VACATIONRESEARCH SCHOLARSHIPS 2020-21

EVENT REPORT







Australian Government Department of Education, Skills and Employment

AMSI Vacation Research Scholarships 2020-21 are jointly funded by:





Australian Government Department of Education, Skills and Employment

AMSI Vacation Research Scholarships 2020–21

Experience Life as a Researcher

AMSI Member Universities December 2020 – February 2021

Foreword	4
Program Manager's Report	5
Student Profile	6
Research Projects	7
Featured Project	10
Featured Blog	11
Participant Breakdown	13
AMSIConnect	14
Feedback	18

FOREWORD

AMSI Vacation Research Scholarships (VRS) provide undergraduate students from around Australia with the opportunity to spend six weeks at the frontline of their chosen area of the mathematical sciences, developing essential research and communication skills. As one of AMSI's premier flagship events hosted each year around Australia, VRS forms part of the Securing Australia's Mathematical Workforce: 2016–2021 agreement between AMSI and the Department of Education, Skills and Employment.

"Vacation Research Scholarship students get research experience while developing their analytical, critical-thinking and science communication skills – skills invaluable for research careers."

> Professor Tim Marchant AMSI Director

The Scholars experience life as researchers while they work closely with a supervisor to complete a project over six weeks. They conclude their summer of research by present their findings at AMSIConnect, the exclusive three-day VRS student conference. As an additional exercise they write blog posts relating to the mathematical sciences, giving them experience in scientific writing for broader audiences.

The AMSI Vacation Research Scholarships 2020–21 program was jointly funded by the Australian Mathematical Sciences Institute and the Australian Government's Department of Education, Skills and Employment.

PROGRAM MANAGER'S REPORT



Angela Coughlin

Australian Mathematical Sciences Institute

AMSI Vacation Research Scholarships fund and support undergraduate students from across Australia to spend their summer working on supervised research projects in the mathematical sciences. Students get research experience by partnering with some of the nation's leading academics to identify a clearly-defined research project with outcomes feasible in a six-week period.

Scholarships are awarded on a competitive basis. Fifty

students from twenty-two AMSI Member Universities – our broadest participation to date – completed the 2020–21 program.

Scholars write up their research in the format of an academic paper and submit a blog post written in a non-technical manner. For some students, their Vacation Research Project results in their first published paper. At the end of summer, students complete the experience by coming together to present their results at AMSIConnect, the exclusive three-day national conference for Scholars and their supervisors. For most students, this is their first time attending and presenting in a conference setting and provides an important professional development opportunity to develop their science communication skills and build their national networks.

Due to ongoing COVID-19 travel restrictions, AMSIConnect was held virtually for the first time in 2021. Students presented over Zoom and mingled virtually in Gather.Town, an online networking platform. In addition to the high-quality student research talks, the conference program included several presentations to highlight evolving career and graduate-study opportunities. Alex Browning shared his maths journey since completing his own AMSI VRS project in 2014–15 through to his current PhD studies at QUT, imparting tips and lessons learnt. With experience in academia and industry, Dr Jacinta Holloway-Brown encouraged Scholars to be open to opportunities and embrace a non-linear career path. AMSI Directo Professor Tim Marchant closed the conference with an interactive advice session, providing candid answers to the Scholars' career questions and reinforcing the diverse opportunities open to maths graduates.

To complement the academic program, Scholars had plenty of time to network during the bingo and trivia social events as well as during the breaks. The last day of the conference coincided with the 2021 International Day of Women and Girls in Science. A celebration of the important contributions of women in STEM preceded the announcement of the best presenter winners as voted by the Scholars: Bridget Smart, Meg Tully, and Elizabeth Rose.

Thank you to the 2020–21 VRS academic panel comprising Professors Asha Rao, Mat Simpson, Tim Marchant and Stephan Tillmann.

STUDENT PROFILE



Bridget Smart, The University of Adelaide

Bridget Smart has always loved problem-solving. Fascinated with puzzles as a child, she is now passionate about solving real-world challenges with applied mathematics – a passion that led her to undertake a 2020–21 AMSI Vacation Research Scholarship (VRS).

"When I learnt about AMSI's VRS program, I was excited by the possibility of exploring a new research topic; the role social media plays in shaping our worldly views. I see mathematics as a method for solving critical issues

that affect society and wanted to explore a topic with the potential to drive positive social change," Bridget said.

