# Table of Contents

Table of Contents ......................................................................................................................... 2  
Welcome ...................................................................................................................................... 3  
  About us ................................................................................................................................... 3  
University of Canberra ............................................................................................................. 4  
Looking to connect? ................................................................................................................. 4  
Acknowledgements .................................................................................................................. 5  
Conference Venue ......................................................................................................................... 6  
  QT First Floor Layout ............................................................................................................... 7  
  Canberra Location Map ........................................................................................................... 8  
Social Program .............................................................................................................................. 9  
Guidelines for Presenters ........................................................................................................... 13  
  Wi-Fi instructions ..................................................................................................................... 13  
Keynote Speakers ....................................................................................................................... 14  
Program ...................................................................................................................................... 17  
Social Evening ............................................................................................................................. 18  
  Tuesday January 30 ................................................................................................................ 20  
  Wednesday January 31 ........................................................................................................... 32  
  Thursday February 1 ............................................................................................................... 36
Welcome

Thank you for joining us in Canberra for the 2018 SERC Spatial Reasoning Conference hosted by the STEM Education Research Centre (SERC) and the University of Canberra.

The SERC Spatial Reasoning Conference aims to engage spatial enthusiasts from a variety of fields to inform discussion around spatial reasoning throughout the lifespan. This will be the second meeting of the SERC Spatial Reasoning Conference. Our mission is to achieve a friendly, informal, but high quality conference experience that will make the most of the geographic and discipline diversity of our delegates as well as the Canberra location.

About us

The STEM (Science, Technology, Engineering and Mathematics) Education Research Centre focuses on innovations in technology and STEM education research. Our mission is to influence policy and practice through applied social and cognitive research situated within contextually-bounded settings. Our research covers three overarching themes:

**Mathematical Sciences and Technology: STEM Pedagogy and Practice.**

Our researchers examine mathematics practice(s) in context. We investigate how school and out-of-school learning opportunities and situated environments influence the way in which students solve tasks and problems.

**Policy and Leadership: Comparative Studies.**

In this theme, we consider STEM-related policies, cultures and work practices. In particular, we study how school systems, educational leaders, classroom teachers and their students interact under varied conditions and circumstances. Projects are conducted in a comparative manner to examine dimensions associated with geographic location, cultural beliefs and equity, and international policy and leadership perspectives.

**Learning Environments and Communities: Design Processes and Digital Technologies.**

Given the trend toward using digital technologies, our research in this area explores how technological platforms and tools influence the way in which information is collected, represented, accessed, analysed and interpreted.
University of Canberra

Nestled in the nation’s capital, the University of Canberra (UC) is a young university with a bold vision. We aim to be amongst Australia's most innovative tertiary institutions, continue our ascent in world rankings, and extend our regional, national and international reach.

Our latest position in the Times Higher Education World University Rankings and QS World University Rankings place UC within the top two percent of universities worldwide, and among the top 100 universities in the world under the age of 50.

UC is committed to preparing professional and highly employable graduates with the right mix of skills and knowledge. Key to this goal is our focus on work-integrated learning which offers every student the opportunity to hone their skills in a real-work environment.

Our teaching is enriched by our research culture that produces high-quality and high-impact work and makes an early and significant difference to the world around us.

The University of Canberra is committed to serving its communities through professional education and applied research. Its purpose is to provide education which offers high quality transformative experiences to everyone suitably qualified, to engage in research which makes an early and important difference to the world around us, and to contribute to the building of just, prosperous, healthy and sustainable communities.

Looking to connect?

We invite you to engage with SERC through Twitter: @UC_SERC
To share your thoughts on this year’s conference, please use #SERC Spatial Reasoning Conference 2018

Join our Facebook group to connect with conference delegates: SERC Spatial Reasoning Conference 2018

Disclaimer

All details are correct at the time of publication. However, in the event changes are made to the program the organisers will endeavour to contact affected delegates via email. To be kept up to date, please join the conference Facebook group where program changes will be posted as they occur.
Acknowledgements

Thank you for attending the SERC Spatial Reasoning Conference 2018.

We would like to acknowledge the support of the Faculty of Education at the University of Canberra in the preparations for this conference.

With thanks to QT Canberra for providing a welcoming venue for our gathering and a special thank you to Danielle Harris, Kylie Reece, and the SERC team for their dedication and hard work in organising this event.

Thanks to Samsung Australia for the donation of digital displays for use during the poster session.
Conference Venue

*Luxury Chic & Politics meet in the Nation’s Capital*

We know that for the perfect hotel stay, you’ll need a strong service team, as well as a great bar and restaurant. Winner of the 2016 ACT Caterer of the Year award, with a choice of dining options onsite and magnificent views of Canberra, Lake Burley Griffin and the surrounding mountains, QT Canberra provides a perfect base for enjoying all Canberra has to offer in addition to the exciting conference program.

The iconic Lakeside hotel has been the scene of many a handshake deal and long lunch. In the great tradition of Australian politics we do business with a wink and a nod and know that after a gruelling day of question time (from the kids or the leader of the opposition) you need a place to put your feet up and a soft bed to fall into.

Our 188 guest suites are kitted out with designer décor and all the business savvy mod cons we know you need to get the job done. Expect a seamless technology offering and a team geared to assist you with any left-field requests.

Conference catering

Morning tea, lunch and afternoon tea will be available during the conference in the first floor foyer (except where specified) and is included in your registration fee. Please refer to the table below for catering times.

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<tr>
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<th>Tuesday</th>
<th>Wednesday</th>
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<tbody>
<tr>
<td><strong>Morning Tea</strong></td>
<td>8:30 – 10:00</td>
<td>10:30 – 11:00</td>
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<td></td>
<td>(QT Lounge)</td>
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<tr>
<td><strong>Lunch</strong></td>
<td>12:30 – 1:30</td>
<td>12:45 – 1:30</td>
<td>12:30 – 1:15</td>
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<tr>
<td><strong>Afternoon Tea</strong></td>
<td>3:15 – 5:15</td>
<td>3:00 – 3:30</td>
<td>2:45 – 3:00</td>
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<td></td>
<td>(Lucky’s Speak Easy)</td>
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**Dietary Requirements**

If you have advised the conference organisers of any dietary requirements you will find your meals located on a special table. Please see QT or SERC staff if you are uncertain.
The session rooms are located on the first floor of the hotel. The conference level can be accessed via the elevators or the winding staircase from the hotel reception.
Social Program

Wednesday 31st January includes a free afternoon to allow time to explore the city of Canberra. QT is located in the heart of Canberra which means many tourist sites are within walking distance.

Canberra is the capital city of Australia, and as such hosts some of the nation’s most historically and culturally significant landmarks and attractions. All national exhibits house knowledgeable and friendly attendants who are happy to answer questions, share their expertise and make recommendations. In addition, as Canberra residents, the SERC team will be happy to assist with ideas on how to spend your time in our city.

For those who would like to take it easy, there is a free bus that stops on London Circuit West, where QT is located, that can connect you to some of these attractions. Those located on, or close to, the free city bus loop include the ACT Legislative Assembly, Glebe Park, Canberra Museum & Gallery, and Commonwealth Park.
ACT Legislative Assembly
The ACT Legislative Assembly is the youngest legislature in Australia. Visitors are welcome to visit the Assembly building to learn about important historical changes since self-government began, and how the system works. The Assembly owns a collection of locally significant art, and hosts exhibitions in its public exhibition rooms.

Canberra Museum & Gallery
Canberra Museum and Gallery celebrates the region’s social history and visual arts with dynamic exhibitions and unique programs and events.

CMAG is the home of The Foundation Collection of Sir Sidney Nolan’s paintings, donated by the artist to the people of Australia in 1974.

Glebe Park
Glebe Park is located on the eastern side of the city centre and features a stage, a 19th century style rotunda, barbecues, playgrounds, and a picnic area. This tranquil green space in the city reflects the character of a traditional English park with mostly English Elms and English Oaks.

Commonwealth Park
A beautifully landscaped park in the city, right on the edge of Lake Burley Griffin. You’ll find interesting sculptures, hidden walks and tranquil ponds within the park’s 34.5 hectares.


Australians of the Year Walk
The Australians of the Year Walk is a permanent record of the Australians selected to be Australian of the Year, Senior Australian of the Year, Young Australian of the Year and Local Hero. On this walk you can search for the five metal strips that form the five stave lines of a music score. The plinths represent the notes to the music score of Advance Australia Fair (Australia’s national anthem), which can be read from West to East.

International Flag Display
The International Flag Display colourfully acknowledges the United Nations and those that maintain a diplomatic presence in Australia’s capital. See the 90 plus flags flying from two offset rows of flagpoles along the promenade between the High Court and the National Library on the southern shore of Lake Burley Griffin.

The National Library of Australia
See the beautiful, the rare, and the unexpected at the National Library of Australia. The ever-changing Treasures Gallery gives you free access to some of Australia’s most moving stories. Highlights include material from the 1967 referendum and the campaign for Indigenous rights, as well as intriguing items from the life of poet Henry Lawson, including his fob watch and two of his pens. Onsite at the National Library is the Bookplate Café offering breakfast, lunch and light snacks daily. The SERC team highly recommend this café.

