The Criticality of Mathematics Training in Creating Innovative Futures

Professor Kate Smith-Miles

School of Mathematics and Statistics
The University of Melbourne

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OUTLINE

- PART 1: Popular Myths about Mathematics
  - Why do they exist?
  - How can teachers debunk them?
- PART 2: Classroom ideas to inspire curiosity
  - Where did mathematical ideas come from?
  - What is left to invent for an innovative future?
  - An inspiring tale of a remarkable female mathematician
- PART 3: A personal reflection on my STEM career
  - Why I chose to become a mathematician
  - Career opportunities and societal impact
  - The impact of an inspiring maths teacher

PART 1: Busting 5 popular myths

1. You can only be a mathematician if you are a genius
2. Girls aren't as good at maths as boys
3. Maths is just about adding up numbers
4. Maths isn't relevant to the world or my future
5. There is no new maths to invent

Search YouTube for "Kate Smith-Miles" and/or "myth-busting maths"

Where do these myths come from?

- Student attitudes towards mathematics are formed early
  - It's challenging to undo deeply engrained perceptions that maths is too hard, boring, and irrelevant
  - Often reflects attitudes and experiences of parents
- But these perception issues *must* be challenged
  - Every student deserves equal opportunity for a strong career in a future workforce where high level numerical skills and analytical thinking will be essential and assumed
- These myths seem to stem from two main causes:
  1. Lack of understanding of what mathematics really is, and therefore what it is good for, and why they should study it
  2. A belief that some people have a "maths brain" and others do not

What is maths to most people?

- Most people think they know what mathematics is about
  - They've been studying "maths" since they learned to count
  - After more than a decade of studying a subject, you would be entitled to think you have a clear idea of what it is all about!
- The mathematics studied at school leads to common beliefs that:
  - mathematics is dry and boring, and all about procedures that need to be drilled
  - mathematics is mostly useful for trivial "everyday" applications
    - making recipes using ratios, laying brick patterns using geometry, or figuring out how to place a ladder against a wall!
  - Mathematics is irrelevant to their future

Not even close to the 10,000 hour rule!

Parent counter-argument: "I hated maths at school, dropped it as soon as I could, and have never needed it since!"

Foundations for beauty and power

- Musical scales and exercises are preparation for playing great musical works
- Grammar provides the foundations for literature
- The kind of *mathematics learned at school is foundational* and mere preparation for something more powerful that most students do not ever see
- How do we expose students to the real *power* and *beauty* of more significant mathematics, and inspire them to want to learn more, beyond the basic foundations of numeracy?

Foundations for future jobs

- The future (well-paid) jobs for the current generation of students will demand greater numeracy skills, problem-solving and critical, analytical and logical thinking taught only by studying higher levels of mathematics.
- There is a depth and breadth of the field of mathematics that the school curriculum simply can’t explore.
- We need students to realise that more *advanced mathematics is important for tackling truly significant problems*
- Just like mathematics has done for centuries, it responds to challenges of our time

The challenge for curriculum and pedagogy

- How to ensure a balance between:
  - strengthening the foundations for all students (everyday numeracy)
  - motivating a greater number of students to explore the more creative side of mathematics required for careers that build upon advanced mathematics training?
- How to ensure students see how basic concepts explored at school can be extended to solve real-world problems of great importance?
- https://mathigon.org/applications

“Why do I need to know this?”

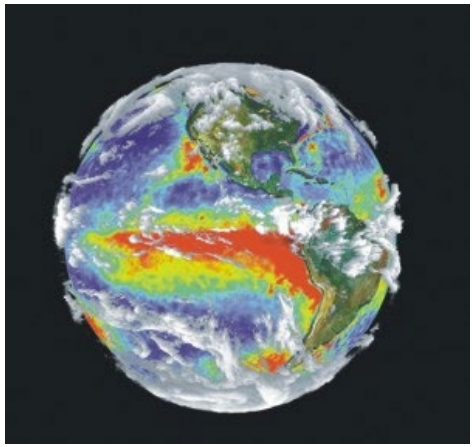
- A simple answer: *Mathematics is a language; we use it to describe our world*
- With mathematics we can:
  - prove facts and estimate uncertainties
  - model a system
  - predict what would happen if we make changes
  - improve the system
- The opportunities for positive impact are endless for those who speak this powerful language
  - Impact in the corporate world and for social good
- Everybody needs to learn to speak it fluently!

traffic networks, the human brain, stem cells, stock markets, etc.