"My supervisor, Associate Professor Lewis Mitchell, had already done some interesting work on social networks using mathematical models, and VRS was an incredible opportunity to learn from him through a supervised project," Bridget added.

Having just completed her Bachelor of Mathematical Sciences (Advanced), Bridget was the perfect candidate for AMSI's VRS program, which provides intending honours and masters students with the opportunity to spend their summer holidays working on supervised research.

"The opportunity to apply research in an industry setting, beyond the classroom, is such a beneficial experience," said Bridget. "When I apply what I'm learning in class to a real-world challenge, I often find there are so many nuances you'd never normally expect. It's a real confidence boost to work through these challenges in a setting such as VRS and correctly apply complex theories."

AMSI's VRS program also includes an exclusive national conference, 'AMSIConnect', where students present their summer research to peers and supervisors. For the first time, this was hosted virtually due to COVID-19 restrictions.

"The AMSI team did a great job of getting everyone involved, despite the conference being virtual. I was lucky enough to meet some amazing students from other universities, who I'm still in contact with today," Bridget said.

Bridget says the VRS project led well into her postgraduate course, a Master of Philosophy in Applied Mathematics. "The research is similar, but with a slightly different focus. I'm grateful for the VRS experience, which helped me establish my research passion."

Where will Bridget be in 10 years' time? "I'm not sure! The mathematical sciences have provided me with incredible skills, and the tools to drive innovation and positive social change. I'm excited to see where I end up," Bridget said.

RESEARCH PROJECTS

Fifty undergraduate students from twenty-two universities completed a 2020–21 AMSI Vacation Research Scholarship.

Student profiles, research reports and blog posts can be viewed on the AMSI Vacation Research Scholarship website at **vrs.amsi.org.au**.

AMSI acknowledges the generous donation of time, expertise and projects by all VRS supervisors – their contribution is integral to the success of the program.

UNIVERSITY	STUDENT	SUPERVISOR/S	PROJECT TITLE
Australian	Nicholas	Dr Vanessa Robins	Entangled Structures
National	Bermingham		
University			
	Pavel Stoilescu	A/Professor James	Arithmetic Algebraic Geometry of
		Borger	Curves
Curtin	Ponpot	Dr Hoa Bui	Pallet-Packing Vehicle Routing
University	Jartnillaphand		Problem
Deakin	Bob La	Dr Julien Ugon	Piecewise Rational Approximation
University			
Flinders	Susanna Grigson	A/Professor Vladimir	Hierarchical Classification of
University		Ejov, Professor Robert	Protein Sequences
		Edwards & Professor	
		Jim Mitchell	
La Trobe	Kristian	Dr Joel Miller	Control Strategies for a
University	Caracciolo		Superspreading Virus at Very Low
			Prevalence
	Nauvoo Perez	Dr Hien Duy Nguyen	Predicting Relapse in Colorectal
			Cancer Patients Using Feature
			Extraction
Macquarie	Gaurangi Gupta	Dr Georgy Sofronov &	When Does Machine Learning
University		Dr Nan Zou	Work in Time Series Forecasting?
	Ashley (Yannan)	Dr Georgy Sofronov &	Exploring Exotic Probability Theory
	Lin	Dr Chong It Tan	
	Peter (Hoang	Dr Georgy Sofronov &	Efficient Estimation of Risk
	Nhat Huy)	Dr Houying Zhu	Measures Using Monte Carlo
	Nguyen		Methods
Monash	Jiayu Li	A/Professor Andrea	The Percolation on Cellular
University		Collevecchio &	Automata
		A/Professor Kais Hamza	
	Aram Perez	Dr Tim Garoni	Limit Theorems for the Curie-
			Weiss Model
	Jacob	Professor Santiago	Performance of Multiscale Finite
	Vandenberg	Badia & Dr Alberto	Element Methods
		Martin	
Murdoch	Monica Seeber	A/Professor Gerd	Accuracy and Limits of Nodal
University		Schroeder-Turk	Surface Approximations of the
			Lonsdaleit Minimal Surface