The High Court of Australia
The High Court of Australia is the highest court in the Australian judicial system. View the
courtrooms where the Court interprets and applies the law of Australia and hears cases of special significance including challenges to the constitutional validity of laws. The stunning building by Lake Burley Griffin in the Parliamentary Zone also has a collection of artwork depicting the role and relevance of the Australian judiciary. Guides are on site to answer questions about the history of Australia’s judicial system and cases that have reached the high court.

The National Portrait Gallery
Look into the eyes of over 400 people who’ve shaped the nation at the National Portrait Gallery, on the shores of Canberra’s Lake Burley Griffin. Gain a greater understanding of the Australian people – their identity, history, creativity, culture and diversity – through portraiture.

Questacon - The National Science and Technology Centre
Questacon’s eight interactive exhibitions feature more than 200 hands-on experiences, designed for visitors of all ages to touch, play and explore. Questacon’s exhibitions cover a range of science topics, from astronomy to zoology and everything in between.

Old Parliament House Gardens
Old Parliament House Gardens offer a pleasant, rose-filled place to pause in the heart of the Parliamentary Zone. The roses in this garden were planted during the Great Depression. When parliament moved, the gardens were opened to the public. They were restored in 2004 to their current beauty.

Museum of Australian Democracy at Old Parliament House
As the first and only museum dedicated to telling the story of Australian democracy, the museum offers a range of innovative exhibitions, tours and activities for all ages. Be inspired by amazing stories of ordinary people who actively fought to shape today’s society, discover where Australia has come from and get involved in where the country is headed.

National Archives of Australia
This heritage building (Canberra’s original Post Office) houses treasures from the Archives’ world-class collection. Visit to discover Australia’s history through exhibitions, events and more. See Australia’s ‘birth certificates’ in the Federation Gallery - often open for ‘sneak peeks’. Exhibitions range from banned books to artwork, historic photographs to spies’ secrets.

The National Gallery of Australia
Art lovers will enjoy meandering through the galleries and admiring the collection, which includes the famous ‘Blue Poles’ by Jackson Pollock and the Ned Kelly series by Sidney Nolan. The new Australian and International art galleries provide plenty of things to see, following a large-scale rehang of almost every piece. The Aboriginal and Torres Strait Islander art collection comprises over 7500 works and is the largest in the world.

National Museum of Australia
The National Museum of Australia (NMA) explores the land, nation and people of Australia. NMA focus on Indigenous histories and cultures, European settlement and our interaction with the environment. The National Museum brings to life the rich and diverse stories of Australia through compelling objects, ideas and events.
Getting Around Canberra

For those that are feeling adventurous Canberra has an excellent bus service that can connect you to locations outside the city centre. The free city bus service will drop you off at the city bus station, which gives you access to buses that connect to all areas of Canberra.

A trip planner for Canberra buses can be found here: https://www.transport.act.gov.au/routes-and-timetables/Plan-Your-Trip

Please note that there are limited bus services between the airport and the city. These can be found here: https://www.transport.act.gov.au/routes-and-timetables/services-to-canberra-airport

A number of taxi services are available in Canberra. Their contact details are:

ACT Cabs: 02 6280 0077
Canberra Elite: 13 22 27 or SMS your name, pickup address and time to be collected to 0417 672 773.
Cabxpress: 1300 222 977
Silver Service: 13 31 00. This premium service features luxury sedans and seven seater vans, accredited silver standards, and guaranteed delivery times with travel bookings.

Wheelchair accessible taxis must be booked ahead. Phone 13WATS (139 287).

The attractions listed in this handbook are just a small number of what’s on offer in Canberra. For further information about activities in and around Canberra please visit: http://visitcanberra.com.au.

Wednesday night social dinner

Conference delegates have the option of signing up to join in a group dinner on Wednesday night (31st January). Tables of 8 have been reserved at a selection of restaurants so please ensure you register your interest in one of the restaurants by Tuesday afternoon. Interested conference delegates, and their travel companions, are asked to nominate their restaurant preference at the conference registration desk.

Main course price range and links to the menus are provided below.

- **Raku**
  Contemporary Japanese Dining ($12-$41)
  Tasting menus are available if whole tables wish to partake ($80 per person)

- **Blu Ginger**
  Indian ($17.90 - $28.90)

- **Sammy’s Kitchen**
  Chinese & Malaysian ($16.50-$25.50)
  Banquet menus are available if the table wishes to partake ($28.50 - $42 per person)

- **Gus’ Place**
  Café style ($18-$26)

- **Guild**
  Informal Italian ($17-$22)
  Guild offers an extensive board game collection for restaurant patrons

- **Italian and Sons**
  Italian fine dining ($29 - $37)
Guidelines for Presenters

A chairperson has been allocated for all sessions consisting of individual presentations. As a courtesy please remain in attendance at your presentation session.

To ensure smooth proceedings, time limits will be strictly enforced by session chairs.

A laptop computer will be available for PowerPoint presentations. Please submit a copy of your presentation prior to 29th January via email (serc@canberra.edu.au) or bring a thumb drive on the day of your presentation. All presenters need to make their PowerPoint presentation available to the session chair at least ten minutes prior to the beginning of the session if not previously submitted via email.

Research Presentations

The standard time allocation for research presentations is 30 minutes; this includes 10 minutes of question time. A warning bell will sound after 15 minutes and again at 19 minutes.

Lightning Talks

A standard time allocation for lightning talks is 15 minutes; this includes 5 minutes of question time. A warning bell will sound after 8 minutes.

Posters

Posters are to be mounted 15 minutes prior to the beginning of the poster session. We will provide pushpins for traditional display boards. For digital poster presentations please bring your own laptop. Cables will be provided. The numbering of the displays coincides with the numbering in the program.

Wi-Fi instructions

Connect to network “QT-events”

Password: GreatEvent
Keynote Speakers

Professor Nora Newcombe

Professor Nora Newcombe is the Laura H. Carnell Professor of Psychology at Temple University and Principal Investigator of the Spatial Intelligence and Learning Center (SILC), headquartered at Temple University and involving Northwestern University, the University of Chicago and the University of Pennsylvania as primary partners. Professor Newcombe completed her degree majoring in psychology at Antioch College and received her Ph.D. at Harvard University in Psychology and Social Relations. Professor Newcombe has served as Editor of the Journal of Experimental Psychology: General and as Associate Editor of Psychological Bulletin, as well as on numerous editorial boards and grant review panels. She is currently an Associate Editor for Cognitive Psychology and Cognitive Research: Principles and Implications. Her Academic Honors include the Distinguished Scientific Contributions Award from the Society for Research in Child Development, the William James Fellow Award from APS, the George Miller Award and the G. Stanley Hall Awards from APA, the Award for Distinguished Service to Psychological Science, also from APA, and the Women in Cognitive Science Mentor Award. She is a fellow of four divisions of the American Psychological Association (General, Experimental, Developmental, and Psychology of Women), of the American Psychological Society, and of the American Association for the Advancement of Science, and has been a Visiting Professor at the University of Pennsylvania, Princeton, and the Wissenschaftskolleg in Berlin. She is a member of the American Academy of Arts and Sciences and the Society of Experimental Psychologists. Professor Newcombe has authored over 200 papers and book chapters.

Professor Mary Hegarty

Mary Hegarty is Professor of Psychological & Brain Sciences and Associate Dean of the Graduate Division at University of California, Santa Barbara. She received her B.A. and M.A in Psychology at University College Dublin and her Ph.D. in Psychology at Carnegie Mellon University in 1988. Her research is on spatial cognition. Current research topics include individual differences in navigation, the role of spatial abilities in science, technology, engineering and mathematics (STEM) achievement, and how people interpret visualizations of uncertainty.

Mary Hegarty served on the governing board of the Cognitive Science society from 2006-2012 and as chair of the board from 2010 – 2011. She is a fellow of the American Psychological Society, a former Spencer Postdoctoral Fellow, and the recipient of an Australian Research Council International Collaboration Award and the Nickerson award for the best paper in Journal of Experimental Psychology: Applied in 2016. She is Associate Editor of Topics in Cognitive Science, former Associate Editor of Journal of Experimental Psychology: Applied and is on the editorial boards of Learning and Individual Differences and Spatial Cognition and Computation. Her current research is funded by the National Science Foundation.
Associate Professor Maria Kozhevnikov

Associate Professor Maria Kozhevnikov currently holds positions as Visiting Associate Professor of Radiology at Harvard Medical School, Athinoula A. Martinos Center for Biomedical Imaging, Department of Radiology and as Associate in Neuroscience at Massachusetts General Hospital in addition to her primary academic appointment as an Associate Professor of Psychology at the National University of Singapore, Department of Psychology and Communication and New Media Programme. She received her PhD from Technion (Israel) jointly with UC Santa Barbara. Since 2001, she held faculty positions at Rutgers and George Mason Universities. During 2005-2007, she has served as a Program Director for the Science of Learning Centers Program at the US National Science Foundation, where she managed awards for large-scale Centers that study learning across multiple disciplines. In addition, Associate Professor Kozhevnikov is an Adjunct Associate Professor in the Department of Education at Tufts University, where she is collaborating with the Center of Science and Math Teaching on the development of science learning materials and curricula.

