the sessions, as

well as semi-structured interviews with the children, their caregivers and the Scitech facilitator. Mapping of the children's home learning environments was also conducted. The A-E of Children's Creativity framework (Murcia et al., 2020) informed the analysis. Findings illustrate how the intentional online learning experiences engaged children creatively through hands-on learning, effective dialogic communication, and quiet time to focus. These findings are significant for distance education and education outreach, offering recommendations to enhance learning outcomes and increase access to science education.

Title
"I'm not good at drawing myself!" Teachers' strategies to engage students in learning through drawing science diagrams

Presenters
Mihye Won

Abstract
Science educators have consistently championed the use of drawing—specifically, conceptual and explanatory diagrams—as a valuable teaching and learning tool. However, the research documenting how educators facilitate and support student engagement with diagram drawing remains sparse. Critical questions arise: Which subjects are most amenable to diagram-based instruction? How do educators motivate students who are hesitant to draw? What type of questions effectively elicit deep thinking? And what kind of feedback prompts students to improve both their diagrams and conceptual understanding? This study delves into these questions through a comprehensive qualitative analysis, incorporating classroom videos of nine Year 7 science classes, interviews with students and teachers, and reflective notes from researchers. The findings underscore the significant challenges that both teachers and researchers face with diagram-based learning, compelling them to re-evaluate their pedagogical approaches and practices. This study not only uncovers diverse strategies that teachers utilise in the classroom but also assesses their impact, thereby contributing valuable insights to the development of practical resources for educators implementing diagram-based instruction. Furthermore, it illustrates the transformative potential of diagram-based learning in enhancing teachers' professional growth and their adoption of constructivist pedagogy. By bridging theoretical knowledge with practical application, this research offers a robust foundation for integrating diagram-based learning into school settings, ultimately enriching the teaching and learning experience.

Friday 11.00am

Title
Reviewing for RISE: A workshop to hone your skills

Presenters
Wendy Nielsen, Kok-Sing Tang

Abstract
Research in Science Education (RISE) is the flagship publication of the Australasian Science Education Research Association. Peer review is foundational to the continued success of the journal as a premier outlet for science education research around the world and a critical feature of academic work. However, knowing how to write a good review can be challenging. In this workshop, RISE Editors will focus attention on reviewing processes and work with attendees to develop skills in reviewing. We will review criteria and expectations for submissions to RISE as well as for journals more commonly, and then, practice some techniques for conducting a review and providing written feedback that address the criteria. Anyone is welcome to come along. This workshop follows on a successful mentoring initiative where mentors from the ASERA membership trialled a number of workshop activities to help our junior colleagues develop their knowledge and skills for reviewing for RISE.

Title
Making the space for K-7 science education research in Canada: A micro level analysis

Presenters
Christine D. Tippett, Todd M. Milford

Abstract
This presentation will provide a micro-level analysis of Canadian science education research at the elementary level (Grades K to 7). Canada's consistent high achievement in international science assessments (e.g., PISA or TIMSS) reflects the quality of its education system. However, a micro-level view of elementary science education research in Canada is limited. Micro-level analyses offer opportunities for synthesis, and the individual cases considered here connect to specific themes seen across larger national and international systems. We analyzed and will provide an overview of 11 studies of elementary science education, representing diverse research topics, contexts, and methodologies. These 11 studies were featured in a recent Springer publication. We will identify details of individual studies that connect to themes in research and pedagogy seen across Canada and internationally (e.g., environmental issues, science teacher preparation, Indigenous perspectives, STEM, and pedagogical approaches). Thus, the presentation will provide insights into various aspects of Canadian elementary science education, offering opportunities for comparison with other nations and ideas for examining education at macro, meso, and micro levels. Our findings, while facilitating a deeper understanding of Canada's elementary science education landscape, also contribute to ongoing discussions about elementary science education pedagogy internationally.

Title
Diagnostic assessment for detecting students at risk in physics learning

Presenters
Nam-Hwa Kang, Hyunju Yoon

Abstract
Given the exacerbated disparity in academic performance observed during the pandemic, this research aimed to create a diagnostic assessment tool to assist teachers in identifying students who are susceptible to academic underperformance. The study utilized the national science curriculum and assessment benchmarks as a basis for establishing micro-level learning progression encompassing basic concepts of physics within the middle school curriculum. Through an iterative process of validation, 116 assessment items were developed and subsequently administered, yielding a total of 355 responses from students attending middle and high schools. In the majority of cases, student responses were in alignment with the anticipated levels stipulated by the assessment benchmarks, thereby highlighting the existence of micro-level learning progressions. However, a limited number of disparities in responses offered valuable insights into the necessary amendments required for aligning learning progressions with students' cognitive patterns. These disparities also underscored the necessity for supplementary learning support. Implications for the professional development of teachers and further research topics are provided.

Title
Science teachers' interactions with science centres: Professional development benefits and how they occur

Presenters
Chloë Nelson, Jan van Driel, Victoria Millar

Abstract
There is a challenge in providing science teachers with effective professional development that takes into consideration the numerous aspects that encompass teacher professional development as well as being flexible to meet teachers' varied needs. Therefore, this research investigated the range of perceived professional development science teachers experienced through a variety of interactions with science centres including accompanying field trips and incursions, as well as undertaking formal professional development (PD) programs.
Through narrative interviews, all teachers in this study perceived they experienced a range of professional development including intellectual, attitudinal, and behavioural (practice-related) benefits. The interpretive analysis highlights the variety of roles that teachers undertook throughout these interactions, enabling the development of the diverse range of benefits teachers experienced. For example, for teachers accompanying field trips being able to participate alongside their students enabled teachers to observe and connect with their students in different ways to what they were able to do in the context of their usual lessons.
This study provides evidence that one-off, informal learning experiences can facilitate lasting professional development for science teachers. Therefore, supporting teachers to participate in interactions with science centres should be considered as part of the ongoing professional development of science teachers.

Title
Addressing bias and advancing equity in the measurement of visuospatial skills

Presenters
Alvir Sangha, Jenna Tashiro, Sam Pazicni

Abstract
Spatial thinking underlies many topics in STEM education—especially in chemistry, where students encounter spatial concepts including but not restricted to chirality, molecular geometry, and stereochemistry. Today, STEM programs have adopted as common practice the assessment of spatial skills. However, many spatial tests are developed with the assumption that men possess superior spatial skills. As such, women in STEM tend to be targeted by spatial training remediation programs, communicating that the everyday experiences men bring into STEM classrooms are higher in value relative to the experiences of women. Guided by Van de Vijver's integrated analysis of bias framework, this study provides insight into how construct, method, and item biases underlie more than 50 years of research perpetuating deficit perspectives that the underrepresentation of women in STEM is due to a lack of spatial skills. Accounting for such biases supports the construction of a revised instrument, ensuring valid and reliable measurement of mental rotation ability while minimizing gendered performance differences in college chemistry courses. This presentation discusses implications for assessment development and evaluation, highlighting the importance of moving beyond approaches that search for deficits within students to research perspectives that account for deficits within the academic contexts students are evaluated.

Friday 11.40am

Title
Publishing in and reviewing for the Journal of Science Teacher Education (JSTE)

Presenters
Emily Dare

Abstract
The Journal of Science Teacher Education (JSTE) is the flagship journal of the Association of Science Teacher Education (ASTE). It serves as a forum for disseminating high quality research and theoretical position papers concerning pre-service and in-service education of science teachers. JSTE features pragmatic articles that offer ways to improve classroom teaching and learning, professional development, and teacher recruitment and retention at pre K-16 levels. In this session, Dr. Emily Dare (one of the new co-Editors in Chief) will present an overview of the journal, focusing on important factors related to writing for JSTE. This will include an explanation of the processes JSTE uses to facilitate peer review and make publications decisions.
This session will also include opportunities to discuss how to become a reviewer for JSTE. Current Associate Editors of the journal will provide insight related to their experiences. This will be an interactive session during which time participants are encouraged to ask questions about the journal and how they may contribute to it as an author and/or reviewer.