Queensland University of	Jack Powers	A/Professor Paul Corry	Optimisation of Surgical Waiting List Management
Technology	Abhishek Varghese	Professor Christopher Drovandi	Adaptive Tolerance Selection for SMC ABC
	Montana Wickens	A/Professor Michael Bode	Optimal Control of Translocation Strategies for Threatened Australian Mammals
RMIT University	Eamonn Kashyap	A/Professor Marc Demange	Online Colouring Overlap Graphs
	Cameron Mclaren	Dr Arathi Arakala	Studying the Human Mobility Patterns in Victoria Pre- and Post- COVID-19
	Angus Walsh	A/Professor Nicolas Menicucci	Entanglement Harvesting in Flat Spacetime
Swinburne University of Technology	Ngoc Phuong Van Nguyen	A/Professor Tonghua Zhang	Mathematical Modelling of Harmful Algal Blooms
	Joshua Rogers	Dr Nathan Clisby	Accurate Multi-Gas Emissions Equivalence Modelling of Greenhouse Gases
The University of Adelaide	Liam Blake	A/Professor Sanjeeva Balasuriya	Improving Clustering Techniques for Identifying Lagrangian Coherent Structures
	Bridget Smart	Dr Lewis Mitchell	Understanding How Influence Affects Information Flow in Online Social Networks
The University of Melbourne	Ashley Hanson	Dr Mark Fackrell	The Price of Anarchy, the Price of Stability, and the Price of Communication in Interacting Intensive Care Units
	Gyu Hwan Park	Dr Heejung Shim	Variational Inference for Bayesian Nonnegative Matrix Factorisation
	Michael Law	Dr Thomas Quella	Topological Phases in Quantum Systems with Quantum Group Symmetries
	Saleh Naghdi	Dr Charles Hill & Dr Thomas Quella	Quantum Boltzmann Machines: An Investigation
	Rebecca Rasmussen	Professor Barry Hughes	What Kind of Random Walk are These Biological Cells Doing?
	Meg Tully	Dr Jennifer Flegg & Dr Sophie Zaloumis	Statistical Modelling of Malaria Parasite Clearance
UNSW	Juan Avila Molina	Dr Vera Roshchina	Finding the Body of Minimal Resistance
	Sona Reddy	Dr Vera Roshchina & Vinesha Peiris	Distribution of Maximal and Minimal Deviation in Multivariate Chebyshev Approximation Problem
	Tiana Tsang Ung	Dr Thomas Britz	Computational Searches for Combinatorial Designs

The University of Newcastle	Bowen Parnell	Dr Hamish Waterer	Lot Sizing on a Cycle
	Cameron Shaw- Carmody	Professor Florian Breuer	Experimental Number Theory with Sage
The University of Queensland	Marcus Flook	Dr Artem Pulemotov	Naturally Reductive Metrics on Homogeneous Spaces
	Wilson Lorensyah	Dr Alan Huang	Robust Adjustments to Random Effects Models for Dispersed Counts
	Benjamin Solomon	Dr Travis Scrimshaw	Super Box-Ball Systems
The University of Sydney	Andrew Rajchert	Dr Alexander Fish & Associate Professor Dzmitry Badziahin	Glasner Property for (Semi-)Group Actions
	Elizabeth Rose	Dr Robert Marangell	Incorporating Spatio-Temporal Convection Effects in Classical Snowball Earth Models
	Dibyendu Roy	Dr Alexander Fish	The Polynomial Method in Additive Combinatorics
	Youheng Yao	Professor Stephan Tillmann	Representation Varieties of Once- Punctured Torus Bundles
The University of Western Australia	Joshua Crawford	Professor Luchezar Stoyanov	Inverse Scattering in the Recovery of a Single Concave and a Finite Union of Disjoint Convex Obstacles
	Jack Mulgueeney	Dr Thomas Stemler & Dr Thomas Jüngling	Stochastic Modelling of Deterministic Time Series
	Luke Thomas	A/Professor Leandro Magnusson & Professor Inge Koch	The Robustness of Limited Dependent Variable Modles to Misspecification
University of South Australia	Benjamin Babu	Dr Bronwyn Hajek & Associate Professor Marta Krasowska	Nanoscale Sessile Droplets Shape Prediction Comparison Between Theory and Experiment
University of Technology Sydney	John Cu	Professor Murray Elder	Length of Embedded Circuits in Geodetic Graphs
University of Wollongong	Alex Paviour	A/Professor Adam Rennie & Dr Alexander Mundey	Facts Are Relative
	Tianze Wei	A/Professor Mark Nelson	The Effect of Population Heterogeneity on the Spread of Contagious Diseases
Western Sydney University	Anthony Warwick	Professor Roozbeh Hazrat	Order Ideal Relations and Structural Properties of Leavitt Path Algebras