Associate Professor Kozhevnikov’s research focuses on examining neural mechanisms of visual imagery as well as in exploring the ways to train visualization abilities. In particular, she examines how individual differences in visualization ability affect more complex activities, such as spatial navigation, learning and problem solving in mathematics, science and art. In addition, she explores ways to train mental imagery skills and design three-dimensional immersive virtual environments that can accommodate individual differences and learning styles.

Associate Professor Kozhevnikov’s teaching career started at Harvard University in 2001, where she worked as a Lecturer at the Graduate School of Education and developed to new graduate courses: "Technology in Science Education" and "Computer-Supported Collaborative Learning". She received the McCoy Technology Award from the Harvard Graduate School of Education for the development of learning materials for these courses. In 2002 she became an Assistant Professor in Psychology at Rutgers University (NJ), and received a Career Award from the US National Science Foundation for the use of visualization tools in learning sciences. One of the main focuses of the project (teaching component) was to develop a new undergraduate Human-Computer Interaction (HCI) curriculum with a focus on innovative 3D visualization technologies. As a part of Maria’s Career Award, she developed a new introductory course (based on virtual-reality modules) on Human-Computer Interaction.

Professor David Uttal

David Uttal is Professor of Psychology and Education at Northwestern University. He is Director of Graduate Studies in the Department of Psychology. He is a Fellow of the American Psychological Association and the American Psychological Society. His work has been funded by the National Institutes of Health, the National Science Foundation, and the Institute for Education Sciences.

His research interests are in spatial and mathematical thinking and their development. He has studied the development of children’s understanding of
spatial and mathematical symbols, and the influence of acquiring this knowledge on development. For example, he studies the early development of map reading skills and the cognitive consequences of using maps on spatial thinking. He is also interested in the role of spatial thinking in Science, Mathematics, and Engineering. His meta-analysis of spatial training programs showed that spatial ability is quite malleable. In collaboration with Catherine Haden of Loyola University, he is studying how children’s early experiences with simple engineering problems in the Chicago Children’s Museum affects their learning.

Professor Rob Fitzgerald

Robert is a Professor of Education and Director, INSPIRE Centre for Innovation in Education and Training in the Faculty of Education, Science, Technology and Mathematics at the University of Canberra. He has been a leader and innovator in the field of STEM Education and Information and Communication Technology Education working across schools, universities and the community development sector in Australia, Hong Kong, Cambodia and Pakistan. Robert is internationally recognized for his research and development work on augmented reality, STEM education, technology enhanced active learning and learning space design.

Robert is Chair of the Australian Research Council’s College Scrutiny Committee, an Expert Assessor for the Australian Research Council and a Principal Researcher in the STEM Education Research Centre (SERC) at the University of Canberra. He was the UC nominee on the ACT Board of Senior Secondary Studies (BSSS) for three years and a current member of the Australian Mathematics Trust, ABC’s Digital Education Advisory Committee and the ACT Ministerial School Education Advisory Committee (SEAC) currently advising the Minister on Devices for Year 7 & 11 Students. He is a member of the Editorial Review Boards for the Australasian Journal of Educational Technology and EDeR Educational Design Research, a new International Journal for Design-Based Research in Education hosted by the University of Hamburg.

Robert is a co-founder of Phonelabs, an innovative Adelaide-based start-up using mobile phones to help children get excited and engaged in STEM education. The team at Phonelabs provides apps and educational challenges that help learners undertake inquiry-led learning. Phonelabs was named iAwards Startup of the Year in 2016 and in 2017 and won the D3 Digital Challenge Initiative (Office for Digital Government, South Australia) under the “People, parks and wellbeing” category. Last year the start-up received Best Android app award, and Google have endorsed the team, collaborating with them to incorporate the Google Science Journal work into Phonelabs.
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<th>Time</th>
<th>Event</th>
<th>Ballroom</th>
<th>Studio</th>
<th>Location</th>
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<tr>
<td>8:30-9:00</td>
<td>Registration</td>
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<td>Foyer</td>
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<td>8:30-10:00</td>
<td>Welcome Brunch</td>
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<td>QT Lounge</td>
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<td>10:00-11:30</td>
<td>Key note</td>
<td><strong>Spatial Bases of Elementary Mathematics.</strong></td>
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<td></td>
<td></td>
<td>Nora Newcombe</td>
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<tr>
<td>11:30</td>
<td>Parallel Sessions</td>
<td><strong>Answering Queries for Near Places.</strong></td>
<td>First Language Speakers: Indigenous Australians and Spatial Reasoning</td>
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<td></td>
<td></td>
<td>Hao Wang, Stephan Winter, Martin Tomko</td>
<td>Robyn Jorgensen, Tom Lowrie</td>
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<tr>
<td>12:00</td>
<td>Parallel Sessions</td>
<td><strong>Look out the window: Is the over reliance on digital outputs causing navigators to ignore or mistrust spatial ability?</strong></td>
<td>Children’s spatial language in Mawng, an Australian Aboriginal language</td>
<td>Cris Edmonds-Watthen</td>
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<td>Steve Harris</td>
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<td>12:30-1:30</td>
<td>Lunch</td>
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<td>Foyer</td>
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<td>1:30</td>
<td>Parallel Sessions</td>
<td><strong>A framework to develop spatial reasoning across the early years and beyond.</strong></td>
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<td></td>
<td></td>
<td>Tom Lowrie</td>
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<td>2:00</td>
<td>Pedagogical CONTENT knowledge in ENACTING A geometry lesson.</td>
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<td>Development of a novel test to measure spatial abilities of architecture students: Preliminary findings.</td>
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<td>Mohan Chinnappan</td>
<td>Michal Berkowitz, Beatrix Emo, Andri Gerber, Christoph Hölscher, Stefan Kurath, Elsbeth Stern</td>
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<td>2:30</td>
<td>Spatial reasoning: Some beginnings of complexity approaches.</td>
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<td>Psychometric properties of the paper folding test.</td>
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<td>Geoff Woolcott</td>
<td>Ajay Ramful, Tom Lowrie, Tracy Logan</td>
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<tr>
<td>3:15-5:15</td>
<td>Poster Session</td>
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<td>Lucky’s Speak easy</td>
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### Wednesday 31st January

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<th>Time</th>
<th>Event</th>
<th>Ballroom</th>
<th>Location</th>
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<tr>
<td>9:00-10:30</td>
<td>Key note</td>
<td><strong>Object and spatial visualization abilities and their relation to different professional specializations</strong></td>
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<td>Maria Kozhevnikov</td>
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<td>10:30-11:00</td>
<td>Morning tea</td>
<td><strong>Classroom-based spatial intervention program: Understanding the keys to success</strong></td>
<td>Foyer</td>
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<td>11:00</td>
<td>Lightning Talks</td>
<td><strong>Spatial Reasoning at the Zoo</strong></td>
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<td>Kay Owens</td>
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<td>11:15</td>
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<td><strong>A real-world spatial problem in the secondary classroom: Whales and tails</strong></td>
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<td>Geoff Woolcott</td>
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<td>11:30</td>
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<td><strong>Pattern – the Password to Maths</strong></td>
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<td>Bruce Ferrington</td>
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<td>11:45</td>
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<td><strong>Developing Indonesian Grade 8 Students’ Spatial Ability to Support Geometry and Measurement Learning</strong></td>
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<td>Destina Wahyu Winarti</td>
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<td><strong>Equity and spatial reasoning: Exploring the diverse spatial knowledges of disadvantaged student groups</strong></td>
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<td>Natalie Downes</td>
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<td>12:15</td>
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<td><strong>Training teachers in visuospatial reasoning: An investigation of any changes in teacher understanding of teaching and learning mathematics</strong></td>
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<td>Paul Kruger</td>
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<td>12:30</td>
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<td><strong>Why does spatial thinking matter for STEM Learning?</strong></td>
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<td></td>
<td>David Uttal</td>
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<td>12:45 - 1:30</td>
<td>Lunch</td>
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<td>1:30</td>
<td>Workshop</td>
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<td>3:00 – 3:30</td>
<td>Afternoon Tea</td>
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<td><strong>Social Evening</strong></td>
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| 9:00 – 10:30 | Workshop         | The Future of Learning: Spatial Reasoning, Visualization & Mixed Reality Education.  
Rob Fitzgerald |  |  |
| 10:30 – 11:00| Morning tea      |  | Secondary mathematics pre-service teachers’ spatial problem solving in the 3-D virtual environment of the CAVE2TM.  
Margaret Marshman, Geoff Woolcott, Shelley Dole | Foyer |
| 11:00        | Parallel Sessions| Developing an evidenced based Learning Progression for comparing and ordering fractions in the middle primary grades of schooling.  
Chelsea Cutting |  |  |
| 11:30        | Perceiving and reasoning about geometric objects in the middle years.  
Rebecca Seah, Marj Horne |  | Spatial mapping technology and 3D applications in Nursing: Exploring students’ perspectives on learning.  
Jane Frost, Lori Delaney, Robert Fitzgerald |  |
| 12:00        | Primary students’ geometric reasoning of three-dimensional solids:  
Connecting research to classroom practice.  
Ann Downton, Sharlyn Livy, Simone Reinhold |  | Children Ages 6-12 Learning Optical Spatial Reasoning during Educational Video Game Play: An ERP study examining the role of cognitive load.  
Joseph Schroer |  |
| 12:30 - 1:15 | Lunch            |  |  | Foyer |
| 1:15         | Research Session | Designing learning environments that support the development of spatial problem-solving skills for mixed-ability primary mathematics classrooms.  
Bernd Wollring, Andrea Peter-Koop |  |  |
| 1:45         | Integration of spatial visualization in the Grade 6 mathematics curriculum: A case study.  
Ajay Ramful, A Bholoa |  |  |  |
| 2:15         | Connecting mathematics learning through spatial reasoning.  
Joanne Mulligan, Geoffrey Woolcott, Michael Mitchelmore, Brent Davis |  |  |  |
| 2:45 – 3:00  | Afternoon tea    |  |  | Foyer |
| 3:00 – 4:30  | Keynote          | Individual Differences in Spatial Thinking: Implications for Education.  
Mary Hegarty |  |  |
| 4:30 – 4:45  | Closing          | Thank you and Farewell |  |  |
Tuesday January 30