The hidden work of mathematicians

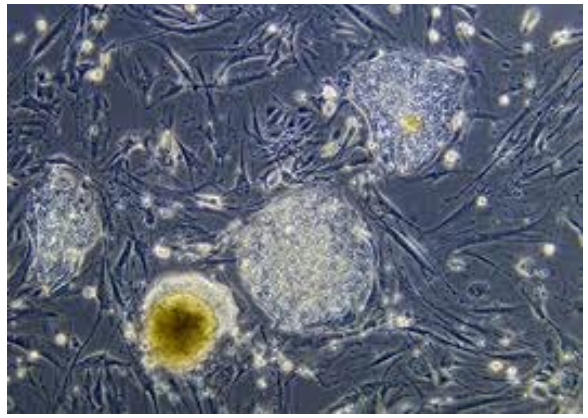
- Who works out the traffic light sequences?
- Who works out which trains we need on which lines at which times?
- Who works out when airplanes should take-off and land?
- Who works out what the weather forecast will be?
- Who works out which stocks investment funds should buy?
- Who works out the best premium to charge insurance customers?
- Who works out how much radiation cancer patients need in various parts of a tumour?
- Who works out if a credit card application is fraudulent?
- Who works out which frequency your mobile phone should be assigned so your call doesn’t interfere with others?

Mathematics underpins many of the grand challenges of our time



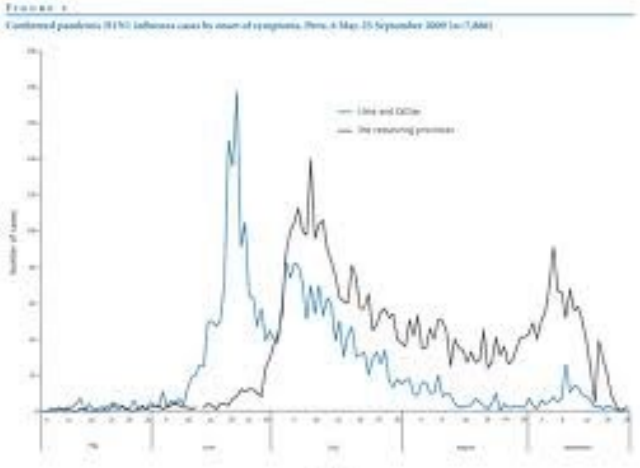
Climate modelling

Traffic modelling

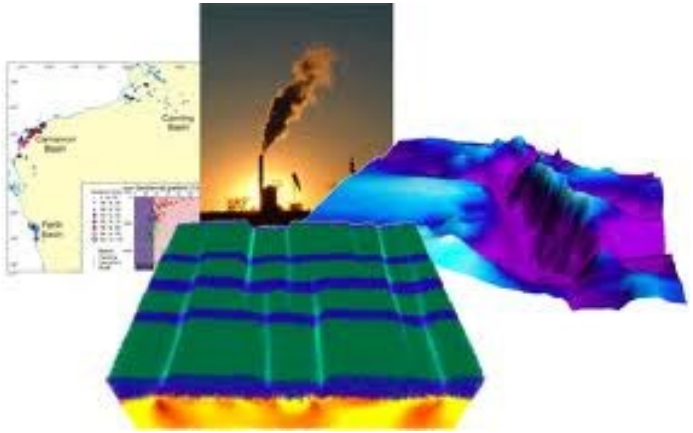


Stem cell modelling

Outbreak detection



Fluid flow analysis



Biosecurity

THE WALL STREET JOURNAL.
WSJ.com

Wish I did a maths degree!

CAREERS | JANUARY 26, 2009, 11:20 A.M. ET

Doing the Math to Find the Good Jobs

Mathematicians Land Top Spot in New Ranking of Best and Worst Occupations in the U.S.

By SARAH E. NEEDLEMAN

Nineteen years ago, Jennifer Courter set out on a career path that has since provided her with a steady stream of lucrative, low-stress jobs. Now, her occupation -- mathematician -- has landed at the top spot on a new study ranking the best and worst jobs in the U.S.

"It's a lot more than just some boring subject that everybody has to take in school," says Ms. Courter, a research mathematician at mental images Inc., a maker of 3D-visualization software in San Francisco. "It's the science of problem-solving."

The study, released Tuesday from CareerCast.com, a new job site, evaluates 200 professions to determine the best and worst according to five criteria inherent to every job: environment, income, employment outlook, physical demands and stress.