FEATURED PROJECT



Under Hierarchical Clustering of Bacterial Protein Sequences

Susanna Grigson, Flinders University

ABSTRACT

Proteins are crucial for biological and molecular functions in living organisms. Due to the everexpanding gap between the number of proteins being discovered and their functional characterisation, protein function inference remains a fundamental challenge in

computational biology. Currently, protein functions are classified in hierarchical ontologies constructed from experimental observations. Recent advancements in natural language processing and machine learning have inspired the development of the Protvec method for embedding amino acid sequences as vectors in a protein space. While Protvec successfully groups proteins with shared functions, the underlying mechanisms facilitating these groupings remain unclear. By analysing the most informative vectors in Protvec models we determine that Protvec groups proteins with similar functions by learning biologically meaningful information. Through embedding protein sequences using Protvec, we identify discrepancies between existing classification procedures and systematic groupings relative to the biophysical and biochemical properties of proteins. By extending Protvec to group sequences with unidentified functions, we propose an alternative approach to select optimal candidate proteins to characterise experimentally. Protein sequence embeddings and hierarchical clustering may be beneficial for reorganising and completing classification frameworks used to label bacterial proteins.

CONCLUSION

This study embedded bacterial protein sequences using word embeddings to evaluate protein sequence classification. Dissection of Protvec models revealed that Protvec models embed amino acid sequences using biologically meaningful information. By grouping proteins with shared functions in a vector space, inconsistencies were identified between the existing Subsystems ontology used to label proteins and hierarchical classifications utilising sequence embeddings. Further, amino acid sequences with unknown biological functions were organised into groups based on the underlying mathematical properties of protein sequences, providing an alternative approach for resolving the fundamental challenge of protein function inference. Redesigning protein classification schemes using a systematic approach would help overcome the limitations of currently used experimental approaches.

Susanna's full research report can be viewed at: vrs.amsi.org.au/student-profile/susannagrigson/

FEATURED BLOG



Collaboration in Climate Modelling

Elizabeth Rose, The University of Sydney

Mathematical models are incredibly powerful tools that use the relationships between variables to understand how a system will evolve. One type of mathematical model is an Energy Balance Model (EBM), where the net energy into a system is considered.

Climate change is one of the most pressing matters facing society today. How can we understand what our

future climate will look like? An EBM, that's how! By considering an EBM for the Earthatmosphere system, we can gain insight into the effects of global warming.

Lighter surfaces reflect more radiation than darker surfaces, so the amount of ice on Earth's surface impacts the amount of absorbed radiation. A simple model first proposed by Budyko [1] and Sellers [2] considers an EBM where the size of the ice cap determines how much radiation is absorbed or reflected.

With a smaller ice cap, there is less ice, and hence more radiation is absorbed, increasing the heat in the atmosphere, and then melting more ice. This type of system is known as a positive feedback system, as any change in one direction causes more change in the same direction, amplifying the change. Therefore, the effects of climate change are amplified simply by the colour of ice.

While simulating solutions to these models is rewarding, my VRS journey taught me something vastly different as well – the collaborative power of mathematics. There are a few key names that kept popping up in my readings – James Walsh, Esther Widiasih, and Richard McGehee. I was led to a paper written by Walsh and Widiasih in 2020, titled "A Discontinuous ODE Model of the Glacial Cycles with Diffusive Heat Transport" [3]. My supervisor, Robby Marangell, had met Esther at a conference a few years ago, so we sent them both an email with some questions about their work. To our delight, they both responded and were very helpful in their answers.

By reaching out to experts in the field, I was able to gain further insight into real mathematical research, where academics use the global network to communicate internationally. With climate change continuing to threaten society as we know it, we must all work together to solve the world's biggest problems.

References

[1] M. I. Budyko, "The effect of solar radiation variations on the climate of the earth," Tellus, vol. 21, no. 5, pp. 611–619, 1969.