8.30am – 9:00am

Registration
Foyer

8.30am – 10.00am

Welcome Brunch
QT lounge (15th floor)

10:00am – 11:30am

Keynote Address
Ballroom

Spatial Bases of Elementary Mathematics
Nora Newcombe

11.30am – 12.30pm

Parallel Sessions
Spatial Orientation
Ballroom

Session Chair: Tracy Logan

Answering Queries for Near Places
Hao Wang, Stephan Winter, Martin Tomko

Communication between people conveniently uses qualitative spatial terms, as shown by the high frequency of vague spatial prepositions such as ‘near’ in natural language corpora. The automatic interpretation of these terms, however, suffers from the challenges of capturing the conversational context in order to interpret such prepositions. This research presents an experimental approach to solicit impressions of near to identify distance measures that best approximate it (nuanced by the type of referent, and contrast sets). The presented model computes topological distances to sets of possible answers allowing a ranking of what is near in a context-aware manner. Context is introduced through contrast sets.
The research compares the performance of topological distance, network distance, Euclidean distance, Manhattan distance, number of intersections, number of turns, and cumulative direction change. The aim of this comparison is to test whether a metric distance or topological distance is closer to human cognition, challenging the well-known paradigm of "topology first, metric second".

The comparison results from our experiments show that topological distance appears to be closer to human perception of nearness than other distance measures only at larger scales, while a metric distance (Euclidean distance or Manhattan distance) is closer to how people perceive nearness in smaller scales. People with different sense-of-direction show no obvious differences in their inclination of the seven distance measures with regard to nearness.

This research contributes to enhanced qualitative spatial reasoning with context. The developed model will benefit broad applications that involve some form of verbal place descriptions, such as local search queries. The findings apply to urban, predominantly grid-like environments and may need further verification in less structured environments.

**Look out the window: Is the over reliance on digital outputs causing navigators to ignore or mistrust spatial ability?**

Steve Harris

Recent shipping collision events have often resulted from a lack of spatial awareness in navigation. Instead, navigators have relied on misinformation from navigation technologies, at times ignoring strong visual cues that suggest errors in the guidance systems. In our increasingly digital world when more and more technologies are available to assist in maritime navigation, the abundance of visual information can lead navigators to overlook or ignore important information, both system alerts and visual spatial cues.

In the last 12 months alone US Navy vessels with the most hi-tech naval equipment in the world have had 4 collisions. Nationally, in the last twelve months in my role as lead Australian Maritime Safety Authority (AMSA) investigator I have identified and investigated several similar collision incidents. I have identified this electronic reliance as becoming an issue and leading to a large number of collision and grounding incidents in our maritime industry.

This presentation will discuss implications for maritime safety and offer suggestions for research directions to revisit spatial reasoning as a key component of safe navigation.

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*Exploring the nexus between space and Indigenous cultures*

Studio

Session Chair: Natalie Downes

**First Language Speakers: Indigenous Australians and Spatial Reasoning**

Robyn Jorgensen, Tom Lownie

As part of a much larger study where spatial reasoning is the focus, this paper draws on the language
in representing spatial engagement. The quarantined part of the project discussed in this presentation is situated in remote Indigenous schools. We draw on the challenges of teaching spatial reasoning where the language of instruction is a foreign language. We pose questions of the nuanced, and often complex, language associated with spatial reasoning. Based on our previous work, the project focuses on three tasks undertaken by Indigenous learners - spatial orientation; spatial visualization, and mental rotation. Collectively, these three tasks cover what we see as the key challenges and growth points in spatial reasoning. The presentation identifies the language aspects of spatial reasoning and the impact this has on learning the three key aspects of our spatial reasoning work. The paper draws on the work of Bourdieu to theorise the importance of building the linguistic capital of this cohort of students so that they are better able to engage in the instructional discourse and, as a consequence, to build the formal knowledges valued in school mathematics.

**Children’s spatial language in Mawng, an Australian Aboriginal language**

Cris Edmonds-Wathen

Although early mathematics learning should build on students’ everyday language, little is known about the everyday spatial language of many Indigenous language speaking students. Some teachers have reported difficulty teaching English spatial concepts to Indigenous language speaking students, including specific problems with ‘before’ and ‘after’ (Graham 1988). ‘In front’ and ‘behind’ have two meanings – an intrinsic meaning related proximity to a feature of a faceted object, and a relative meaning related to the position of the speaker, with cross-linguistic variation in the age of acquisition of these different meanings (Johnston & Slobin, 1978). The contexts in which relative or intrinsic ‘in front’ and ‘behind’ are used can also vary, with some Indigenous language speakers preferring intrinsic uses in contexts where English speakers prefer relative; this use is also observed for some child speakers of Indigenous languages when speaking English (Edmonds-Wathen, 2014).

Using quasi-experimental one-on-one interviews and paired language-in-interaction activities, this project describes spatial concepts in the Mawng language, spoken in North West Arnhemland, as they are understood and used by children 5 – 8 years old. The linguistic findings, currently being analysed, will be compared to the assumed learning of spatial terminology in the Australian mathematics curriculum, to better inform the design of mathematics programs for Mawng speaking children and speakers of other indigenous Australian languages, as well as inform curriculum support and teacher preparation.

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<td><em>Theory and Practice</em></td>
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A framework to develop spatial reasoning across the early years and beyond.
Tom Lowrie

Spatial reasoning is considered critical for everyday tasks and helps us to understand, appreciate and interpret our geometric world. Spatial reasoning is identified as a core component in the Numeracy general capability within the Australian Curriculum; with an expectation that such reasoning be incorporated into all school curricula. Spatial reasoning is central to learning in mathematics and science understanding, however such reasoning is equally important in non-STEM disciplines.

This presentation describes the conceptual framework of the Early Years STEM Australia (ELSA) program, a play-based program for early year’s education. The conceptual framework is developed from STEM practices, rather than from traditional understandings of content within the four STEM disciplines. It grounds learning in real-world skills and focuses on the underlying practices of STEM; that is the use of an idea, method, and value to achieve a goal. Spatial reasoning is a way of thinking and a set of skills that promotes STEM practices. The capacity to locate, orientate, and visualise objects; navigate paths; decode information graphics; and use and draw diagrams are critical to success in STEM practices. Given spatial reasoning has strong associations with mathematics and is also the best predictor of an individual choosing a STEM-related profession beyond schooling, a focus on these skills in the early years is critical.

Recent research has also identified that spatial thinking can be improved in primary school-aged children through exposure to explicit spatial reasoning activities and intentional teaching (Lowrie, Logan & Ramful, 2017). Providing such spatial activities to young children in play-based environments will develop children’s spatial reasoning.

Pedagogical CONTENT knowledge in ENACTING A geometry lesson
Mohan Chinnappan

In their effort to refine Shulman’s (1987) Subject-Matter Knowledge and Pedagogical Content Knowledge, Ball and her associates (Ball, Thames, & Phelps, 2008) developed the framework of Mathematics Knowledge for Teaching (MKT). MKT provides a powerful map for visualizing and understanding the multidimensional nature of knowledge that drives the work of mathematics teachers. In so doing, to date, the model has spawned numerous lines of inquiry that aimed at a) extending current understandings about the different strands of MKT and b) analyzing the character of knowledge strands within a variety of mathematics topic areas. Pedagogical Content Knowledge (PCK) strand was hypothesized as involving Knowledge of Content and Teaching and Knowledge of Students and Teaching. The reconceptualization of PCK presented challenges in constructing tasks in order to measure the underlying sub-components. However, most of this effort has been invested in the context of primary mathematics. Ball (personal communication) has suggested that there is a need to analyze the viability of PCK for teaching secondary mathematics. More critically, Ball has identified three problems with measurement of these knowledge strands. One of these measurement-related problems is that ‘our measures of mathematical knowledge for teaching are designed to situate knowledge in the context of its use, but how such knowledge is actually used and what features of pedagogical thinking shape its use remain tacit and unexamined’ (Ball, et al., 2008: 403). In this
presentation, I will be reporting our previous (Chinnappan & Lawson, 2005) and on-going work in addressing the above issue by analyzing one teacher’s actions and knowledge use during the course of enacting a geometry lesson.

