

**AMSI VACATION RESEARCH
SCHOLARSHIPS 2016/17
& AMSIConnect 2017**

AMSI Member Universities

December 2016 to February 2017

AMSI Vacation Research Scholarships 2016/17 would like to thank the following sponsors for their support:



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AMSI Vacation Research Scholarships 2016/17

AMSI Member Universities
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INTRODUCTION

AMSI Vacation Scholars experience life as a researcher, completing a six-week research project in the mathematical sciences of their choice, and present their findings to their peers at AMSI's two-day student conference, AMSIConnect. Aiming to inspire students to continue with further research in the future, the AMSI Vacation Research Scholarship research project has led some students to their first academic publication.

This annual scholarship program is open to intending honours and masters students studying at an AMSI Member University, and is viewed as an exciting opportunity to advance mathematical skills, develop an interest in research and expand the academic experience.

Applicants are required to outline a core research component to their proposed project and identify clear outcomes, as well as meet high academic standards and be supported by their AMSI Member University. These scholarships are awarded on a competitive basis for projects in the mathematical sciences.

In 2016/17, after receiving 69 applications, the program funded 43 Scholars to spend their summer holidays working on academic research in the mathematical sciences with a supervisor at their home university. Each Scholar was required to prepare an academic research report, and a blog post accessible to a non-specialist audience for submission, and to present their research and findings at AMSIConnect.



AMSIConnect, the two-day residential student conference was hosted by AMSI on 8–9 February 2017 at The University of Melbourne's International House. Scholars are funded to travel to and stay in Melbourne to participate in this event, which was viewed as an invaluable professional-development experience in communication and networking skills.

The AMSI Vacation Research Scholarships 2016/17 program was jointly funded by the Australian Mathematical Sciences Institute and the Australian Government's Department of Education & Training.

“AMSI Vacation Research Scholarships represent a unique chance for young scholars from AMSI Member Universities to experience life as researchers. The 2016/17 program proved highly fruitful, with participants presenting a number of promising research projects at AMSIConnect in February. As Director of AMSI, I wish to thank AMSI Member Universities, Research Scholar supervisors, AMSI staff and especially Program Manager Paul Ulrick for coordinating such a successful program.

The 2016/17 AMSI Vacation Research Scholarships were made possible through the generous support of the Department of Education & Training and the BHP Billiton Foundation. On behalf of AMSI, I thank all those involved in the 2016/17 VRS and invite potential partners to join us in supporting future events.”

Professor Geoff Prince

Director

Australian Mathematical Sciences Institute

“VRS Scholars experienced life as a researcher — completing actual research projects under the supervision of academics at their home university — giving them a taste of what it’s like. The program inspires students to continue with further research in the future and, for some, the Vacation Research Scholarship project leads to their first academic publication.”

Paul Ulrick

***Program Manager, Research & Higher Education
Australian Mathematical Sciences Institute***

RESEARCH PROJECTS

43 Scholars from 16 AMSI Member Universities were awarded an AMSI Vacation Research Scholarship in 2016/17 and completed research with a supervisor for their chosen project. Each student prepared a research report and a blog post for submission, before presenting their research and findings at AMSIConnect in February 2017.

Research reports and blog posts can be viewed on the AMSI Vacation Research Scholarship website at <http://vrs.amsi.org.au/>.

AMSI would like to express its appreciation to all Vacation Research Scholarship supervisors who gave their time and expertise to the Scholars and their projects. Their contribution is integral to the success of the program.

UNIVERSITY	STUDENT	SUPERVISOR	PROJECT TITLE
Australian National University	James Bailie	Vigleik Angelteit	Stable homotopy theory and category of spectra
Federation University	Leonard Whitehead	Alexander Kruger	Visualisation of subdifferentials
La Trobe University	Luke Agosta	Yuri Nikolayevsky & Grant Cairns	Unital associative algebras over the field \mathbb{F}_q and how they relate to the groups $SU(2)$ and $Spin(3)$
	Jonathan Baldwin	Yuri Nikolayevsky & Grant Cairns	Hopf fibration
	Daniel Vidali Fryer	Andriy Olenko	Functionals of long-range dependent fields and Hermite distributions
	James Koussas	Tomasz Kowalski	Complex algebras of graphs
	Melissa Scott	Agus Salim	Statistical challenges and approaches in analysis of small-RNA sequencing data
Monash University	Randall Chu	Hans De Sterck	Numerical optimisation methods for Big-Data analytics
	Antony Kennett	Kais Hamza & Andrea Collevocchio	The percolation of cellular automata
	Peizheng Ni	Daniel Mathews & Norman Do	Counting curve on surface
	Samuel Schneider	Hans De Sterck & Gregoire Loeper	Deep neural networks: algorithms and applications