Title
Successful primary science education in New Zealand: Understanding the barriers and enablers

Presenters
Jared Carpendale

Abstract
Increasing student interest and achievement in science, including addressing the inequitable patterns by ethnicity and gender, requires understanding the enablers and barriers that impact students' experiences in primary school. Data shows this is when students' attitudes towards science decrease significantly. This presentation reports findings from a systematic literature review, which was part of a project with the Office of the Prime Minister's Chief Science Advisor to develop a better understanding of barriers and enablers for successful primary science education in New Zealand. Findings showed barriers are either internal and external. Internal barriers include teachers' professional knowledge, along with their views of science education. External barriers include school structures, prioritization of subjects, funding, resources, and professional development. Enablers were identified in the form of teachers with rich content and pedagogical knowledge, or those who valued science education. Reducing barriers, and promoting enablers, requires careful policy considerations for effective and systemic change. For instance, exploring how changes to educational policy could be used to support the development of teachers' knowledge and views for science education, along with reducing structural barriers. Such changes would go some way towards solving issues around students' attitude towards and achievement in science declining at a critical age.

Title
Collaborative natural language processing for automatic scoring of open-ended questions in science education

Presenters
Van Thi Hoang Ngo, Chun-Yen Chang, John Jr-Hung Lin

Abstract
Amidst the challenges in science education, where educators grapple with the escalating demands of evaluation and assessment of increasingly intricate higher-order thinking skills, the imperative for automated assessment grows more pronounced. While substantial efforts have been invested, educators have encountered initial success in leveraging artificial intelligence to address the intricacies of automatic assessment. Despite these strides, the automatic scoring of open-ended questions remains a pivotal challenge in the education scenerio due to the inherent complexity of language. This research pioneers the development of Natural Language Processing (NLP) to urgently address the necessity for impartial and efficient evaluation of open-ended questions in science education. The NLP is intricately designed to automatic evaluating the reasoning ability, placing a paramount emphasis on sustaining high accuracy. Furthermore, the study introduces a collaborative strategy for humans and artificial intelligence, where the NLP furnishes valuable feedback, aiding educators in refining the input data set for optimal training. The outcomes showcase the model's performance, achieving an impressive ROC-AUC score of 94.94%. This synergy between human and AI collaboration not only enhances precision in open-ended question assessments but also contributes to the ongoing refinement of educational practices.

Title
Science teacher Facebook groups: Productive communities of practice?

Presenters
Robertson Burgess, Elena Prieto-Rodriguez, Katie Waters, Erika Spray

Abstract
While Facebook groups dedicated to teachers are numerous, populous, and active with many group memberships exceeding the thousands and even tens of thousands, the focus of discussions within these groups and their implication for the needs of science teachers remain underexplored. Consequently, it prompts the question; What topics are being discussed in these groups, and what insights do these groups provide us about the needs of science teachers? Do these groups effectively fulfil their intended purpose of supporting teachers, or do they primarily feature a few prolific posters and advertise promotional content?
Additionally, amidst the vast opinions regarding teachers' needs in the current climate, what questions and inquiries are the teachers themselves posing? This study examined the content of four different groups dedicated to science teaching, including Biology, Chemistry, and Physics and general science teaching. 500 posts from each group were coded using a combination of generative AI and human coders to develop a deeper understanding of the prominent themes emerging in these groups. We investigated whether these posts offer insights into the educational requirements of teachers, particularly early career teachers or those teaching beyond their specialised field, and whether such insights could inform interventions or initial teacher education (TE) programs.

Title
Promoting the traditional use of wood ashes and salt in preserving animal skins for drum making and drumming

Presenters
Angelius K. Liveve, Martha Nyamakuti, Kenneth M. Ngcoza

Abstract
This research delved into the traditional practice of utilizing wood ashes to preserve animal skins, particularly in the context of teaching alkalinity. Wood ashes are rich in chemicals, predominantly alkaline, boasting a pH ranging from approximately 10 to 12. The cultural standpoint presented in this study acknowledges the conventional scientific pedagogy as an endeavor to impart a scientific subculture to learners. Animal skins serve as fundamental materials in the leather-making process. The investigation drew insights from Vygotsky's socio-cultural theory and utilized Marx's concept of reality as an analytical framework. The study was conducted in Yinsu village within the Tondoro constituency of the Kavango West Region in northern Namibia, participants included were the Unongo Cultural Youth Group and Grade 10 science teachers. The primary objective of soaking animal skins in this study was to devise an enzyme-assisted dehairing method, offering an alternative and environmentally friendly approach to reduce the reliance on harsh chemicals in skin processing. The indigenous technologies explored in this study provided an avenue to elucidate the chemistry principles inherent in wood ashes, notably their alkaline components. Furthermore, it was observed that science teachers often introduced wood ash as a mediatory substance and clarified its composition, highlighting alkaline compounds such as calcium carbonate, potassium carbonate, and magnesium carbonate. It is recommended that incorporating wood ash into lessons on alkalinity can facilitate a more profound comprehension of the concept through practical experimentation and observation. Additionally, science teachers are urged to prioritize safety measures when handling chemicals and equipment.

Title
Relating visitor personas to guest experiences in a dinosaur gallery

Presenters
Rebecca Hite

Abstract
Dinosaur galleries remain a staple of natural history and science museums among guests. Moreover, the science content of these galleries can be quite complex and convey abstract concepts like ecological interdependence, size and scale, structure and function, comparison of past to present organisms, evolution, and change over time. The types of science learning, understandings, and affective states that guests garner from dinosaur galleries are important not only to their life-long science learning, but also to their motivation for further learning and return visits. The present study engaged 50 guests in a public museum in West Texas to take photographs in a dinosaur gallery and share their thoughts about the gallery's object-based experiences. Using Falk's taxonomy of guests' personas that motivate attendance (Explorers, Facilitators, Experience Seekers, Professionals/Hobbyists, and Rechargers), sampled guests were categorized as experience seekers (n=17), facilitators (n=16), and explorers (n=14), respectively. Findings suggest guests were most interested about the lived experiences of dinosaurs (in the exhibit), learned the greatest about structure to function (after the exhibit), and wished to see more species of the local area (for a return visit). Results help to address prior conceptions about dinosaurs related to personal belief systems and prior formal education learning experiences.

Title
Engaging students through STEM practice learning strategies in a life science course

Presenters
King-Dow Su

Abstract
Research shows that STEM education and research are increasingly popular. Internationally (Ong et al., 2024). However, existing interactive observation of STEM classrooms in higher education lacks information on the characteristics of STEM experience courses and how to bring about expected results. This study designed a STEM Belgian siphon pot experience in the life science course to bridge the above gap and recruited 70 first-year students from the University of Science and Technology in Taiwan. All students who elect this course engage in teaching practice. This experiential activity enables students to acquire scientific knowledge, high-order cognitive abilities and design skills to solve the problems related to gravity and pressure balance during the experience process and improve their interest in participation. STEM practical learning strategies encourage students to engage in the learning process actively. Results from thematic interviews indicate that students find these courses interesting. Their understanding of science concepts, siphon flame management, coffee particle grinding, and material volume calculations seemed

to improve. They also believe they are more focused and value the insightful opinions of their peers. To promote student engagement, this report of experiences with hands-on STEM learning strategies in living science courses is a resource for researchers and instructors

Title
Exploring the cumulative impact of professional learning from a regional perspective

Presenters
Anthony Anning, Linda Hobbs, Lihua Xu

Abstract
Teacher learning, as identity formation, is complex. Existing literature on sustainable teacher learning often overlooks broader systemic factors. This presentation reports on a literature review and theoretical framing of a project exploring the cumulative effects of regional STEM teachers' learning, emphasizing lasting impacts shaped by a complex interplay of teacher-related and external factors. Additionally, extant literature on professional learning (PL) often relies on linear models, offering clear frameworks for program evaluation but overlooking the complexity of teacher learning. This current study explores the enduring effects of STEM teachers' PL in a regional context. It adopts a more comprehensive approach, considering systemic factors like government policies, school policies and culture, and community engagement, among others. The study combines sociocultural theory (SCT) with an ecological framework to understand the complex interactions influencing STEM teachers' identity, autonomy, and the sustained effects of PL in a regional setting. The ecological model identifies factors impacting teachers' learning over time, while SCT elucidates how sociocultural backgrounds shape their identity and autonomy. This dual approach enhances the study's ability to inform tailored and effective professional learning programs, guiding stakeholders in supporting STEM teachers' ongoing development and fostering sustainable learning environments.