**Spatial reasoning: Some beginnings of complexity approaches**  
Geoff Woolcott

Spatial reasoning, or spatial thinking, develops from interactions with the world that present in a complex way to each individual. These interactions are categorised, analysed and reassembled in a complex way as memories that guide further interactions with the world. This presentation illustrates some beginning approaches to studies of such complex interactions; four that have used network analysis (social network analysis) to examine experimental and archival data, and one that is in an early theoretical stage of development.

1. Examining complex connectivity in multiple choice assessment in Years 3 to 6, including development of spatial concepts longitudinally, using network analysis

2. Examining complex relationships between the levels of structural development and structural groupings coded from student responses in the Awareness of Mathematical Pattern and Structure (AMPS) in Years K-2

3. Research on connections across spatial reasoning research: education as a knowledge dissemination hub

4. Examining social ecology networks in undergraduate education: success networks; consensus interrelationships mapping; and complex identity mapping

5. Curriculum and spatial reasoning: connections within a complex constellation of learning

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**Psychometrics and Testing**  
Studio

Session Chair: Danielle Harris  
*Note this session begins at 2pm

**Development of a novel test to measure spatial abilities of architecture students: Preliminary findings.**  
Michal Berkowitz, Beatrix Emo, Andri Gerber, Christoph Hölscher, Stefan Kurath, Elsbeth Stern

Architects are commonly held to have high spatial abilities. We suppose that the long course of study refines the spatial abilities of the students. While spatial abilities in other domains have been studied quite frequently (e.g, engineering, chemistry), the special nature of spatial thinking among architects has not been given as much empirical focus. Moreover, whilst many standard tests of spatial abilities exist, no spatial test is specifically aimed at measuring spatial abilities among architects, without having to rely on prior knowledge in architecture.
We report the preliminary findings of a novel test designed to measure spatial abilities of architecture students. In the first phase of the project, we administered a series of established spatial ability tests (e.g., mental rotations test, paper folding test) to architecture students from several levels of expertise in order establish a ‘baseline’ of general spatial abilities.

In the next phase we have developed a novel test, which is composed of three sub-scales: A perspective taking task ('Street view test'), a 3D assembly task ('packing'), and an indoor perspective task. The test is based on architectural design tasks relied to spatial abilities. In the street view test, participants choose which ground view corresponds to an axonometric or a plan view of a virtual urban scene. In the packing test, participants combine elements to form a whole, or decompose a whole into its elements. In the indoor perspective test participants choose which view corresponds to a given viewpoint from inside an object.

We report the initial findings from testing sessions of architecture students using the novel test. 350 students from three universities in Switzerland were given the new test along with two standard spatial tests and a general reasoning task. The idea behind the new test, its validity and relevance for architecture will be discussed.

**Psychometric properties of the paper folding test**
Ajay Ramful, Tom Lowrie, Tracy Logan

Although dated to the 1970s, the Paper Folding Test (PFT, Ekstrom, French, & Harman, 1976) is still a commonly used instrument for measuring spatial visualization ability. While the test manual recommends its use for Grades 9 to 16, it is observed that PFT is also being used with primary school students. This paper assesses the psychometric properties of the two parallel forms (Part 1 and Part 2) of the test in a sample of 785 Grade 6 students. The reliability for both parts of the test was below conventionally accepted benchmarks. In terms of construct validity, factor analysis yielded a two-factor solution for Part 1 (accounting for 42% variance) and a three-factor solution for Part 2 (accounting for 41% variance). Rasch analysis indicated that the first two items from each part of PFT were not sufficiently challenging for the Grade 6 students while 25% of the items were beyond their reach. Based on our analysis, we make the following suggestions to calibrate the instrument for Grade 6 students: Firstly, we suggest the removal of some of the ‘problematic’ items. Secondly, we recommend the combination of the two parts of the test to increase its reliability. Additionally, we make a number of practical suggestions with regard to the implementation of the test for Grade 6 students. We also comment on the negative scoring procedure that underpins the test.

**Poster Session and SERC Showcase**
Lucky’s Speak Easy

Lucky’s is located on the ground floor of QT Canberra. It can be found at the rear of the building, past the wall of political icons, through the Barber Shop.

The numbers on each abstract will match the numbers on each of the displays.
1 - Distinct effects of two different mental-rotation tests on the results in a subsequent paper-folding test of males and females
Martina Rahe, Vera Ruthsatz, Claudia Quaiser-Pohl

In psychometric mental-rotation tests (MRT), males usually outperform females. Additionally, they display higher ratings regarding their performance in the test and their confidence in their abilities, which could be caused by stereotype threat effects. Furthermore, the cube figures of the MRT could be more familiar to males or more threatening to females and might therefore at least partly explain the male advantage in test performance. In this study, we administered an MRT (either with cube figures or similarly structured pellet figures) and a subsequent paper folding test to 79 participants (33 males, 46 females, age: M = 21.52, SD = 4.37). For the MRT, gender differences in favor of males appeared only for the cube figures but not for the pellet figures. For the paper folding test, a significant interaction of gender and the previously solved type of MRT appeared. After solving the MRT with cube figures, males completed the paper folding test significantly better than females, while there was a reversed but not significant effect after first solving the MRT with pellet figures. Females rated both versions of the MRT as more difficult than males; this effect was higher after solving the MRT with cube figures than with pellet figures. Apparently, males benefit more from the cube figures in the MRT and seem to gain more confidence in this test. This could lead to the better performance in the following paper-folding test.

2 - Identifying the solution strategy in a gender-stereotyped chronometric mental-rotation test - An exploratory eye-tracking approach
Mirko Saunders, Martina Rahe, Vera Ruthsatz, Claudia Quaiser-Pohl,

In psychometric mental-rotation tests with cube figures, males usually outperform females, however chronometric tasks tend to produce smaller gender differences.

Recent studies with gender-stereotyped objects point out that performance factors such as dimensionality (rotation in-depth or in picture-plane), stimulus familiarity, and the stereotyped nature of the items themselves seem to mediate the gender effect (Ruthsatz et al., 2017). Different strategies in mental-rotation tests are another explanation for the gender differences. However, the strategy used when solving a mental-rotation task (e.g. holistic vs. analytic) also seems to depend on the complexity of the items.

Besides using strategy questionnaires eye-tracking methods are useful for identifying the solution strategy. The eye-tracking method also enables to identify disparities in complexity of the stimuli within one mental-rotation test. In an earlier study (Rahe et al., 2016) we examined the influence of different strategies on mental-rotation performance in a computer based mental-rotation test. Overall, participants with shorter fixation-times reacted and rotated faster.

Using an eye-tracking approach this study tried to answer the question whether familiar, gender-stereotyped stimuli influence strategy use and task performance in mental rotation.

The sample consisted of 15 women and 15 men (age: M=27.12; SD=3.44) who solved a chronometric mental-rotation test consisting of male- (e.g. model airplane) and female-stereotyped objects (e.g.
doll), either rotated in picture-plane or in depth. Eye-movements were recorded with a TOBI eye-tracker; scan paths were registered and heat maps were produced for every item. Mental-rotation performance, the self-estimated solution strategy and handling familiarity were also assessed.

Results show that the different objects used in the stimuli produce different individual eye-tracking patterns, but when summed up preferred solution strategies can be identified. The strategy used depends on the complexity of the objects, the rotational angle and the solution accuracy, as well as, on performance factors like the handling familiarity.

3 - Solving a psychometric mental-rotation test with or without experience: better performance of males in the second part of the MRT
Linda Schürmann, Martina Rahe, Claudia Quaiser-Pohl

Psychometric mental-rotation tests (MRT) produce stable gender differences in favor of men. Research supports the idea that training can improve mental-rotation ability; however, results are mixed with regard to its distinct effects on women and men (e.g. Uttal et al., 2013). We compared the results of n = 131 males and n = 213 women (M=22.3, SD=3.1) in the first and second part of a psychometric MRT with respect to whether they already had experience with participating in MRTs. We hypothesized that men would outperform women and that participants who had already participated in MRTs would outperform participants who had not. Additionally, we explored whether there were gendered effects of prior experience on mental-rotation ability in the first and second part of the test, as males and females differ in in mental-rotation speed and accuracy.

Men and participants with MRT experience outperformed women and subjects with no experience, respectively. The proportion of correctly solved items to items that had been attempted to solve was higher in men in the first and the second part of the MRT, but not in subjects with MRT experience. Under the condition that they had already participated in an MRT, men and women did not differ in their mental-rotation ability in the first part. However, in the second part, women performed significantly worse and also tried to solve less items than men. This might for example be due to the different solving strategies resulting in a slower operation speed in women (e.g. Janssen & Geiser, 2010; Hirnstein et al., 2009). Experience with MRTs seems to have different effects on male and female participants: Only males appear to benefit from the training in solving the items more quickly and therefore manage to solve the second part of the MRT more successfully.