Queensland University of Technology	Sean McInerney	Matthew Simpson & Elliot Carr	How to cool a burn using maths
	Phuong Tran	Chris Drovandi	Statistical methods for accelerometer data
RMIT University	Fei Lu	Vera Roshchina	Unfoldings of polytopes
Swinburne University of Technology	Oliver Clemenston	Tonghua Zhang	Time delays in gene expression
The University of Adelaide	Kimberley Becker	Daniel Stevenson	How to assemble simplicial sets
	Lachlan Bridges	Giang Nguyen	The effect of boundary constraints on Markov-modulated diffusion processes
	Adam Hamilton	Matthew Roughan	Privacy-preserving integer linear programming
	Nicholas McLean	Finnur Lárusson	Chaotic dynamics on the Riemann sphere
	Jessica Penfold	Lewis Mitchell	Determining the link between influenza dynamics and climatic factors in Australia
	Bethany Phipps	Patricia Solomon & Tyman Stanford	Longitudinal data analysis for improving patient outcomes
The University of Melbourne	Robert Dusanovic	Thomas Quella	Topological invariants in quantum systems
	Edmund Lau	Barry Hughes	Extending stochastic agent-based model for evolutionary dynamics of phenotype-structured population
	Qiuyi Li	Yan-ban Chan & Nathan Clisby	Endless self-avoiding walks in two dimensions
	Nicholas Liu	John Sader & Daniel Ladiges	Monte Carlo simulation of low-Mach number oscillatory Couette flow and applications
	Alexander Nunn	John Sader & Jesse Collis	Flapping of leaves and inverted flags in a steady flow
	Nicolau Andres Thio	Charl Ras	Minimum weight triangulations
	William Troiani	Daniel Murfet	Programming in three dimensions
The University of Newcastle	Elliot Catt	Pablo Moscato & Luke Mathieson	Edge elimination and vital edges in the travelling-salesman problem
	Joshua Connor	Brian Alspach & Thomas Kalinowski	Cycle spectrum for honeycomb toroidal graphs
	Jacob Crawford	Brian Alspach & Thomas Kalinowski	Hamiltonian laceability in honeycomb toroidal graphs



The University of Queensland	Seamus Albion	Ole Warnaar & Chul-Hee Lee	Characters and q-series
	Adele Jackson	Benjamin Burton	The unknotting problem and fixed-parameter tractability
	Julia Lynch	Toby Meadows	Forcing and set-theoretic geology
The University of Sydney	Timothy Collier	Daniel Hauer	Navier-Stokes equations: a Millennium Prize problem
	Courtney Darville	Nathan Brownlowe	Characterising unitaries in Leavitt algebras
	Terry Shang	Robert Marangell & Holger Dullin	Complex-valued Hill's equations
	Asem Wardak	Stephan Tillmann	Negatively-curved structures in dimensions three and four via discrete geometry
The University of Western Australia	Stephen Lamb	Lyle Noakes	Classical problems in the calculus of variation
University of South Australia	Alycia Winter	Yalçın Kaya	Study of a generalised Newton method for solution of nonlinear equations
University of Wollongong	Wern Shing Ng	Mark Nelson	Harvesting algae
	Kyle Stevens	James McCoy & Ngamta Thamwattana	Spatial modelling of invasive species
Western Sydney University	Olivia Michael	Oliver Obst	Representation learning for mobile robots in dynamic environments

"I enjoyed the opportunity to research and collaborate with a professor, as well as meeting peers with diverse mathematical research interests at AMSIConnect. The VRS program has really strengthened my interest in doing further study in research after my undergraduate degree."

Nicholas McLean
The University of Adelaide

AMSIConnect

AMSIConnect (formerly Big Day In), a two-day residential conference for successful AMSI Vacation Research Scholars, provided the opportunity for students to not only have the experience of presenting their research in a conference setting, but to network, engage in debate and conversation, and explore future career pathways. And outside of academic pursuits, a number of ice-breakers and team-building and social events were held, including dodgeball, dinners and drinks!

Dodgeball Icebreaker

Scholars were welcomed to AMSIConnect in Melbourne at International House by the AMSI Research & Higher Education team, and got the ball rolling with the annual VRS Dodgeball tournament. In an effort to “break the ice”, Scholars were allocated to colour-coordinated teams, and all participated in the friendly round-robin matches, as well as a creative team photo competition, exciting their competitive nature and showing team-working skills.