[2] W. D. Sellers, "A global climatic model based on the energy balance of the earth atmosphere system," Journal of Applied Meteorology (1962-1982), vol. 8, no. 3, pp. 392–400, 1969.

[3] J. A. Walsh and E. R. Widiasih, "A Discontinuous ODE Model of the Glacial Cycles with Diffusive Heat Transport," Discrete and Continuous Dynamical Systems Series B, vol. 22, no. 7, pp. 2687-2715, 2020.

Elizabeth's research report can be viewed at: <u>vrs.amsi.org.au/student-profile/elizabeth-</u><u>rose/</u>

PARTICIPANT BREAKDOWN

UNIVERSITY	
Australian National University	2
Curtin University	1
Deakin University	1
Flinders University	1
La Trobe University	2
Macquarie University	3
Monash University	3
Murdoch University	1
Queensland University of Technology	3
RMIT University	3
Swinburne University of Technology	2
The University of Adelaide	2
The University of Melbourne	6
UNSW	3
The University of Newcastle	2
The University of Queensland	3
The University of Sydney	4
The University of Western Australia	3
University of South Australia	1
University of Technology Sydney	1
University of Wollongong	2
Western Sydney University	1

RESIDENCY STATUS		
Australian Citizen	39	78%
Permanent Resident	2	4%
Student Visa	9	18%

STATE/TERRITORY		
ACT	1	2%
NSW	17	34%
NT	0	0%
QLD	6	12%
SA	4	8%
TAS	0	0%
VIC	17	34%
WA	5	10%

ABORIGINAL AND TORRES STRAIT ISLANDER				
Yes	0	0%		
No	59	98%		
Prefer not to disclose	1	2%		

UNDERGRADUATE YEAR LEVEL		
2 nd year	11	22%
3 rd year	39	78%

GENDER		
Female	14	28%
Male	35	70%
Prefer not to disclose	1	2%



from 22 universities

completed a 2020–21

AMSI Vacation Research Scholarship

"What I enjoyed most was working with a researcher at my university in a field that I was interested in. This gave me the time and freedom to explore interesting concepts in mathematics which may not usually be taught within standard courses for a mathematics degree."

> Cameron Shaw-Carmody The University of Newcastle

AMSICONNECT

At the end of summer, all VRS students were able to showcase their research and network with their peers from around Australia at the exclusive AMSIConnect 2021 virtual conference held from 9–11 February.

"I enjoyed the experience of presenting at an academic conference. I learnt new skills that will better prepare me for higher degree research presentations."

> Jack Powers Queensland University of Technology



NETWORKING EVENTS

After the official conference welcome scholars got their first chance to meet each other in Gather.Town (an online networking platform that replicates how attendees would move around in a traditional face-to-face conference). A game of Networking Bingo broke the ice; students had to find others who matched the traits on their bingo card, e.g. someone with the same number of siblings, someone who is studying a different maths discipline etc. This resulted in a flurry of movement as avatars raced around the screen popping in and out of video chats. In the afternoon, Scholars were divided into teams to test their general knowledge over three friendly rounds of trivia. Attendees could log into Gather.Town for each of the breaks throughout the conference to continue to mingle, play online games together and collaborate using virtual whiteboards.



"I was pleasantly surprised how effective Gather.Town was for networking with other students. Even in an online setting, I was able to connect and make friends with the other vacation scholars during AMSIConnect."

> Ashley Hanson The University of Melbourne

STUDENT RESEARCH PRESENTATIONS

Each Scholar prepared a 15-minute presentation to communicate their research and outcomes to fellow VRS students and their supervisors over the course of the three-day conference program. Following their talks, presenters participated in Q&A sessions to further convey their work. Research topics were spread across disciplines and gave students the opportunity to hear about work from fields they may not otherwise have been exposed to.



"Seeing other students research introduced me to fields I would otherwise have had no contact with, facilitating creative thinking as I made sense of what they were presenting and seeing how it was similar and different to my research."