4 - Visuo-spatial lateralisation is related to perceptual reasoning when the pressure’s on
Penny Kirk, Greg Savage, Nic Badcock

The neural specialisations for language and visuospatial information processing are typically localised in the left and right hemispheres of the brain respectively. This has implication for surgical procedures, for example, resection in intractable unilateral epilepsy; however, the benefits or costs to these specialisations have been difficult to demonstrate empirically. In this project, we explored the behavioural relevance of the cerebral lateralisation for visuospatial function attempting to overcome previous methodological limitations. Twenty-four undergraduate students completed a speeded landmark task (sometimes referred to as line-bisection) while cerebral lateralisation was assessed using functional transcranial Doppler ultrasound (fTCD). A key distinction from previous research was
the manipulation of task difficulty by altering the position of a short vertical line bisecting a longer horizontal line. This was set on an individual basis using an adaptive staircase procedure to return spatial distance thresholds associated with 50 and 85% accuracy, providing hard and easy conditions respectively. Lateralisation indices estimated using the hard but not easy landmark task were significantly related to the Perceptual Reasoning Index (Wechsler Adult Intelligence Scale-Fourth Edition). As a control, unrelated to visuospatial capacities, reading efficiency (Test of Word Reading Efficiency-Second Edition) was not reliably predicted by the lateralisation indices, indicating a visuospatial specificity of the observed relationship. This methodology is the first to demonstrate the behavioural relevance of visuospatial lateralisation using fTCD, providing a key step towards mapping the developmental trajectory of this neural specialisation and elucidating its relation to language lateralisation.

5 - New ways of teaching: The development of spatial reasoning activities for Indonesian mathematics curriculum
Sitti Maesuri Patahuddin, Robyn Lowrie

Spatial reasoning is a type of spatial cognition needed for daily activities. It is associated with one’s ability to manipulate objects in space and to process information in visual forms, including pictorial properties such as shape, size, and colour. Spatial reasoning is correlated with mathematics performance with recent studies showing that heightened spatial reasoning improves mathematics performance.

In a society, which challenges schools to be abreast of 21st century skills, it is increasingly important for classroom teachers to possess a high level of spatial reasoning in order to engage students in spatial thinking.

The digital poster presentation describes the attempts with engaging Indonesian mathematics teachers (Grade 7-9) in spatial reasoning experiences and to design geometry lessons aimed to improve mathematical understanding while simultaneously developing students’ spatial reasoning. The poster provides examples of the spatial reasoning activities undertaken by the Indonesian teachers during the professional development sessions at University of Canberra. The activities include topics associated with way finding, perspective taking, mapping and integrated activities that promote explicit spatial thinking.

This digital poster also illustrates examples of geometry lessons aimed to develop students’ spatial reasoning and highlight teachers’ responses about the opportunities and challenges of developing spatial reasoning skills within current school mathematics curriculum in Indonesia.

6 – Gender differences in mental rotation performance in STEM and Non-STEM students and the role of childhood preference for spatial toys and sports
Petra Jansen, Angelica Moè, Stefanie Pietsch

Mental rotation is the process to imagine three- or two-dimensional rotated objects in mind. Gender differences favouring male in mental rotation task have been well established (Voyer, Voyer, & Bryden, 1995) and have been linked to the under-representation of females in some STEM subjects.
Furthermore, environmental factors like the spatial play (Newcombe, Bandura, & Taylor, 1983) and sports activity (Pietsch & Jansen, 2012) have been shown to influence specific spatial performances.

This study aimed at investigating the impact of childhood preference for spatial toys and sports in mental rotation performance in STEM students (40 men and 40 women) and non-STEM students (40 men and 40 women). Participants were required to solve a Mental Rotation Test (MRT: Peters et al., 1995) and to self-report the sports and toys preferred as a child. The results confirmed that males outperformed females, $F(1, 76) = 23.48, p < .001; \eta^2 = .23$ and STEM-students outperformed Non-STEM students, $F(1, 76) = 4.73, p < .05; \eta^2 = .06$ in mental rotation performance. There was no interaction between both factors. Women reported to have preferred less spatial toys, $F(1, 76) = 36.23, p < .001; \eta^2 = .32$ and sports, $F(1, 76) = 6.49, p < .05$ then men; $\eta^2 = .08$, whereas this effect was qualified by an interaction between field of study and gender, $F(1, 76) = 4.23, p < .05; \eta^2 = .05$. The multiple regression results show that 28.3% of the variance ($R^2 = .328$) is explained by the predictors gender and degree, $F(7, 74) = 7.233, p < .001)$. Speed of processing, preference for spatial toys and sports did not predict mental rotation performance.

The results will be discussed concerning the importance of environmental factors and the choice of the field of study on gender differences in mental rotation.

7- Spatial training in the 21st Century Mathematics Classroom: The Role of Teachers
Alexandre Forndran, Tom Lowrie, Danielle Harris, Tracy Logan

The link between spatial ability and mathematics performance, particularly in early years of development, has been well documented. It has also been found that spatial ability can be trained, and that such training can have positive effects on mathematics performance. Despite this, there has been some resistance to introducing spatial training into classrooms to supplement or replace current mathematics content. As part of ongoing ARC projects examining the link between spatial ability and mathematics performance in primary and high school children, we sought to investigate means through which effective implementation of spatial training programs could be ensured. To this end, teachers were recruited to participate in professional development sessions designed to: (1) explain the theoretical underpinnings of the spatial program; (2) make connections between spatial reasoning and mathematics curriculum; and (3) develop spatial classroom activities to be utilised in the training program. We hypothesized that involvement of mathematics teachers at the development stage would aid comprehension, increase confidence in, and uptake of activities, increasing the likelihood of classroom engagement during implementation of the training program. Qualitative findings and implications for the involvement of educators in the development and implementation of spatial training activities are discussed.

8 - Spatial Reasoning and Early Learning STEM Australia (ELSA): A springboard for success in school and beyond.
Kym Simoncini, Kevin Larkin

In 2018, 100 preschools across Australia are participating in the Early Learning STEM Australia (ELSA) Pilot. The ELSA Pilot is a play-based digital learning program for preschool children to explore a range
of practices that science, technology, engineering and mathematics (STEM) share.

Underpinning the ELSA project are STEM practices: a set of ideas, methods and values that we recognise as fundamental to STEM. STEM Ideas include: Finding and validating evidence and Questioning. STEM Methods include: Generating ideas, Processing information and Thinking critically. STEM Values include: Curiosity, Teamwork and Imagination. STEM practices are also closely aligned to the Early Years Learning Framework.

The pilot comprises four children’s apps, an Educator app and a Families app. The apps go beyond the screen to encourage active play and are designed to act as a springboard for children to explore their natural world. The pilot is based upon an Experience, Represent, Apply (ERA) framework whereby children first experience ideas through play-based activities and intentional teaching. They then represent their ideas using the apps. Later they apply their learning to further play-based, off-app activities.

The first two children’s apps are centred on spatial reasoning. The focus of the first app is Patterns and Relationships. Children are required to sort items according to attributes, sequence temporal pictures, create, extend and find missing patterns. Children can generate their own content to sequence and create patterns with.

The second app focuses on Location and Arrangement. In this app, children are asked to follow directions: placing objects using positional language, finding locations in their preschool settings, listening to directions, mapping and viewing their preschool playground, and wayfinding in a zoo environment.

Given the strong link between spatial reasoning and STEM-related disciplines, these play-based apps provide young learners with a springboard for later success in school and beyond.

9 - Getting creative: The role of extracurricular activities in spatial training effectiveness.
Danielle Harris, Alexandre Forndran, Tom Lowrie, Tracy Logan, Mary Hegarty

Spatial reasoning has received a great deal of attention as a strong predictor of STEM performance and its receptiveness to training. Recently, studies have shown a transfer between spatial training and STEM performance (Cheng & Mix, 2014; Lowrie, Logan & Hegarty, under review; Lowrie, Logan & Ramful, 2017). Psychological experiments such as these offer opportunities for participants to enhance their spatial and STEM skills through targeted instruction. However, little research to date has paid attention to the impact of males’ and females’ extracurricular activities on this improvement.

Recent work by Lowrie, Logan and Hegarty demonstrated the benefit of a three week spatial visualisation intervention program on spatial and mathematics performance. Additional to, and in conjunction with the program was a survey of students’ extracurricular activities, with students in grade 5 across both intervention and control groups encouraged to participate. Using factor analysis, the survey data revealed four categories of activity: 1) Navigation, 2) Construction, 3) Sport and 4) Creative. Gender differences in reported participation were found for the Creative factor in favour of females and the Sport and Construction factors in favour of males. Scores on the Creative factor significantly predicted the differences between pre- and post-test scores on the spatial assessment for
females in the intervention group but not for males. The results suggest that the impact of extracurricular activities on control group scores were not influential in such a short period of time; however we know from research that participation in certain activities has been linked to higher spatial scores. Future research may investigate the role of extracurricular activities over an extended period of time.
Wednesday January 31

9:00am – 10:30am

Keynote Address
Ballroom

Object and spatial visualization abilities and their relation to different professional specializations
Maria Kozhevnikov

10:30am – 11:00am

Morning Break

11:00am – 12:45pm

Lightning Talks
Ballroom

Session Chair: Kevin Larkin

Classroom-based spatial intervention program: Understanding the keys to success.
Tracy Logan

Over the past 3 years, the team at SERC have successfully implemented two classroom-based spatial reasoning intervention programs in the primary grades. These studies have been part of Australian Research Council Discovery projects with some additional support from industry partners (i.e., Samsung Australia). There were two common features attributed to the success of these programs, namely: (1) embedding cognitive spatial thinking into curriculum lessons, rather than as a standalone activity; and (2) the teachers were immersed in the design of the program. Additionally, we were able to make modifications to the program to maintain strong results with greatly reduced intervention length. The second program included a stronger focus on a pedagogical framework to underpin the program, a more explicit, student-centred approach to visualisation, and the inclusion of digital resources.