Title
Ambitious science teaching: It definitely got easier with practice

Presenters
Barbara Billington, Eva Nelson

Abstract
Pre-service science teachers (PSTs) must learn to navigate a complex array of pedagogical skills, dispositional attributes, and moment-to-moment decision-making. Science education researchers and science methods textbook publishers (Llewellyn, 2013b, 2015; Windschitl et al., 2018) emphasize the importance of student-centered learning strategies to increase equitable science teaching practices. This study utilized the Ambitious Science Teaching (AST) framework (Windschitl et al., 2018). This study looks to identify which strategies and to what depth PSTs explicitly apply AST in their submitted lesson plans. The method used is a descriptive multiple case study of the PSTs in science education during Fall of 2023 and Spring of 2024. This approach will determine the individual PST's understanding of the elements of AST in their lessons. Preliminary findings reveal some PSTs are able to orchestrate a complex array of overlapping strategies in a classroom activity, while others rarely use more than one at a

time. Those PSTs with multiple strategies in their plans in Fall 2024 revealed a lively nuanced view of student-centered instruction, while other PSTs fell back on teacher-centered strategies. Spring 2024 comparison data is forthcoming. This study enabled the instructors to reflect on best practices for teaching PSTs.

Title
Evaluation of simulators helping sixth-grade students understand "bioaccumulation of chemicals by microplastics"

Presenters
Yuka Matsuyama, Tomokazu Yamamoto, Shinichi Kamiyama, Hideo Funaoi

Abstract
In Japanese elementary education, students must develop the ability to judge food safety based on scientific evidence. Recently, from the viewpoint of food poisoning prevention, the increasing bioaccumulation of chemicals by microplastics (MPs) has become significantly problematic. We developed two simulators to learn about bioaccumulation by MPs. This study aimed to clarify their effectiveness from the standpoint of ""students' usability"" and ""students' understanding" by introducing them to two sixth-grade science classes (41 students total). The simulators allow comparison of chemical accumulation in creatures with and without MPs. These were introduced to students who had already learned the basic mechanisms of bioaccumulation. The class asked students to think scientifically about the effects of MPs on bioaccumulation through the accumulation of chemicals in the ocean without and with MPs. Analysis of the questionnaire before and after the class showed that all items of ""students' usability"" scored at least 3 out of 4 points, with a significant improvement in the question asking about the extent of bioaccumulation effects ($Z = -2.555$, $p < .05$, $r = .40$). The simulators were an easy-to-use teaching tool for sixth-grade students, promoting an understanding of bioaccumulation and its effect

Title
Analysis of the educational and social meaning of the "Visiting Maker Program": Focusing on practical examples of social enterprises

Presenters
Hyeonah Noh, Jaehyeok Choi

Abstract
In Korea, there is support for maker education as part of integrated education, but the benefits vary depending on regional conditions. This study investigated the meaning and educational significance of the maker program provided to students who don't receive these benefits due to regional constraints. For this, the study analyzed the case of a social enterprise that visited students in island areas with limited access to Science and Technology. We interviewed the operator of the maker program, and the product of the maker program, including students' logs and perceptions, was analyzed. According to the analysis, the program was designed to utilize materials easily found in everyday life, and students were encouraged to develop the use and application of tools. Through these activities, students were able to express themselves and learn the value of cooperation. This study found the

significance of maker education and the growth potential of participating students in areas where science and technology education is not activated due to a lack of infrastructure and educational resources. However, understanding the impact of visiting maker programs that strengthen students' problem-solving skills through practical experience and cooperation requires an understanding of the mission-driven initiatives undertaken by social enterprises.

Title
Assessment of science instructional explanation competency of pre-service science teachers

Presenters
Insun Lee, Hye-Gyoung Yoon

Abstract
The importance of the teacher's explanation has been overlooked because it is linked to the image of passive learning of students. However, among the various activities that take place in class, the teacher's explanation is essential. This study aims to explore science instructional explanation competency of pre-service science teachers. To this end, two tasks were designed and given to 10 pre-service science teachers who voluntarily participated: 1) Why are aluminum cans attracted to straws rubbed with tissue? (electrostatic induction) 2) Why does it bend to one side when you heat the aluminum foil attached to the paper? (thermal expansion). They were provided with textbooks and teacher guides and were given time to prepare their explanation. The pre-service teachers acting as students were guided on what questions to ask. Each topic was explained for approximately 10 minutes and 20 videos were analyzed using Kulgemeyer (2018) framework. We found pre-service teachers' competency was insufficient in asking students' previous knowledge, encouraging and providing feedback on the student's questions, clearly revealing the main science idea, and helping students maintain focus. Based on the results, implications for teacher education are discussed.

Title
Navigating SSI education in South Korea: Two decades of research, policy, and curriculum evolution

Presenters
Hyunok Lee, Yeonjoo Ko

Abstract
Over the last two decades, South Korea has dedicated significant efforts to studying socioscientific issues (SSIs), closely linking this research with the evolution of national education policies and curricular reforms. This period has escalated challenges such as infectious diseases, climate change, and environmental degradation, introducing increased complexity and uncertainty into society. In response, the Ministry of Education (MOE) has highlighted the critical need for students to develop the competency to apply knowledge in real-life contexts and tackle complex problems, moving beyond the mere acquisition of fragmented information. The 2022 National Science Curriculum integrates democratic values, character education, and transformative skills across various disciplines. The curriculum is designed to produce individuals who are academically equipped and poised to make meaningful societal contributions. This initiative aims to enhance scientific literacy through community engagement and collaborative problem-

solving, focusing on Vision III. This strategic Korean educational approach has significantly impacted SSI research, as evidenced by its presence in academic literature. Our analysis focuses on how educational reforms and policies in Korea have influenced research on SSI. We examined the representation of SSI research in scholarly publications and identified trends and future directions.

Title
Exploring the multidimensional knowledge, willingness to act and climate action: Insights from a preliminary study with Taiwanese high schoolers

Presenters
Rung Yu Shiu

Abstract
To take action on climate change issues, one needs to possess relevant knowledge. However, many studies have found that the direct impact of environmental knowledge on environmental behavior is relatively weak, often requiring reinforcement through psychological factors (such as willingness to act) to strengthen its influence on behavior. Yet, these studies typically use self-assessment of knowledge or investigate the nature and causes of environmental issues, overlooking the role of action strategies and efficacy knowledge, this oversight may lead to an underestimation of the importance of environmental knowledge in driving behavior change. This preliminary study, involving 137 high school students in Taiwan, SEM was used to initially explores the relationships among different forms of knowledge, self-assessed knowledge of action possibilities, willingness to act, and climate actions. Results indicate that knowledge of action possibilities has a significant indirect effect on climate action through willingness to act ($t=3.575$, $p<0.001$), while different forms of knowledge can influence willingness to act ($t=1.985$, $p<0.05$) but cannot indirectly affect climate actions through willingness. The study suggests that while teaching fundamental environmental knowledge is necessary in environmental education, it is even more crucial to make students aware of their knowledge and capability to make changes, thereby enhancing their willingness to act and ultimately linking to actual environmental actions.

Title
Exploring the impact of systems thinking teaching on students' engagement in environmental issues

Presenters
Ya Chun Chen

Abstract
Developing environmental awareness and responsibility for sustainable development is an essential topic and emerging trend in science education. Systems thinking is higher-order cognitive thinking and the ability to understand and ultimately interpret systems' characteristics and behavior. This study attempted to develop teaching strategies to guide students to discuss possible solutions to environmental issues in the real world and understand the complexity of deciding or choosing solutions through systems thinking in order to promote students' engagement in environmental issues that are awareness and have responsibilities for environmental issues, and have willing to take corresponding actions. The participants were sixty-six experimental group

students with systems thinking intervention and eighty-four comparison students without systems thinking intervention from a comprehensive university. The integrated systems thinking curriculum was eight weeks in total. The Engagement in Environmental Issues questionnaire (EEIQ) with a four-point Likert scale is used in this study. The EEIQ contains four subscales: awareness of environmental issues, responsibility for sustainable development, self-efficacy for addressing environmental issues, and participation in environment-related activities. The ANCOVA results show that the experimental group significantly outperforms the comparison group in the engagement in EEIQ total score and the four subscales ($p < .05$) after the intervention of systems thinking teaching.