> Anthony Warwick Western Sydney University



BEST PRESENTER COMPETITION

The student talks were of high quality, with session chairs and attending supervisors impressed by the Scholar's skill in communicating their research. Students voted for their favourite talks with the following three identified as the top presenters:

- Bridget Smart, The University of Adelaide Understanding How Influence Affects Information Flow in Online Social Networks
- Meg Tully, The University of Melbourne Statistical Modelling of Malaria Parasite Clearance
- Elizabeth Rose, The University of Sydney Incorporating Spatio-Temporal Convection Effects in Classical Snowball Earth Models



WOMEN IN STEM

The 2021 International Day of Women and Girls in Science coincided with the final day of the AMSIConnect program. The significant contributions of female researchers to the STEM fields were acknowledged, including a tribute to the AMSI VRS 2020–21 female Scholars, supervisors, chairs and guest speakers. Attendees were encouraged to think about and discuss ways they could support and encourage diversity at their own universities and workplaces so that the number of women in the mathematical sciences at all levels can continue to grow.

"I had a fantastic experience in the program and I'm really glad I was encouraged to apply." Meg Tully The University of Melbourne

GUEST SPEAKERS

In addition to the Scholar presentations, the AMSIConnect program included three guest talks by researchers in a different career stages to give students an insight into life after their undergraduate studies:

- Life as a PhD Student Alex Browning, Queensland University of Technology
- Life as a Researcher
 Dr Jacinta Holloway-Brown, Queensland University of Technology
- Career Advice Q&A Professor Tim Marchant, Australian Mathematical Sciences Institute

Alex Browning took Scholars through his maths journey since completing his own AMSI VRS project in 2014–15. Sharing hot tips on how to juggle PhD studies and casual tutoring, the importance of networks and work-life balance.

With experience in academia and industry on a national and international level, Dr Jacinta Holloway-Brown encouraged Scholars to be open to opportunities when they present themselves and embrace a non-linear career path.

G	Jacinta Holloway-Brown @thejholloway · Feb 9 Looking forward to speaking about 'My life as a researcher' for the @DiscoverAMSI Connect student conference today.				
	There will be talk of using stats for environmental monitoring 🌳 🐨, my non-linear career path & some memes because #relatable				
	People still lik	e memes, right?			
	Q 1	tl 2	V 21	Ţ	

Professor Tim Marchant spoke of the current demand for mathematical science graduates and highlighted the many different jobs and industries open to those with a maths degree. This advice session was very interactive with Scholars able to get candid answers to their burning careers questions.

> "AMSI VRS gave me an insight into the world of research. This is definitely helpful in planning for my life after graduation."

> > Cameron McLaren **RMIT University**

FEEDBACK



Fifty-eight per cent of Vacation Research Scholars completed the online survey to provide their feedback and comments on the program and AMSIConnect.



In rating their overall experience at the event on a scale of 1 to 10, where 1 is poor and 10 is excellent, the respondents' average rating was 9.1

UNDERTAKING A POSITIVE AND REV	RESEARCH F NARDING	PROJECT WAS	PRESENTING AT A POSTIVE AND REV	MSICONN VARDING	IECT WAS
Strongly Agree	86%		Strongly Agree	79%	
Agree	14%		Agree	14%	
Neutral	0%		Neutral	7%	
Disagree	0%		Disagree	0%	
Strongly Disagree	0%		Strongly Disagree	0%	
VRS HAS STRENGT	HENED MY	RESOLVE TO	I MADE USEEUL CO	ONTACTS	AND NETWORKS

	IVIASIERS	HUNUUKS
Strongly Agree	71%	
Agree	21%	
Neutral	7%	
Disagree	0%	
Strongly Disagree	0%	

AT AMSICONNECT

Strongly Agree	29%	
Agree	11%	
Neutral	39%	
Disagree	21%	
Strongly Disagree	0%	

VRS WAS A GOOD OPPORTUNITY TO				
EXPLORE MY CHOSEN AREA OF				
MATHEMATICS				
Strongly Agree	72%			
Agree	14%			
Neutral	14%			
Disagree	0%			
Strongly Disagree	0%			

AMSICONNECT W	AS WELL	ORGANISED
Strongly Agree	61%	
Agree	36%	
Neutral	3%	
Disagree	0%	
Strongly Disagree	0%	

"AMSI VRS is an invaluable experience regardless if you're planning on working in the private sector, government or academia."

> Jack Mulqueeney The University of Western Australia







Australian Mathematical Sciences Institute

Research and Higher Education Building 161 C/- The University of Melbourne VIC 3010 Australia

events@amsi.org.au www.amsi.org.au