Top 5 jobs are:

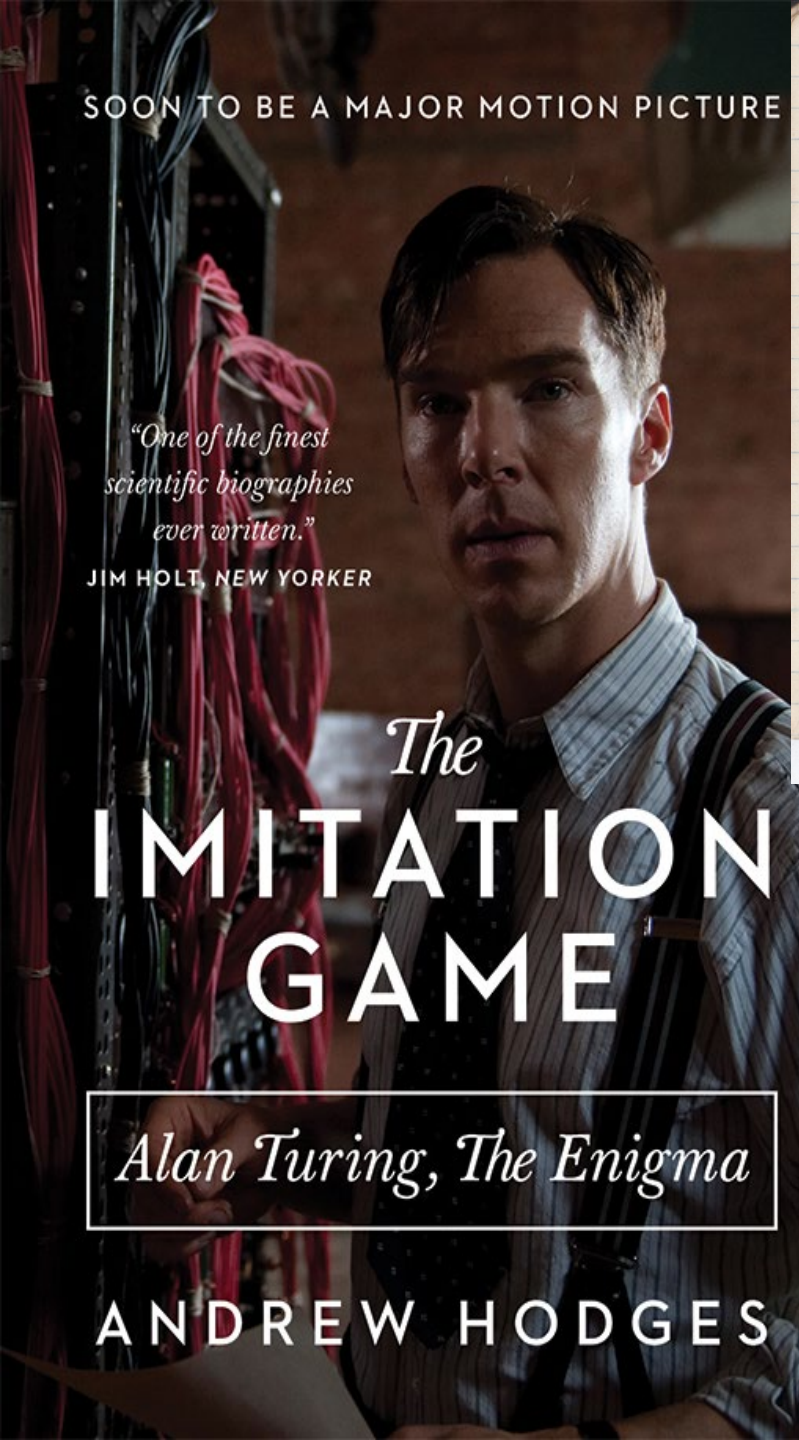
1. Mathematician
2. Actuary
3. Statistician
4. Biologist
5. Software Engineer

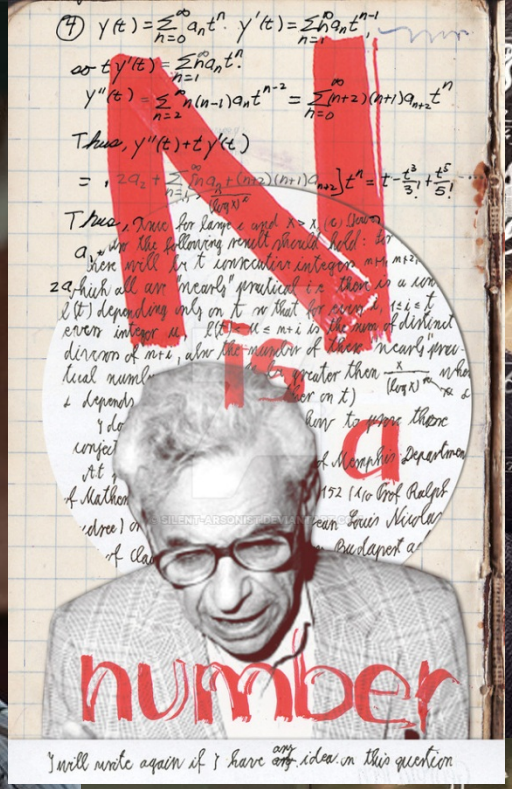
“OK, so maths is important … but I don’t have a maths brain”