Title
Impacts of contextual and problem-based learning on secondary students' systems thinking, scientific competency, and attitudes toward science

Presenters
Ya Chun Chen

Abstract
Systems thinking and solving complex problems are critical abilities required in the workplace. In addition, students' attitudes toward science are also closely related to students' learning performance, scientific literacy, and scientific engagement. Research shows that it is difficult for students to understand concepts of complex systems. Students also often need help transferring what they have learned to new situations when solving problems. Moreover, it presents a continuous declining trend in students' interest in science or the proportion of students taking science-related courses or choosing science-related careers. This study is intended to develop a contextual and problem-based course that incorporates systems thinking and investigate the effectiveness of this teaching strategy. The instruments include the 'Systems Thinking Ability Test,' 'Scientific Ability Assessment Test,' and the 'Attitudes Towards Science Questionnaire.' The participants are eighty-six senior high school students. The intervention of contextual and problem-based learning is 16 weeks in total. The results showed that student's performance in the post-test of systems thinking, scientific competencies of explaining phenomena scientifically, evaluating and designing scientific inquiry, interpreting data and evidence scientifically, and attitudes towards science (e.g., interest in science, enjoyment of science, engagement in science-related activities) are significantly higher than in the pretest ($p < .001$)

Title
Comparison between Grade 7 students' cognitive abilities, metacognition, stress and achievement in biology learning about life in the CMEN Teaching Model and in the traditional teaching model

Presenters
Suwit Uopasai, Pornpimon Phapimul

Abstract
The purpose of this study was to examine the effects on the learning outcomes of Grade 9 students after the intervention of constructivism, metacognitive, and neurocognitive based (CMEN) and traditional teaching models to the experimental and control

groups respectively. The CMEN teaching model consists of composed of six phases as follows: (i) perception and attention; (ii) objective of planning and monitoring; (iii) multisensory integration; (iv) linking; (v) rehearsal and practice, and (vi) summary and evaluation that had been refined and quality checked by experts. The total participants were 56 students from Namphongphatthanasueksa School in Khon Kaen province, Thailand. They were equally distributed to 26 students in each group. Researchers employed experimental research pre-test and post-test control group design. Results of this study showed that there was no significant difference between groups on the dependent variables before the intervention. However, all the dependent variables namely the cognitive ability (working memory and attention), metacognitive ability and biological knowledge achievement in the experimental group had significantly higher, and had lower stress levels than students in the control group. As a result, the CMEN teaching model can enhance students' abilities in biological knowledge achievement, raise their metacognitive ability, and promote their working memory and attention ability.

Title
Gender evolution in Korean STEM: Two decades and faculty inspiration

Presenters
Hyang-yon Rhee

Abstract
Since the 2002 Act on Fostering and Supporting Women in STEM, South Korea has advanced in reducing gender bias, aimed at addressing the underrepresentation of women in STEM. However, eliminating gender bias in male-dominant and female-dominant fields remains unclear. Two decades on, it is crucial to assess the specific achievements and remaining challenges in this endeavor. The methodology employed an explanatory sequential design: Study 1 reviewed 20 years of gender distribution in STEM majors; Study 2 conducted STEM identity-based interviews with faculty in biased fields. Study 1 showed that for the past 20 years, the percentage of female students in overall STEM fields had consistently been slightly above 30%. In sciences, this percentage exceeds 50%, while in engineering, it is around 20%. Upon a detailed examination within science and engineering, the chart reveals a significant gender disparity: home economics, a female-dominant field, shows a 70-90% female student ratio, whereas automotive engineering, male-dominant, has less than a 10% female ratio. In Study 2, faculty identified gender stereotypes in department names and the exclusion based on gender in faculty hiring as factors contributing to the issue. As remedies, they suggested diversifying university demographics, revising department names and images, and changing parenting attitudes.

Title
Investigating the implementation of education for sustainability through science in Australian secondary schools: Perspectives and practices of students and teachers

Presenters
Sabira Sultana, James Deehan, Kathleen Smithers

Abstract
The twenty-first century is seeing unprecedented technological advancement, environmental degradation, and complex socio-economic issues jeopardizing the planet's sustainability. Given these concerns, UNESCO calls for education for sustainable development to promote social transformation toward a sustainable present and future. Like many countries across the world, Australia is committed to promoting education for sustainability (EfS). Consequently, sustainability has been included as a cross-curricular priority (CCP) in the Australian Foundation-10 curriculum and is intended to be taught through all the subjects. Scholars of science education highlight its disciplinary features and emphasize its role in the school curriculum for developing critical skills among students to promote social activism and individual and collective agency toward sustainability. Little to nothing is known about how sustainability is being implemented through science in Australian secondary schools. Therefore, the proposed Ph.D. study intends to explore the views of science teachers and students. Further, how sustainability is reflected in the secondary science curriculum and how EfS is translated into classroom teaching and learning will be investigated. The proposed study will

adopt a convergent mixed methods design following the pragmatic research paradigm. Data will be collected by using survey questionnaires, document analysis, semi-structured interviews, focus group interviews, and classroom observation.

Title
Teacher Pedagogical Content Knowledge for STEM Education: Case of a science teacher implementing the electrical circuit STEM Education

Presenters
Pairoh Sohsomboon, Chokchai Yuenyong

Abstract
STEM education is a specific approach to integrate knowledge and practice to solve real-world problems. Teachers seem to face difficulties implementing STEM in classrooms, therefore, examining Pedagogical Content Knowledge for STEM Education (PCK-STEM) is significant. PCK-STEM was framed comprising five main components: Knowledge of subject matter and relevance of curricular (S), Knowledge of instructional strategies (I), Knowledge of students' understanding and practice (P), Knowledge of assessment (A), and Knowledge of technology and engineering design process (T&E). PCK-STEM was interpreted through teachers developing STEM lesson plans, classroom observation, and follow-up interviews. Case of a science teacher (ST01) implementing the Electrical Circuit STEM teaching scenario was illustrated, and the teacher's PCK-STEM was interpreted through descriptive analysis. ST01 demonstrated excellent knowledge of PCK-STEM in (S) and (T&E) as ST01 considered alignment of curriculum goals to implication of Electrical Circuit matter (S) and attempted to design problem-solving activity related to the string of human needs (T&E). Meanwhile, ST01 showed good level of PCK-STEM in (I), (P), and (A) since ST01 led students through problem-solving process step by step (I), considered identifying and eliciting students' understanding of electrical current and resistance (P), and attempted to design and implement assessment materials aligned to goals of STEM education (A).

Title
The network perceptions of STEM teachers in teacher leadership programs compared to non-participants

Presenters
Andrea Reeder, Cathy Cerosaletti, Joshua Reid, Gregory Rushton

Abstract
STEM teacher attrition continues to impact the quality and access to educational opportunities, especially for students in high-needs schools. This study investigated 167 K-12 STEM teachers in the US, of which 85 participated in a leadership program aimed at enhancing classroom retention. The study aimed to explore the variation in perceived social networks of participants in STEM teacher leadership programs and non-participants, focusing on understanding how leadership opportunities relate to teacher decisions to stay, move, shift, or leave the profession. Data sources for this mixed-methods study include visual network scales, social networks, and interviews. Data analysis indicated that as the leadership network's size expands, program participants exhibit increased bridging within their teacher networks. This expansion enabled them to introduce and disseminate innovative ideas, adding value to their networks and influencing their self-efficacy and classroom retention. Furthermore, participants often acted as

bridges between curriculum initiatives at the district and national levels. The critical distinction in leadership between participants and non-participants was in the exposure of the former to national STEM reforms advocated by individuals outside their districts.