Networking & Social Events

As well as exploring unfamiliar areas of research, Scholars were encouraged to network, collaborate and socialise with other like-minded individuals during AMSIConnect, with a number of formal and informal opportunities throughout the program, including the Welcome Pizza Dinner, BBQ and break times.

Guest Speakers

Careers in Maths

Professor Geoff Prince (Australian Mathematical Sciences Institute)

AMSI Director Geoff Prince closed this year’s AMSIConnect event with information and advice on where mathematics and statistics can take Scholars in the future. Geoff shared his experience as a teacher and researcher of mathematics at RMIT, the University of New England and La Trobe University, and as Director at the Australian Mathematical Sciences Institute with VRS Scholars, as he outlined the significant opportunities available for a career in maths and stats.

Life as a PhD Student

Kate Saunders (The University of Melbourne)

Kate spoke highly of the successes and challenges she has experienced while completing her PhD, which examines how large-scale climate drivers such as the El Niño Southern Oscillation (ENSO) affect extreme rainfall in Australia. Kate reflected on her journey of discovery both academic and personal, giving some extremely valuable advice:



- choose a PhD for the right reasons
- find the right topic for you
- identify the right academic team
- place yourself in the right environment to work
- pursue the right opportunities (i.e. conferences, travel, funding)



Life as a Researcher

Dr Peter Steinle (Bureau of Meteorology)

Peter Steinle spoke to the AMSIConnect VRS Scholars about his life as an industry researcher at the Bureau of Meteorology, a multidisciplinary career involving pure and applied mathematics, statistics, information technology, social sciences and environmental modelling. Peter also discussed how studying higher-education mathematics and statistics can lead to a rewarding career as a Mathematical Scientist, and covered the ideas and values that influenced his own career choices.

Research Presentations

Over the two days, Scholars delivered high-quality 20-minute presentations, providing an overview of their project and findings, conveying their research in a professional and engaging manner. Presentations were held in parallel sessions and Scholars were encouraged to carefully select and attend other presentations, to learn from others and improve their own skills and knowledge in the mathematical sciences.

Best Presentations

Kimberley Becker (The University of Adelaide) won the Best Presentation award for her research talk, “How to Assemble Simplicial Sets”, in the peer voted competition. Honourable mentions were awarded to **Sean McNerney** (Queensland University of Technology) for his presentation, “How to Cool a Burn using Maths” and **Kyle Stevens** (University of Wollongong) for “Spatial Modelling of Invasive Species”.



PARTICIPATION BREAKDOWN

UNIVERSITY

Australian National University	1
Federation University Australia	1
La Trobe University	5
Monash University	4
Queensland University of Technology	2
RMIT University	1
Swinburne University of Technology	1
The University of Adelaide	6
The University of Melbourne	7
The University of Newcastle	3
The University of Queensland	3
The University of Sydney	4
The University of Western Australia	1
University of South Australia	1
University of Wollongong	2
Western Sydney University	1
TOTAL	43

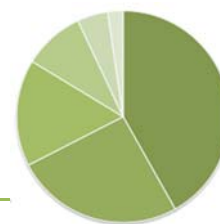


RESIDENCY STATUS

Australian Citizen	37	86%
Permanent Resident	1	2%
Student Visa	5	12%

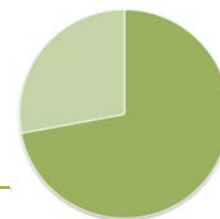
STATE/TERRITORY

ACT	2	5%
NSW	11	26%
QLD	4	9%
SA	7	16%
VIC	18	42%
WA	1	2%



GENDER

Male	31	72%
Female	12	28%



ATSI STATUS

Yes	0	0%
No	43	100%



“The VRS experience was fantastic! The research project gave me a great understanding of what it would be like to pursue research after my undergraduate degree, and the AMSIConnect experience was very positive — presenting my work made the whole experience real, I was slightly nervous but it was truly exciting... I think the whole program was organised incredibly well.”