Spatial Reasoning at the Zoo
Kay Owens

Mathematics trails have been common for many years and this one focussed on three-dimensional (3D) shapes at a zoo. Out-of-classroom mathematical activities generally inspire students to engage in mathematics. This presentation provides a qualitative analysis of Year 4 students’ visuospatial
reasoning during these learning experiences. The main way of understanding how students were thinking was from observation and interactions at the zoo as they were completing their mathematics trail workbooks together with their workbook entries. These interactions were captured on videotape. At each station, students were encouraged to make different kinds of representations of the buildings and structures in the zoo, and were asked to reason about different spatial arrangements and objects. Students’ reasoning involved one-, two- and three-dimensions. Despite the active 3D geometry experiences, a class routine of individual work directed by the teacher going through a worksheet seemed to impact on students’ verbal language, collaboration, and attempts to problem solve in the 3D geometry experiences. Following the 3D geometry learning experiences, individual videotaped interviews about paper-and-pencil items on 3D geometry assessed how students were visuospatially reasoning. This presentation also provides analysis of students’ insights, language, what they noticed, ways of mentally manipulating images, and the types of strategies or tactics used to respond to the items. Visuospatial reasoning was evident in their predicting possible results of manipulations of a net to produce a 3D shape, perceiving parts of wholes, and focussing on certain features.

A real-world spatial problem in the secondary classroom: Whales and tails
Geoff Woolcott

This presentation outlines the presentation of a real-world spatial problem within a lesson designed around scientific research. Teachers of two separate high school classes of Year 7 students (n = 37) each delivered two lessons from the same lesson plans, one lesson related to identification of individual whales and the other related to the rates of travel of identified whales from the feedings grounds in the Antarctic to their breeding grounds in tropical waters of eastern Australia. These lessons were designed to integrate real-world problem solving into the broader secondary science and mathematics curriculum using spatial skills considered foundational to STEM education. Classroom observations indicated that while four theoretical categories of spatial skills could be identified as static/dynamic and intrinsic/extrinsic, the categories appeared tied to context. Teaching approaches in both lessons indicated the potential benefit of the development of new spatial skill typologies that can be contextualized across socio-cultural and scientific explorations.

Pattern – the Password to Maths
Bruce Ferrington

Throughout the year, my Year 2 students have been working with patterns for the first 20 minutes of each day. What have they done? What did it look like? How has this impacted on their mathematical understanding? And is it really maths or are they just making pretty pictures?

Inspired by Marilyn Burns and Jo Mulligan, I decided to use spatial tasks, with a specific emphasis on patterning, as the basis of all our maths investigation for the whole year. It was fun, it was exciting but most significantly, it produced results that I was not expecting. My students started thinking mathematically, making observations and connections in deeply authentic ways, and demonstrated real passion and love for maths.

Isn’t this what it is all about?
Developing Indonesian Grade 8 Students’ Spatial Ability to Support Geometry and Measurement Learning
Destina Wahyu Winarti

Spatial ability is a strong predictor of success in Science, Technology, Engineering and Mathematics (STEM), and especially critical for students’ wellbeing into the future. Although the impact of spatial reasoning is a burgeoning field of research, almost all studies focus on western societies and high-income contexts. This study will expand the area of enquiry into non-western and middle-low income countries (i.e., Indonesia). This study has two central aims, namely to investigate (1) the relationship between students’ spatial ability and their mathematics performance; and (2) the effect of a spatial reasoning intervention program on developing students’ spatial ability and mathematics performance. The intervention design will be implemented across 12 classrooms (N = 720 students) in a highly disadvantaged region of Indonesia. The results of this study are likely to have impact on school and research communities, national educational agencies and government.

Equity and spatial reasoning: Exploring the diverse spatial knowledges of disadvantaged student groups
Natalie Downes

This talk will discuss a research project that explores the spatial reasoning skills of students typically seen as disadvantaged in mathematics. In particular, we focus on understanding the diversity of their spatial skills, how a tailored spatial training program can be designed and implemented based on their spatial knowledges, and if this impacts on their mathematics skills.

To gain an understanding of the students’ spatial knowledges, ethnographic case studies across diverse communities (rural, Indigenous, low SES, high SES & culturally diverse) are being conducted. In these case studies students’ in and out of school spatial reasoning knowledges are being explored through video diaries about their day to day activities, and participation in spatial reasoning lessons.

Through initial school visits & lessons with students it was evident that Indigenous & rural students have a diverse range of spatial orientation skills, with the use of cultural & locational landmarks being particularly important when mapping their environment. From these case studies a tailored spatial training program will be developed and implemented in each school. The impact on the students’ spatial reasoning skills and mathematics scores will be tested, with students participating in both pre & post testing. Longer term post testing will also be conducted to understand the long-term impact of this training program. Given spatial skills can be trained, and spatial skills are linked to increased mathematics performance, this program has the potential to address the disproportionate outcomes experienced by those considered disadvantaged in mathematics.

Training teachers in visuospatial reasoning: An investigation of any changes in teacher understanding of teaching and learning mathematics.
Paul Kruger

Aim: This project aims to describe the nature of any resultant changes in teacher understanding of teaching and learning of mathematics (and numeracy? within other STEM areas?) as a result of professional development in visuospatial reasoning, and what are the mechanisms of these changes.
Topic: Secondary Numeracy, Secondary Mathematics

Purpose: The aim of this research is to explore the mechanism of any changes in teacher’s understanding of teaching and learning mathematics (and numeracy).

12:45pm – 1:30pm

Lunch break

1:30pm – 3:00pm

Workshop
Ballroom

Why does spatial thinking matter for STEM Learning?
David Uttal

3:00pm – 3:30pm

Afternoon Tea

3:30pm – 6:30pm

Free Afternoon

6:30pm

Social Evening
Thursday February 1

9:00am – 10:30am

Workshop
Ballroom

The Future of Learning: Spatial Reasoning, Visualization & Mixed Reality Education
Rob Fitzgerald

10:30am – 11:00am

Morning Break

11:00am – 12:30pm

Parallel Sessions
Classroom Research
Ballroom

Session Chair: Alexandre Forndran

Developing an evidenced based Learning Progression for comparing and ordering fractions in the middle primary grades of schooling.
Chelsea Cutting

Mathematics education in Australia has been under intense scrutiny and criticism over the past two decades, due to primary and secondary students’ performance on international high stakes mathematics tests and our own national numeracy assessments. One of the most significant areas of mathematics students need to become proficient in, is proportional reasoning, as this big idea in mathematics is an important determiner of numeracy success at school and beyond (Hilton, Hilton, Dole & Goos, 2016). This big idea is developed by student’s ability to work meaningfully and flexibly with numbers, including proper fractions, mixed fractions, decimal fractions and percentages (Siemon et.al, 2015). A fundamental skill required to understand the basic principles of fractions is to be able to visualize the magnitude of any given fraction, through informal and formal estimation and reasoning skills (Johanning, 2011). This, in turn, allows the learner to be able to compare and order these quantities which are essential skills underpinning proportional reasoning. Whilst there has been several international research projects that have investigated the natural and intuitive development children demonstrate when learning fraction concepts, there is the need for a succinct and unambiguous framework that clearly illustrates key mathematical ideas and the strategies required for conceptual development (Siemon, Bleckley & Neal, 2012).
Although Presmeg (1986) has suggested that visualisation strategies may be beneficial for estimating, ordering and comparing like and unlike fractions, this proposition has not been systematically explored in primary schools. This presentation will explore the theoretical framework underpinning a PhD research project that aims to explore the role of visualisation in this context. In particular, it will consider the contested notion of visualisation and make a case for investigating an evidenced-based visualisation approach to the teaching and learning of fractions at this level of schooling.

**Perceiving and reasoning about geometric objects in the middle years**
Rebecca Seah, Marj Horne

Although spatial thinking and reasoning is recognised as key component for promoting STEM discipline, very little research has been done on its promotion in middle years in Australia. How do students perceive three dimensional geometrical objects? Are they able to recognise the objects from different perspectives and explain their reasoning for their drawing of the object? This study reports students’ responses to two items designed to investigate students’ ability to visualise in three dimensions: (1) to perceive a group of geometric objects from a different perspective, and (2) to visualise a three-dimensional object made from a net and draw it from different perspectives.

Of the 436 Year 4 - 10 students who responded to the first task, only 22% could correctly name all three objects albeit often with incorrect spelling. More than one third of all students gave incorrect spelling for geometric terms. Students invented words such as rectangular hexagon and prement (pyramid) in an attempt to name the objects they saw. For the second task, 41% of the 274 students could correctly identify the net as making a pentagonal pyramid, with a further 14% at least identifying it as a pyramid. Only 25% could correctly spell the geometric terms they used.

When asked to draw the image of objects from a different perspective, 42% could provide a correct diagram in either two-or three dimensions. Fifty percent could draw the pentagonal pyramid from above, and 52% were able to draw a reasonable facsimile from the front.