Title
Enhancing inquiry abilities: A yearlong science curriculum for junior high students

Presenters
Meichun Lydia Wen, Pei-Shan Chang, Sheng-Han Lee

Abstract
Based on PISA 2015, the underperformance of Taiwanese students in “evaluating and designing scientific inquiry” underscores the need for increased implementation of inquiry-based curriculum. Building upon a prior study of senior high school curriculum, this research endeavoured to develop an inquiry-based curriculum tailored to junior high school students. This curriculum comprised four units designed for all 7th-grade students (N=133) and spanned two semesters. The first unit “Cards Playing” introduced the scientific method, while the second unit “Mosquitoes Around You” provided opportunities for students to observe with precision. The final two units “Enzyme Science I & II” engaged students in understanding how pH value and temperature factors affected enzymes. The study employed the Multimedia-based Assessment of Scientific Inquiry Abilities (Kuo et al., 2015), which focused on 23 items across the subscales of planning and carrying out “investigations”, “analyzing”, and “argumentation”. Data from student feedback sheets and semi-structured interviews were collected following the completion of the course. The results indicated significant improvement in students’ inquiry abilities across all four subscales. Student feedback revealed that they had acquired these inquiry abilities and were impressed by the curriculum, expressing a desire for more such learning experiences in the future.

Title
Unveiling the pedagogical practices in the STEM classroom: A scoping review

Presenters
Mohammad Alamgir Hossain, James Deehan, Leanne Gibbs

Abstract
STEM education is considered a crucial aspect of fostering skills and innovation among students in the 21st century. In 2015, the Australian Education Ministry endorsed the National STEM School Education Strategy, which focuses on teaching and learning strategies for STEM subjects. This scoping review aims to explore the pedagogical strategies used by teachers in STEM classes. The research includes a thorough investigation of 27 peer-reviewed articles published between 2015 and 2023, using the search engines Academic Search Complete and ERIC via EBSCOhost. The study investigates pedagogical approaches used in STEM classrooms at the early childhood, primary, and secondary school levels, taking into account demographic factors. The articles were mostly published in Australia and Asian countries where the majority of research was published on primary and secondary-level participants. Initial findings show that various pedagogical strategies are used, such as inquiry-based learning, project-based, problem-based learning, collaborative learning, real-life activities, and technology integration. With the support of proper classroom settings, these pedagogical approaches can develop skills among students. By synthesizing information from the chosen papers,

this study provides an overview of common pedagogical practices in STEM education, clarifying the efficacy of various teaching strategies in promoting student involvement, conceptual comprehension, and skill development across STEM disciplines. The findings of this study will contribute to the current project in explaining Australian teachers' pedagogical practices in the STEM classroom. This study intends to inform evidence-based practices and highlight the diversity of pedagogical approaches and their effects on student learning, ultimately improving the quality of STEM education worldwide.

Title
PLC Protocol Development to Improve Pre-service Elementary Teachers' Digital Competency in Science Class

Presenters
Eunyoung Jeong, Mirim Seo, Jong-Hee Kim, Kiyoung Lee, Youngsun Kwak

Abstract
In this study, we developed a protocol to cultivate pre-service elementary teachers' digital competency in science classes. Based on a review of previous research including protocols for teacher PLC, and a survey on the current status of digital tools used in elementary schools, we developed a protocol and finalized it through expert review.
The protocol includes four stages: Introduction, Application, Implementation, and Reflection.
Stage 1 consists of two sub-protocols, 'An invitation to cultivate digital competency in class' and 'Watching science class videos', where teachers recognize the need to develop digital competency.
Stage 2 consists of two sub-protocols, 'Building digital competency in connection with science classes' and 'Planning science classes to cultivate students' digital literacy', where teachers plan science classes using digital tools.
Stage 3 is connected to the teacher education university's teaching practicum, where pre-service teachers plan and implement science classes for elementary students using what they learned in the previous stages.
Stage 4 is 'Reflecting on science classes to develop digital competency', which involves reflecting on the classes implemented in Stage 3.
We need to explore the effect of the protocol in cultivating digital competency of pre-service teachers, field applicability of the protocol in the teaching practicum, etc.

Title
Perceptions of pre-service science teachers on integrating AI into science education

Presenters
Yeonjoo Ko

Abstract
With a global emphasis on artificial intelligence (AI) in education, this study investigates pre-service science teachers' (PSTs) perceptions regarding the integration of AI into science education. The study engaged twenty-four PSTs enrolled in a science methods course, which emphasizes teaching methodologies, instructional strategies, and the incorporation of AI tools (e.g., teachable machines, machine learning for kids, chatbots) into science classrooms. The PSTs developed and tested hands-on

activities that used AI as a method of scientific inquiry and participated in focus group interviews to share their experiences and changes in perception regarding AI integration. All transcriptions, lesson plans, and presentation slides were analyzed. The results reveal a significant shift in PSTs' perceptions, transitioning from viewing AI as a daunting challenge to recognizing its synergistic potential in enhancing science education. The PSTs not only gained a deeper understanding of AI's fundamental concepts and selected appropriate topics aligned with the science curriculum, but they also highlighted the importance of incorporating AI in a manner similar to scientific research and problem-solving within science classes. The study discusses the pedagogical implications and the limitations of using AI in science education.

Title
Teachers' existing ideas of TPACK for STEM education in Thailand

Presenters
Pornchai Chinnasa, Chokchai Yuenyong

Abstract
Technology may scaffold students to learn STEM education. To develop assumptions of a PD program for integrating technology in STEM education, this research examined teachers' existing idea of a Technology Pedagogical Content Knowledge (TPACK) for STEM education. The participants included 29 science teachers. TPACK for STEM education were categorized via their responses on questionnaires that elicited teacher ideas in 4 components including (1) TK, (2) TPK, (3) TPACK, and (4) applications or barriers of TPACK. Teachers' responses to S-TPACK STEM were categorized. The
results suggest that participants had a basic understanding of technological knowledge (TK) rather than integrated knowledge of TPACK. Teachers' existing ideas about TK for STEM teaching and learning could be viewed as their knowledge of specific ways of thinking, working, and plausibility of using technology, tools, and resources. Technological-pedagogical knowledge (TPK) is the understanding of how teaching and learning can change when certain technologies are used in certain ways. The TPACK mentioned providing opportunities to represent concepts and pedagogical techniques in
constructive ways, making learning concepts difficult or easy, students' prior knowledge, and building on existing knowledge to develop new epistemologies for STEM education. This paper could have implications for the program of TPACK for STEM education.

Title
*Cultivating hope and action in climate change education: Case study of a master program in Taiwa*n

Presenters
Yu-Chi Tseng

Abstract
Since 2010, Taiwan has prioritized environmental education, recognizing universities as key in training environmental educators. This study, employing action research, aimed to bolster climate literacy and action competencies among graduate students. Initially, three modules were designed and delivered over 18 weeks in a masters course. Then, the curriculum was refined to four

modules in the second year. Participants were master's students from a central Taiwanese university in the first year, and, for a control group, students from a northern university were added in the second year. Quantitative data were collected via questionnaires, while qualitative insights were gleaned from focus group interviews. The first year utilized the Wilcoxon sign rank test and the second year applied repeated measures ANOVA and ANCOVA. The result revealed significant enhancements in climate knowledge and action skills in both years. Notably, the second year's modules also significantly increased students' sense of hope, demonstrating superior outcomes in the experimental group compared to the control group. Strategies identified to effectively raise hope included setting clear action goals, diversifying action paths, and peer-sharing of success stories. The presentation will highlight the applicability of Snyder's Hope Theory in Taiwanese higher education and climate change instruction in empowering future environmental educators. increase postgraduates' sense of hope. The study highlights the applicability of Snyder's Hope Theory in Taiwanese higher education and climate change instruction.