Phuong Tran

Queensland University of Technology

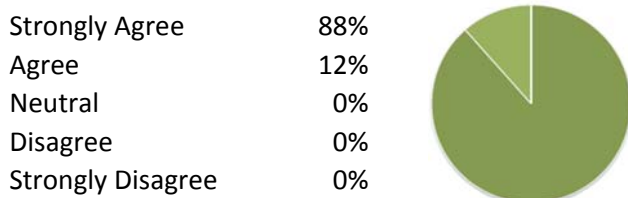
FEEDBACK ANALYSIS

Sixty per cent of VRS Scholars completed the online survey to provide their feedback and comments on the scholarship program and AMSIConnect event.

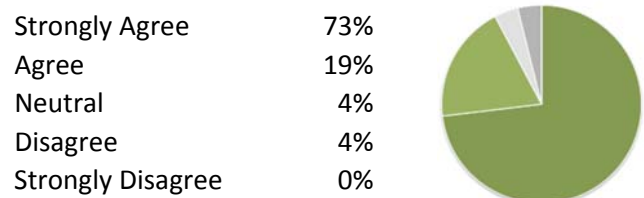
There was unanimous support for the satisfaction with the quality of the scholarship program with 100 per cent of responses agreeing or strongly agreeing that VRS experience was positive and rewarding.

In rating their overall VRS program and AMSIConnect event experience on a scale of 1 to 10, where 1 is Poor and 10 is Excellent, the respondents' average rating was 9.4.

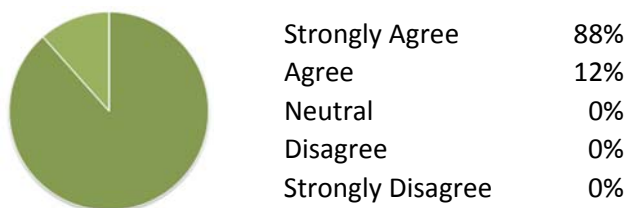
THE EXPERIENCE OF UNDERTAKING A RESEARCH PROJECT WAS POSITIVE AND REWARDING



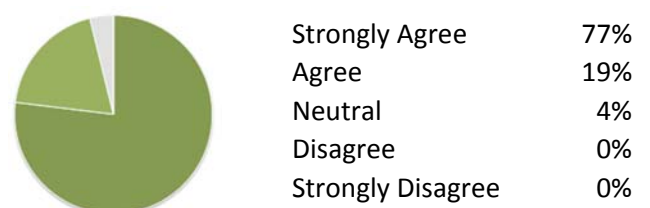
THE EXPERIENCE OF PRESENTING MY RESEARCH AT AMSIConnect WAS POSITIVE AND REWARDING



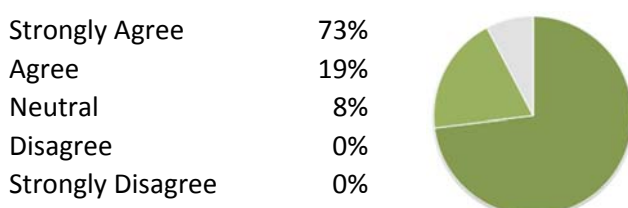
I FOUND THIS RESEARCH PROJECT A GOOD OPPORTUNITY TO EXPLORE MY CHOSEN AREA OF MATHEMATICS



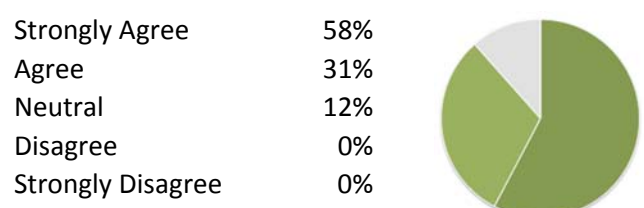
I MADE USEFUL CONTACTS AND NETWORKS AT AMSIConnect



VRS HAS STRENGTHENED MY RESOLVE TO CONTINUE ONTO A MASTERS/HONOURS COURSE



OVERALL, THE AMSIConnect EVENT WAS WELL-ORGANISED BY AMSI



FEATURED PROJECT

SURVIVAL DATA ANALYSIS FOR IMPROVING PATIENT OUTCOMES

Bethany Phipps, The University of Adelaide

1 INTRODUCTION

For a patient to undergo elective joint replacement surgery (JRS), clinicians must decide that coexisting chronic conditions are stable and impose minimal surgical risks. However, the increased risk of patient outcomes after JRS due to comorbidity and multi-morbidity is not always addressed (where multi-morbidity is the presence of additional diseases or disorders co-occurring with a primary disease or disorder). In 2009, 49 per cent of people aged 65 to 74 had five or more long-term chronic health conditions and this prevalence increased with age (Statistics 2009). This means that patients presenting with JRS are likely to have multi morbidities. So the management of patient care for patients with multiple morbidities needs to be improved.