The data show that many of the middle years students have had little experience working with three dimensional objects and are unable to interpret images from different perspectives. To develop spatial reasoning, there is a need for increased attention in schools to strengthen the connectedness between visualisation, geometric language and discourse, and multiple representations.

**Primary students’ geometric reasoning of three-dimensional solids: Connecting research to classroom practice**
Ann Downton, Sharyn Livy & Simone Reinhold

Much of the research relating to geometric reasoning has focused on classification of geometric objects and the application of the van Hiele levels of geometric thinking (Bleeker, Stols & Putten, 2013; Clements & Battista, 1996). Moreover, most of this research was interested in geometrical concept knowledge on two-dimensional shapes, neglecting investigations into children’s knowledge of three-dimensional objects. Previous studies have also highlighted the important role of spatial visualisation, including the “ability to comprehend [and apply] imaginary movements in three-dimensional space or manipulate objects in imagination” (Pittalis, Mousoulides, & Christou, 2007, p.
Visualisation, orientation, and relations are considered to be the constructs that encompass spatial ability associated with students’ performance in geometry (Knight & Wright, 2014). The importance of visualization for the development of conceptual knowledge on shapes has been discussed, yet, only few studies have enlightened this field of research, so far in relation to three-dimensional objects.

This presentation will report on six Australian children’s responses to a German one-to-one geometric reasoning interview. The interview was developed and elaborated for students in Grades 3 to 5, and has been used with students in Germany, Malaysia and Australia, since 2015. The results of data analysis of interviews in these three countries reveals many students can state rote learned properties of three-dimensional objects. However, misconceptions and inconsistencies appear when they attempt to construct solid representations of cubes and rectangular prisms; when commenting on their own constructions; and also, when describing the relationship between rectangular prisms and cubes (Woeller & Reinhold, 2016; Downton et al., in prep.). Adding to these studies, the research presentation will also provide insights of some Australian Grade 3 and 4 students’ responses to a challenging geometric reasoning task when using cubes to construct rectangular prisms. These findings may have implications for future curriculum design.

Secondary mathematics pre-service teachers’ spatial problem solving in the 3-D virtual environment of the CAVE2TM
Margaret Marshman, Geoff Woolcott, Shelley Dole

Multiuser virtual reality environments offer the potential for exploring spatial contexts not previously available. This presentation reports on secondary mathematics pre-service teachers’ experiences solving spatial problems in the CAVE2TM. This 320-degree cylindrical 3D virtual environment is especially suited to collaboration, as everyone shares the same experience simultaneously. In this pilot study, a group of pre-service teachers experienced a flyover video of the campus and surrounding region including local coastline and mountain terrain. The pre-service teachers were asked to develop and solve a mathematical question or problem using the CAVE2TM experience. In the ensuing discussion pre-service teachers considered their own ability to think in spatial contexts and how this could be useful in their future classrooms.

Observations and recordings of some of the students’ discussions were analysed thematically as were the questions/problems and solutions that five of the pre-service teachers developed. These indicated that whilst students were imaging two dimensional planes in the 3D environment many struggled to think holistically about their problems in 3D. The implications for future teaching are that pre-service teachers need more 3D specific activities both virtual and using physical resources to encourage and support the development of their 3D visualisation and reasoning skills. This is the subject of ongoing investigation.
Spatial mapping technology and 3D applications in Nursing: Exploring students’ perspectives on learning
Jane Frost, Lori Delaney, Robert Fitzgerald

Background: Simulation is recognised internationally as a safe and effective way to teach health students. However, there exist limitations to this learning experience due to the static nature of mannequins and the complexity of the learning required. The evolution of spatial mapping technology and 3D applications has the potential to change nurse education, and enhance the understanding of both anatomy and physiology, to advance physical assessment skills. The integration of immersive technologies have been explore for their application in medical training, however, there is sparse research exploring how these technologies can be used to advance nurse education.

Objective: The aim of the study was to explore students’ perspectives of learning through spatial mapping and 3D technology and the application of this emerging technology can enhance nurse education.

Methods: A cross-sectional survey of second year nursing students was recruited to explore the educational application of two different technologies: HoloLens (Microsoft) and Primal Pictures (3D Realworld) based on the instructional theory of whole-task training. Participants were required to undertake a nursing assessment and documentation of a projected hologram patients based on a developed case study.

Discussion: Nursing education requires the integration of complex concepts of physiology, adaptive expertise and collaborative practice. Researchers will present the findings of this study and how these technologies can potentially transform health education to provide meaningful education applying the instructional theory of whole-task training, via the domains of active, constructive, intentional, authentic and co-operative transfer of learning.

Children Ages 6-12 Learning Optical Spatial Reasoning during Educational Video Game Play: An ERP study examining the role of cognitive load.
Joseph Schroer

This talk will provide an introduction into the area of Optical Spatial Reasoning, and will examine cognitive correlates through an ERP analysis of children’s video game play. Three main research questions guided this research: Can children increase spatial reasoning abilities through video game play? Are there developmental and gender differences in behavioral performance during spatial reasoning video game play? What are the significant neural correlates of the brain in learning optical spatial reasoning? Twenty-one children aged 6-12 participated in this EEG study by playing a behavioral educational video game based on the premise of Naïve Optics and learning the Law of Reflection. The discussion and conclusions will center on the concept of naive optics. Special attention will be paid to ERP results related to cognitive load, gender, and child development. Implications supporting children’s optical spatial play will also be discussed.
Designing learning environments that support the development of spatial problem-solving skills for mixed-ability primary mathematics classrooms
Bernd Wollring, Andrea Peter-Koop

Presented is a learning environment involving a spatial problem-solving task and a related “meta task” (MT) based on Lego blocks. The task allows for various options to support the solution process with respect to its technical and/or social organisation: In how many ways can two identical six-stud-blocks (2 x 3) be plugged together?

First of all, this task serves to elicit what problem-solving essentially means and how to distinguish PS-tasks from routine tasks. The task setting is fuzzy and needs to be specified, i.e. it has to be determined what kind of constructions are relevant in this context. We discuss on how to proceed from non-systematic trials to systematic approaches and on how to support this shift by an organisational frame involving the concepts of “scope” (“Spielraum”), “document” and “mind map” to express spatial reasoning.

The core of this learning environment is the related meta task: Suppose you have three partners helping you to solve the problem, which sub-tasks would you ask them to do? This task requires the learner to reflect and reason about the problem-solving strategy and to specify the individual team members’ contributions so that everyone can participate according to her/his potential. We discuss solutions to both tasks developed by students as well as pre- and in-service teachers.

Integration of spatial visualization in the Grade 6 mathematics curriculum: A case study
Ajay Ramful, A Bholoa

During the past decade there has been an accrued push for the inclusion of spatial reasoning in the primary school curriculum. The challenge for curriculum developers is to integrate spatial elements in the mathematics curriculum within the tight curricular space available. In this paper, we illustrate the strategies that we used to elevate the spatial dimension in the Grade 6 mathematics curriculum in the Geometry and Measurement strands through the textbook in a curriculum renewal exercise.

Foremost, in contrast to the conventional approach of beginning the textbook with the strand ‘Numbers’, we prioritized 2D and 3D shapes as the entry point in the curriculum. We embraced Dienes’ principle of perceptual and mathematical variability to widen the spatial dimension of geometrical concepts beyond stereotypic images. At the practical level, the textbook includes templates to prompt students to perform visualization maneuvers such as folding nets to construct 3D
models. Using ‘Stop and Think’ prompts, we create the conditions for students to engage in spatially-rich topics such as symmetry, perimeter, area and surface area. We have exploited the graphic design possibilities to provide 3D displays that can potentially help students visualize the arrangement of cubes to make sense of volume. We have included spatial tasks beyond the classical problems that are usually found in conventional textbooks. However, there is still more improvement to be made with regard to spatial orientation and mental rotation, two important dimensions of spatial ability. Despite integrating a range of spatial materials in the textbook, the challenge remains to convince teachers about the importance of spatial ability, especially in exam-oriented education systems where geometry rather than spatial reasoning is more visible.

**Connecting mathematics learning through spatial reasoning**
Joanne Mulligan, Geoffrey Woolcott, Michael Mitchelmore, Brent Davis

This project aims to develop an innovative knowledge framework based on spatial reasoning that identifies new pathways for mathematics learning, pedagogy and curriculum. Novel analytical tools will map the unknown complex systems linking spatial and mathematical concepts. A Spatial Reasoning Mathematics Program (SRMP) is being designed, implemented and evaluated in a longitudinal intervention study of primary students, from Grades 3 to 5 from 2017 through 2109. The classroom teacher is integral to the development and implementation of the SRMP, supported by the project team and professional learning. Students are assessed on spatial reasoning, general and mathematics ability as well as tracking of individual profiles of learning. Preliminary findings of the first phase of the project will be reported. Benefits will be seen through development of critical spatial skills for students, increased teacher capability, and informed policy and curriculum across STEM education.

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<td>2:45pm – 3:00pm</td>
<td>Afternoon Break</td>
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<td><strong>Keynote</strong></td>
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<td>4:30pm – 4:45pm</td>
<td><strong>Conference Closing</strong></td>
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**Individual Differences in Spatial Thinking: Implications for Education**
Mary Hegarty