Title
Developing a conceptual framework for narrative science identity

Presenters
Junhee Kim, Sungmin Im

Abstract
The status approach, widely adopted in the current methodology for studying science identity, focuses on measuring the present with an expectation that it will extend into the future. In contrast, the narrative approach centers on reconstructing past experiences to better understand the present and anticipate the future. While the status approach has been criticized for failing to capture the socio-cultural background of individuals, it might be the narrative approach that can be the key to this point. This paper aims to capture the characteristics of individuals' narrative science identity by employing a narrative approach. Subsequently, it also aims to develop a conceptual framework for narrative science identity.
The research was conducted with four college students aspiring to pursue careers in the field of science. We interviewed these students and analyzed the data using narrative inquiry. In this paper, we present a conceptual framework for narrative science identity consisting of three dimensions: Experience, Cognition, and Commitment. Experience is composed of two factors: personal experience and socio-cultural experience. Cognition represents the current science identity. Finally, Commitment is composed of two factors: personal and socio-cultural.

Title
Science teachers' attitudes toward development and application of AI-integrated STEM education programs

Presenters
Yongseok Jeong, Yoen-Hee Kim, Hae-Ae Seo

Abstract
As we are facing the era of AI and forced to innovate STEM education with AI integrated, it is necessary for science teachers to

develop and apply the programs. To understand the driving force behind the development and application of AI-integrated STEM education programs, the study employed a research method of in-depth interviews with nine science teachers at a high school. Findings revealed that science teachers exhibited two types of responding to challenges in developing and applying AI-integrated STEM education programs. Some teachers were more inclined to take on challenges without fear, while others were willing to try if they had supportive colleagues. The latter group highlighted the importance of creating systems for teacher collaboration and emphasized the role of experts in expediting the development of expertise. The results indicated that teacher professional knowledge development in AI-integrated STEM education programs could benefit from a system that promotes collaborative learning with experts, co-teaching during lessons, and opportunities to teach various programs within a system that fosters interaction among teachers and experts, ultimately increasing the efficiency of teacher training in developing new professional knowledge about AI-integrated STEM education.

Symposium Title: *Developing an ASERA position statement on the future science education we need: Implications for policy, research, and practice.*

Presenters: Carol Aldous, Vaille Dawson, Tanya Doyle, Linda Hobbs, Carrie Swanson, David Treagust, Russell Tytler, Leonie Rennie

Overview: Please refer to abstract in paper one

Paper 1: Developing an ASERA position statement: An overview

Abstract: In Australasian science education, we find ourselves at a policy moment that presents both challenges and opportunities. The Australian STEM School Education strategy (Education Council, 2015) laid out 10-year goals for science education that conclude in 2026. Similarly, New Zealand's 10-year strategy A Nation of Curious Minds He Whenua Hihiri i te Maha (New Zealand Government, 2014) concludes in 2024. We can seize this policy moment to consider and articulate a range of imperatives that can help shape the next iteration of national science education policy. Consequently, ASERA has formed a working group of members interested in being proactive for the future. Much discussion has been taking place to identify areas of science education that have strategic significance. Three cross-cutting themes — together with a range of sub-themes or foci — have emerged from these discussions. The themes are (1) Curriculum and Pedagogy, (2) Positioning the Sciences, and (3) Communities of Practice: context-based decision making. In this symposium we seek to canvas your views on the appropriateness and suitability of these important themes and issues, as an initial step in a process of consultation leading to an ASERA document, for the benefit of a prospering science education in and for the future.

Paper 2: Developing an ASERA position statement: Curriculum and Pedagogy

Abstract: This presentation will open up discussion around what should be an ASERA position on contemporary science curriculum and pedagogy. The five foci identified as important for exploration and commentary are climate change education and sustainability, indigenous knowledges, assessment, pedagogies and teacher knowledge and practice. The session will open up possible approaches to an ASERA position on these foci. As instances, we will briefly open up lines of inquiry on: 1) how climate change education has emerged from education for sustainability with a particular and sharp focus and a sense of urgency in science education, and the key directions for research; 2) the growing recognition of the legitimacy and importance of indigenous knowledges in educating for the Anthropocene, 3) the current challenges and opportunities for developing assessment regimes that open up deeper teaching and learning practices; or 4) the variation in methodologies and value positions sustaining current debates about pedagogy, and the need for policy clarity arising from research. In the symposium we will seek your input on the current research landscape on these five foci, challenges and opportunities, and implications for policy, research and practice.

Paper 3: Developing an ASERA position statement: Positioning the Sciences

Abstract: Science and STEM are often positioned by government policy and industry groups as critical to national economic prosperity and technological competitiveness. In contrast, discourses within the science and STEM education and research communities often align with more inclusive, and socially oriented agendas. This session will explore three foci in relation to how science is positioned by policy, research and schools and the interaction between competing agendas: 1) the role of the disciplines in informing/shaping school curriculum, teacher preparation/specialisation, and teacher and student identities; 2) cross-disciplinarity that occurs within scientific practice that filters into schools and initial teacher education, such as through a STEM agenda; and 3) the role of science disciplines as enablers of innovation in relation to critical and emerging technologies central to the aspirations of economic diversification for the nation. Critical questions when considering positionality of the sciences are: whose research counts and for what purposes; and how can schools and universities be positioned as enablers and drivers of determining and enacting science for the future. This symposium seeks your input on how science/STEM are positioned in political discourse, the challenges and opportunities that arise, and implications for policy, further research and transforming practice.

Paper 4: Developing an ASERA position statement: Communities of practice, context-based decision making

Abstract: ASERA is a model example of a community of practice where members are both engaged in and informed by research practices and outcomes in the field of science education. ASERA members use a range of quantitative, qualitative and mixed methods approaches to produce quality research that contributes to ensuring that all young people (from early childhood to tertiary) have equitable access to an evidence-informed robust science education. Our members provide research leadership, through mentoring, supervision, teaching, and dissemination of our research. Research contexts range from global (e.g. large comparative studies) to local (e.g. a single teacher). Initial teacher education now, and in the future is a particularly important role for many ASERA members as they use their research findings and knowledge to prepare future generations of teachers and support teachers of science. With this collective expertise, ASERA members need to have input into public debate and future policies impacting science education. In this symposium, we seek your input on the challenges and opportunities of research in science and the implications for informing policy, further research and transforming practice.

Symposium Title: *International perspectives on climate change education*

Presenters: Peta White, Chris Eames, Yu-Chi Tseng, Rose Hipkins

Overview: We ask: How are we supporting our future generations to understand and manage Anthropocene challenges through science education research? This symposium presents three discussions from the perspectives of academics in Taiwan, New Zealand, and Australia. Each presentation shares the countries practices as well as specific foci related to climate change education. With close attention paid to the curriculum and to current/recent curricula initiatives and reform, this symposium considers what is possible in climate change education, when it feels like the mandated curriculum has let us down. The discussant is Dr. Rose Hipkins – Chief Researchers at the NZCER (New Zealand Council for Educational Research).

Paper 1: Shaping Climate Change Education in Taiwan: Policy Initiatives and Impact on the School System

Abstract: In Taiwan, the rise in sea levels, temperatures, and greenhouse gas emissions surpasses global averages, requiring improved responses to climate and hydrological disasters. The government launched the Environmental Education Act in 2010, followed by the 'National Climate Change Adaptation Policy Guideline' and related education programs in 2012, incorporating climate change as a key learning theme in 2019's curriculum reforms. Surveys on environmental and climate literacy since 2013 have informed policymaking. A significant step was the 2023 'Climate Change Response Act', mandating climate change education focused on sustainable development at all educational levels, enhancing teacher training, curriculum development, and the cultivation of interdisciplinary talent for climate adaptation. Despite legal and policy progress, efforts mainly target in-service training with supplementary materials, teacher workshops, a national teaching online platform, funding for climate-themed courses and internships for youth in climate adaptation. However, gaps remain in pre-service education and specialization in climate change instruction, with limited effectiveness assessments for educational policies. This presentation showcases Taiwan's decade-long effort to weave climate change education into its school system, highlighting curriculum innovations and teacher development strategies.