We can also see that The Australian Orthopaedic Association National Joint Replacement Registry fails to provide data on the success of JRS in terms of subjective reports of symptomatic relief and patient satisfaction (AOA National Joint Replacement Registry, Annual Report 2014). From the literature, on average between 25 per cent and 50 per cent of patients report persistent postoperative pain and function limitations at 1 to 2 years after JRS by which time there should be resolution of symptoms (“When Musculoskeletal Conditions and Mental Disorders Occur Together”, AIHW Bulletin no. 80, 2014). Therefore, the intended advantages of JRS, such as reducing individual, social and health care burdens, are not fully realised. This study will develop predictive algorithms to determine the likelihood of poor symptomatic recovery and dissatisfaction with surgery within the first two years following JRS. Not only will this enable patients to make an informed decision before choosing to undergo surgery but it can also optimise pre-operative patient education with a greater holistic approach.

2 AIM

The aim of the study is to develop a statistical model to predict post-operative patient pain and function using individual (pre-operative) patient multi-morbidity data. The ultimate purpose of the statistical analysis is to provide clinicians with a diagnostic tool for assessing the potential benefits of knee- and hip-replacement surgery for patients with multi morbidities (initially looking at the effect that these pre-operative factors such as co-morbidity have on patient survival, as the pain and function data arrived later than the patient survival data).

The full research report can be found at <http://vrs.amsi.org.au/bethany-hipps-2017/>.

BLOG POST

“... FROM ZERO TO HERO IN ABOUT 8 MONTHS”

Daniel Fryer, La Trobe University

I started studying maths at age 25, in January 2013. When I was 24 I wondered what the word “calculus” meant, possibly for the first time in my life. I assumed it had something to do with calculators, but I knew that Isaac Newton had discovered it sometime in the 1600s. Did Newton predict calculators?

I remember learning to add fractions around April 2013. By June I reached a section of a textbook that read, “We commence with the definition of a logarithm”. I was almost embarrassingly excited. I was reading through a textbook series consisting of nine modules that would take me from zero to hero in about eight months (hero meaning roughly the level of knowledge in a standard Year 12 maths course). I knew I was ready for the definition of the logarithm, because my course was on rails and it ran at my own pace. So, whatever the definition was, I knew I was going to be able to understand it. That’s what was so exciting: I had the time, the space and the skills. The logarithm was a complicated mathematical construction that I had heard of but known little about, and I was about to understand it.

I still get this rush now. It is the rush of truly learning something. It is the rush of climbing a mountain, when you have a map and a compass, and all the right gear and training. I crave that rush and even sometimes feel that I live for it.

By 2014, when I started my science degree, I didn’t want to make maths my main course of study. First, I was pretty sure I wasn’t “smart” enough to do well in maths. Second, to me maths was just a tool for studying physical phenomena; it didn’t exist for its own sake. I found out how wrong I was some time during second year. To quote Paul Lockhart in *A Mathematician’s Lament*:

Mathematics is *the music of reason*. To do mathematics is to engage in an act of discovery and conjecture, intuition and inspiration; to be in a state of confusion — not because it makes no sense to you, but because you gave it sense and you still don’t understand what your creation is up to; to have a break-through idea; to be frustrated as an artist; to be awed and overwhelmed by an almost painful beauty; to be alive, damn it.

At this time, I saw a new world. I had been blind to it my whole life. A world in which space could have infinitely many dimensions, where everything could have distance “1” from everything else, and where seemingly simple intuitive assumptions (like the Axiom of Choice) could lead to alarming and disturbing paradoxes. It is no wonder that Lewis Carol was a mathematician.

This year, 2017, I want to reach out to others who are in a similar position to the one I was in when I was 24. People who want to know, but don’t know where to start. I want to leverage the wealth of free educational tools that exist online (places like KhanAcademy.org, edX.org, Udacity.org, Coursera.org, and so on) to give interested people a chance to learn introductory maths and science for free in a tutored and low-stress environment, with assistance from volunteer uni students. The project is called Science Stems. Check it out at ScienceStems.com.

STUDENT PROFILE

FROM RESEARCH TO INDUSTRY: CONNECTING THE DOTS — A VRS LIGHT-BULB MOMENT

Asem Wardak, The University of Sydney



Asem Wardak's recent Vacation Research Scholarship (VRS) placement was something of a light-bulb moment. The program, including presenting at AMSIConnect, was the first time the University of Sydney maths and physics student had encountered industry research.