Paper 2: Climate Change Education Curriculum and Teacher Readiness

Abstract: The Aotearoa New Zealand school curriculum has been undergoing a ‘refresh’ over the past few years. The existing *New Zealand Curriculum* (Ministry of Education, 2007) contains useful references to learning for a sustainable future but lacks specificity and has no mention of climate change. The ‘refresh’ has been underpinned by a much more critical, culturally-inclusive and potentially transformative agenda. In the draft of the ‘refreshed’ science curriculum there are real opportunities for guiding teachers in this most important work. However, we need to work hard now to ensure this draft persists into reality and gain governmental and non-governmental support and resources to make a real difference for teachers in preparing our students for the challenges of the Anthropocene.

Paper 3: Climate Change Education: Practice and Politics

Abstract: The Australian Curriculum was reviewed in 2022 and released in 2023 with little attention paid to climate change education in science. Each state/territory is now developing their adaptations (or will accept the Australian curriculum as is). An interesting analysis will result that illustrates how much each state or territory prioritises a response. It seems that Victoria is attempting little change while South Australia has some interesting conceptual plans underway. More analysis will be possible. Similarly, international curriculum analyses suggest that our country may not be making bold shifts that others are. What leverages are possible to influence necessary change? Beyond Curriculum mandates what can we do to support change? Some suggestions might be: curriculum resources, teachers professional learning, policy work to initiate change, and research to leverage change. Australia is hosting a Climate Change Education Summit and Action Plan this year.

Symposium Title: *Empowering Educators for Environmental Change: Examining contextual classroom practices within South Korea and Australia focusing on environmental education through a design thinking lens*

Presenters: Rachel Sheffield, Rekha Koul, Michelle De Kok, Nicole Fairhurst, Ella Fitriani

Overview: Empowering Educators for Environmental Change: Examining contextual classroom practices within South Korea and Australia focusing on environmental education through a design thinking lens

Paper 1: Empowering Future Educators: Integrating STEAM and Design Thinking in Pre-Service Teacher Education for Global Challenges

Abstract: “I am struggling to find a defined path through this unit”. This presentation focuses on integration of Hasso-Plattner design thinking model into STEAM education. It emphasizes a holistic approach to education that incorporates transformative learning principles and aligns with the United Nations' SDGs, aiming to make education both academically rigorous and socially relevant through problem-based learning (PBL).
The significance of this approach lies in its ability to prepare students for future challenges by addressing not only academic requirements but also emotional and psychological needs. This is particularly relevant in the context of global challenges and the need for education that aligns with UNESCO's directives and national curriculum focuses, such as the Australian Government's emphasis on STEM education.
The aim of this research is to explore the practicalities and potential of implementing including the affordances and challenges. The methodology involves a detailed examination focusing on its integration into course structures and digital learning environments. It includes an evaluation of the model's effectiveness in preparing student teachers by replicating transformative learning experiences that emphasize emotional support and understanding.
The presentation will share insights into the effectiveness of integrating the Hasso-Plattner design thinking model into STEAM education. It highlights how this approach equips future educators with necessary skills to teach STEM subjects effectively.

Paper 2: Educators for Environmental Change: Examining contextual classroom practices within South Korea and Australia focusing on environmental education through a design thinking lens

Abstract: This study focuses on the importance of education in tackling real-world challenges, particularly environmental and climate change issues. It highlights the role of educational experiences in enhancing students' problem-solving abilities, empathy, and self-efficacy, leading to greater student autonomy and lifestyle changes that contribute to societal well-being.
The significance of this research explores design thinking as an effective educational approach for implementing community-focused environmental sustainability education through teachers professional learning.

The research explores the impact of design thinking-focused professional development for teachers in South Korea, in collaboration with Australian educators. It investigates how this professional development influences teachers' perceptions, their classroom practices, preferences in professional learning, and their planning of design thinking units.
Employing a mixed-methods approach, the study examines the current contextual classroom practices in South Korea, teachers' perceptions of their teaching, their preferences in professional learning, and their experiences with design thinking units. This research encompasses five schools and one science centre in South Korea, providing a comprehensive view of inquiry-based pedagogy and environmental education.
The findings offer insights into the application of inquiry-based pedagogy and environmental education in South Korea, highlighting the current practices, teachers' perceptions, and their experiences with design thinking. It reveals the value of biocultural diversity and the enhancement of international design thinking professional development programs, suggesting the effectiveness of design thinking in addressing environmental sustainability through education.

Paper 3: Exploring Lecturer's Experiences in Implementing Constructivist Learning Through Design Learning Process in Indonesian University

Abstract: The demand for graduates with transversal competencies has been increasing worldwide. Traditional learning approaches (teacher-centred learning or TCL) often fail to promote acquiring these skills, favouring content knowledge acquisition instead. Conversely, constructivist learning, a form of student-centred learning (SCL), has proven to better equip students with transversal competencies than traditional learning (TCL). This research
explored the experiences of a lecturer who implemented constructivist learning through a design thinking process in an Indonesian university. The study employed a qualitative research approach, exploring the lecturer's experiences through reflective journaling during a 16-lesson unit involving 67 pre-service teachers from the chemistry education department. Thematic analysis of the lecturer's journals revealed two emerging themes: pedagogy and
teacher quality. These themes captured how the lecturer experienced the challenges of constructivist learning in guiding students' thought and emotional processes in the new learning experience. The series of actions to shift learning control from the lecturer to more student autonomy was also discussed. Additionally, the transition from traditional to constructivist learning was an emotional process that remained dynamic throughout the 16-
week unit. Based on this study, regular self-reflection after teaching can assist the lecturer in effectively self-regulating emotions.

Paper 4: Design Thinking for Sustainability Education: Professional Learning Program for Primary School Teachers

Abstract: Design Thinking represents a structured approach to education, collaboration, and problem-solving, facilitating the development of transversal competencies as outlined in the Australian Curriculum. This framework guides the identification of issues, data collection, generation of potential solutions, refinement of ideas, and testing of solutions.
The significance of incorporating Design Thinking into educational practices lies in its potential to enhance problem-solving skills and develop critical competencies in students.

The research aims to document and analyze the experiences of primary school teachers participating in workshops focused on Hasso Plattner's Design Thinking model. It seeks to understand how teachers can apply this model's five stages to address sustainability issues within their classrooms, using authentic problems relevant to their school's location.
The methodology involved conducting two half-day workshops for four primary school teachers in the fourth term of 2023. The workshops introduced participants to the stages of Design Thinking with a focus on sustainability. Following the workshops, in the first term of 2024, the teachers applied what they learned in their classrooms, addressing specific sustainability issues such as car idling's impact on air quality and managing a large lost property box.
By focusing on authentic problems like air quality and waste management, the research is expected to demonstrate how Design Thinking can foster practical environmental stewardship and problem-solving skills among students, reflecting the model's applicability and effectiveness in educational settings.

Symposium Title: *Where STEM disciplines converge: Integrating cognitive knowledge*

Presenters: Gillian Kidman, Hazel Tan, Roland Gesthuizen, Simone Macdonald

Overview: This symposium explores transdisciplinary integration in STEM education. However, our work can be used across all integration approaches (disciplinarity, multidisciplinarity, and interdisciplinarity). Each approach has value, and there is a need and role for each. Focusing on transdisciplinarity will give rise to new understandings of other integration approaches. The emergence of transdisciplinarity as a concept can be traced to the Organisation of Economic Cooperation and Development (OECD) International Conference on Interdisciplinary Research and Education in 1970 What is transdisciplinary thinking? Since then, transdisciplinary research has evolved to include studies integrating knowledge, methods, and expertise from multiple disciplines to form novel frameworks to catalyze scientific discovery and innovation. In this symposium, we align our presentations to the four features that characterise research on transdisciplinarity in education: (a) it entails a deep search for a unity of knowledge – Presentation 1, (b) it transcends and integrates disciplinary paradigms – Presentation 2, (c) it involves participatory research – Presentation 3, and (d) it relates to socially relevant issues – Presentation 4. We draw upon the cognitive sciences to understand how we think, plan and act in a complex, interlinked manner when we think and teach laterally, imaginatively, and creatively – how STEM knowledge is integrated.