"Linking industry and maths research allowed me to develop a clearer picture of the multi-discipline opportunities available within mathematics."

Now completing Honours in Physics, Asem spent six weeks from December to February exploring negatively-curved structures in dimensions three and four via discrete geometry. These higher-dimensional versions of making a saddle out of triangles have angle sums greater than 360 degrees around a point, meaning they are negatively curved.

"Negatively-curved structures are extremely important in natural sciences such as general relativity and molecular structure in chemistry," says Asem.

As well as being used in general relativity — a branch of physics focused on understanding the nature of gravity in the universe — these structures are also used in knot theory. Inspired by knots in everyday life, such as those in a rope or a shoelace, this field of research enables prediction of molecule properties.

Having completed a Bachelor degree in Pure Mathematics and Physics, Asem experienced the VRS project as a chance to bring together two subjects of passion.

"This project looked at metric spaces and differential geometry. This type of research greatly interests me and I hope to pursue it in the future," he says.

During 2017, however, Asem will focus on his Honours in Physics and a project at the bridge of neuroscience and artificial intelligence. He hopes to apply some of the skills developed during VRS to these studies.

"I realised how vital communication is to the production of research. With effective communication, existing ideas may be improved in subtle ways which end up making significant contributions," he explains.

For Asem the biggest drawcard for completing the intense six-week VRS program was the opportunity to tackle real-world research challenges alongside field leaders, the program's beauty being the opportunities for students to see their work have impact and to propel themselves forward as researchers.

"My main aim, which I achieved, was to participate in current research in pure mathematics and produce real scientific outcomes," says Asem.

A program highlight, AMSIConnect, acts as a punctuation mark for the experience, giving VRS participants a platform to both present their work and hear from industry and research experts. The two-day conference allows students to connect the dots between research and commercial application and the many opportunities beyond their studies.

“The various events expounding this connection between industry and research were enormously valuable. It allowed me to develop a clearer picture of the opportunities available in a range of disciplines within mathematics,” he says.

With PhD and postgraduate research on the horizon, Asem discovered that at VRS anything is possible.

PROGRAM MANAGER'S REPORT

PAUL ULRICK

Australian Mathematical Sciences Institute



AMSI's Vacation Research Scholarship program has been a highly sought-after scholarship since 2003/04. The program funds undergraduate students from across Australia to complete a six-week research project over their summer break. The scholarships are awarded on a competitive basis for projects in the mathematical sciences.

In 2016/17, 43 students completed the program having been selected from 69 applicants to become AMSI VRS Scholars and complete their research project. Applicants were required to outline a clear research component to their project and to identify outcomes.

VRS Scholars experienced life as a researcher — completing actual research projects under the supervision of academics at their home university — giving them a taste of what it's like. The program inspires students to continue with further research in the future, and for some the Vacation Research Scholarship project leads to their first academic publication.

At the end of summer, VRS Scholars came together in Melbourne to present their findings to their peers and supervisors at AMSIConnect, a two-day student conference formerly known as Big Day In. This provided the VRS Scholars with a valuable professional development experience in communication and networking skills, and a unique opportunity to meet like-minded students in a mathematical conference setting.

A highlight of AMSIConnect 2017 was the opportunity for Scholars and Supervisors (academics) to network. The conference commenced with an informal evening on 7 February, which was highlighted with an ice-breaking dodgeball tournament. Scholars were allocated to random teams and following a series of games, the two best-performing teams played off in a high-standard final. The tournament was well-received with Scholars showing their competitive streak and exhibiting excellent team-working skills.

AMSI's Director Professor Geoff Prince opened the 2017 AMSIConnect with a warm welcome to students and supervisors from all across Australia. Kate Saunders took the students on a fascinating journey as she talked about life as a PhD student at The University of Melbourne. Dr Peter Steinle of the Bureau of Meteorology spoke of the importance of mathematics in weather prediction whilst also covering the ideas and values that influenced his career choices.

Over the two days, Scholars delivered high quality presentations about their research projects, prompting questions and debate amongst the audience. As well as formally finding out about each other's research, they had plenty of time for networking with other like-minded individuals, during dinner and break times.

A highlight of the conference for the Scholars was the presentation made by the AMSI Director Professor Geoff Prince outlining the significant career opportunities available generally for mathematicians and statisticians. AMSIConnect 2017 was hosted by AMSI at The University of Melbourne's International House and was a wonderful experience for all those attending.

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VACATION
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2016/17



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