Paper 1: STEM Knowledge Creation Through Cognitive Integration: An Operational Framework

Abstract: The research on transdisciplinary teaching and learning in education notes that we need to explore the integration of cognitive factors involved in knowledge acquisition in addition to the solutions to wicked STEM problems themselves. However, scant educational research is available in this area, and an operational framework for cognitive integration in classroom settings is needed. The presentation will address this absence by considering the unity of knowledge and the conceptualisation of cognitive integration as an operational framework. The framework was derived from a review of the interdisciplinary research process, sociology, anthropology, and psychology literature. Cognitive science principles and conceptual change theories from the education research literature complete the operational framework of Knowledge Creation Through Cognitive Integration.

Paper 2: Makerspaces as interdisciplinary environments: Cognitive integration during skill development

Abstract: Makerspaces, by their very nature, are interdisciplinary environments where learners from diverse backgrounds come together to collaborate, innovate and create. Makerspace users learn to integrate knowledge and skills from various disciplines, facilitating solution generation to complex problems. This experiential learning approach also promotes the application of theoretical knowledge from different disciplines in a practical context, leading to a deeper understanding of concepts and their real-world applications. Ideas flow freely, and the learners explore connections between seemingly unrelated disciplines. Cognitive integration often leads to innovation as individuals draw inspiration from diverse sources and combine concepts from different disciplines to create something new and unique. Learning occurs in ways that transcend traditional disciplinary boundaries. This

presentation uses the Knowledge Creation Through Cognitive Integration operational framework to investigate cognitive integration and conceptual change in makerspace contexts. We find inspiration, deep thinking, creativity, and insight critical as learners redefine, expand, and transform their ideas and understandings. Artefact analysis and discourse analysis during makerspace interactions provided empirical data.
Paper 3: Negotiation of pedagogical reasoning: Cognitive Integration during Teacher Co-planning
Abstract: Educators spend their day primarily participating in reciprocal interactions. Despite this centrality of social interaction in their professional lives, the study of the social-cognitive processes supporting educators' co-planning interactions has largely been ignored. To study the social-cognitive processes supporting co-planning interactions, it is necessary to use experimental paradigms that involve participants in authentic, dynamically unfolding co-planning interactions. This presentation describes the participatory research of two very different STEM educators as they co-planned a 6-week unit of work. The interactions took place in real-time and were reciprocal, such that one educator's actions affected the other and vice versa. The social-cognitive processes during the co-planning are interpreted through the Knowledge Creation Through Cognitive Integration operational framework. Of particular relevance to educator co-planning is the Transform and Organise components of the Redefine, Extend, Transform, and Organise (RETO) cognitive process. We will unpack the Transform and Organise processes during the presentation, highlighting critical incidents of cognitive integration during idea transfer. The recordings of the negotiations of pedagogical reasoning during the co-planning interactions provided empirical data.
Paper 4: Promoting Knowledge Creation Through Cognitive Integration in classroom practices – a pedagogical model
Abstract: This presentation concludes the symposium by further discussing the Redefine, Extend, Transform, and Organise (RETO) cognitive process of the Knowledge Creation Through Cognitive Integration operational framework introduced in Presentation 1. This operational framework depicts cognitive integration of existing knowledge across disciplinary boundaries. We advocate embedding the RETO cognitive constructs into STEM education through a design thinking learning approach. Collaborating with Southeast Asian educators, we co-developed the STEM Design Learning model: empathising, developing design ideas, prototyping and modelling, and proposing solutions. Knowledge creation through a cognitive integration process operates moment-by-moment, where students engage in iterative cycles of analysing, creating, evaluating, and synthesising information to generate new knowledge. In this respect, certain stages of the design learning process, such as drawing a sketch to develop design ideas, facilitate the RETO process by integrating students' thoughts, feelings, and societal/cultural norms. During the presentation, we unpack the RETO cognitive process within the broader classroom context, using teaching strategies and learning examples. An online pilot study on a socially relevant issue ("Used Face Mask: A Waste Management Crisis") taught by Malaysian teachers for Grade 4 students provided empirical data.

Symposium Title: *Innovation in science education: Responding to climate crises*

Presenters: Russell Tytler, Maija Aksela, Peta White, YingShao Hsu, Chris Eames

Overview: Anthropogenic Climate Change is the challenge of our times. The burden of the Anthropocene falls heavily on young people currently in school who will live their lives in a world characterised by multiple socio-ecological crises. In responding to these, students need knowledge, a critical perspective that informs decision making and action, and an enlightened disposition towards environmental and social justice.

Climate Change Education (CCE) is a response to the urgent need to rethink the fundamental purposes of science education curriculum processes that currently emphasise abstract knowledge, decontextualised problem solving and value free approaches to scientific practices.

This symposium will present the research of an international project – "Enacting Climate Change Education: Building student and teacher agency through representing scientists' practices in classrooms"– that focuses on contemporary scientific knowledge and practice, critical thinking, futures thinking and student agency. The three presentations will focus on the project's response to three major challenges to CCE in science education: 1. The challenge for teachers of developing confidence in knowledge about CC; 2. The lack of resources that support approaches to CCE; and 3. The challenge of developing content and pedagogies that represent contemporary scientific practices and their entanglement with complex societal values and processes.

Paper 1: Science teachers' perspectives on climate change education

Abstract: Teachers, their knowledge and beliefs, are crucial to the implementation of CCE within science education or the humanities (Tytler & Freebody 2023 https://theconversation.com/how-should-we-teach-climate-change-in-schools-it-starts-with-turbo-charging-teacher-education-207221). This presentation will report on the findings of a survey of science and humanities teachers in Australia, Finland and Taiwan concerning their perspectives on teaching about climate change. The survey probed teachers' knowledge, confidence and self-efficacy concerning a range of aspects of climate change teaching, their current practice including their approach to student concerns and values and the inclusion of human values and practices, their professional learning strategies and support structures, and beliefs about purposes. The survey was translated for each country. We report on preliminary analyses of the patterns of results for each country, and cross-country analyses of difference on the different categories of response, in order to ascertain differences in teacher knowledge and commitment, practices, self-efficacy and professional learning processes for teachers of science compared to those of humanities. The results will be interpreted in the light of the researchers' familiarity with the culture of curriculum and teaching in their country, with implications for trajectories of climate change education in science education.

Paper 2: Textbook representations of climate change across three countries

Abstract: In any country, teachers' knowledge and practice is strongly shaped by the resources at their disposal. In Australia, secondary school curricular are strongly patterned on textbook writers' interpretation of the curriculum. In different countries, textbooks have a differing place in subject teaching and learning cultures. In Taiwan, for instance, ratified textbooks dominate primary science curricular practice, unlike in Australia. For any curricular change, textbook writers are influential in interpreting this for classroom realities. Recently, in Australia Climate Change has appeared in the national curriculum at Year 9 and 10 levels but not elsewhere. In Taiwan and Finland different patterns are evident. This presentation presents a comparative analysis of textbook content in relation to a range of aspects of climate change including scientific modelling practices, science content, a sense of urgency with the issue, the role of science in mitigation and adaptation, effects on the environment and on human life, and implicit values and possible human actions. We discuss the methodological approach to coding and comparative analyses and interpret the comparative results in terms of the different cultures of science and humanities teaching in the three countries. Implications are drawn for the shaping of resources to support innovation in CCE within science.

Paper 3: Co-designing with teachers learning sequences that represent scientific research on CCE and support student agency

Abstract: The development of science curricula and pedagogies focusing on Climate Change present significant challenges for teachers and students, given the fast changing scientific research in CC, the complexity and interdisciplinary nature of the knowledge, the socio-ecological entanglements involved in mitigation and adaptation practices, the competing values, and the need to focus on student decision making and agency for Anthropocene challenges (https://www.oecd.org/publications/agency-in-the-anthropocene-8d3b6cfa-en.htm). This presentation will describe the processes of co-design of learning sequences and pedagogies with teachers in Finland, Taiwan and Australia as part of this international CCE project that includes interactions with the contemporary science research community. We will present the approach taken to the co-design process in each country and the challenges and variations in how we work with teachers and support their learning, illustrating this with examples of learning sequences and activities, and student learning outcomes. We argue for this co-design process as a model for curriculum innovation in CCE/school science and canvas the different ways that this proceeds in the different teacher learning cultures in the three countries.

Mā te wā

Photo Credit: Liam Spicer