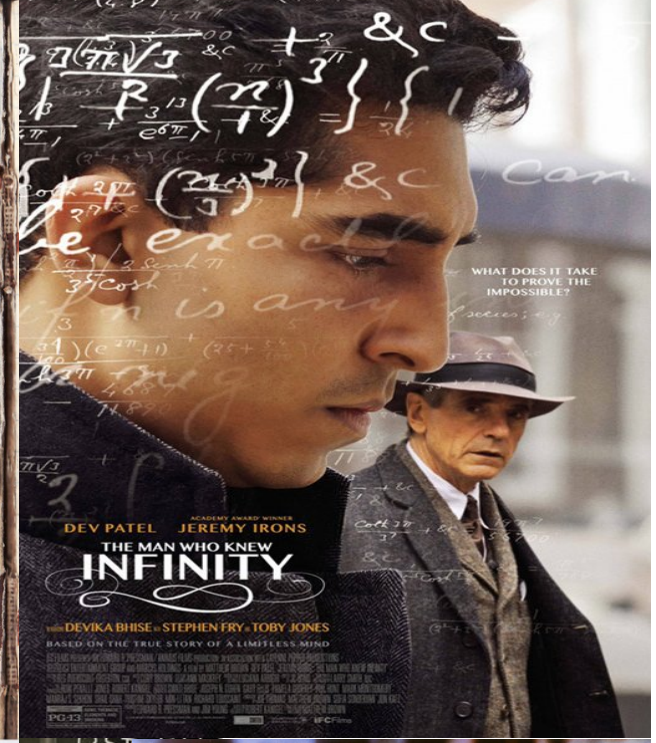
- Early negative experiences can be detrimental to student perception of ability
- Gender differences?
  - Evidence that girls *disengage* in maths earlier and in greater numbers than boys
  - *No* evidence that girls *perform* more poorly than boys in mathematics
  - Evidence that girls are less *confident* than boys in their mathematics ability
- AMSI ChooseMaths has shown confidence (∀) can be changed with simple intervention exercises (the power of “yet”)
- The impact of “maths anxiety” and use of mind-shift thinking to increase confidence should inform strategies around teacher training and influencing parental attitudes

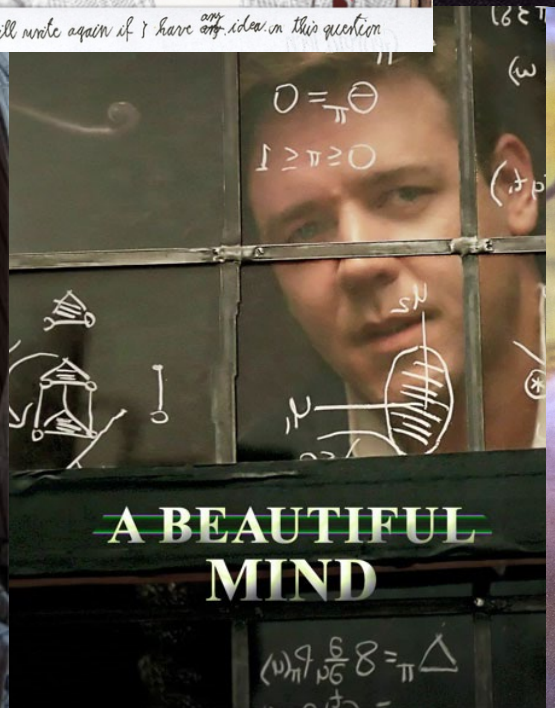
“OK, I can do maths, but I’m not a genius …”

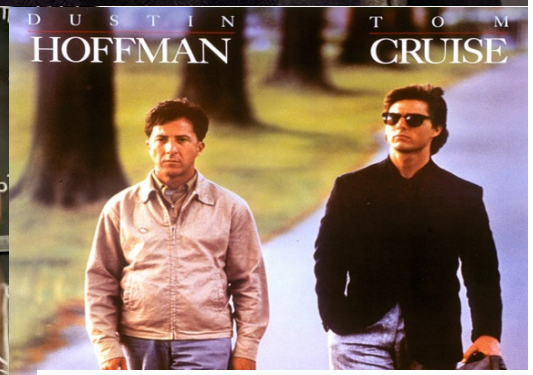
- *All* students can be taught to thinking mathematically and problem solve
  - just as all students can be taught to read and decipher and understand concepts and messages discussed in literature
- You don’t need to be a genius to become a mathematician!
- There is an urgent need to communicate more effectively in order to change student perceptions and attitudes towards mathematics
  - what mathematics really is
  - its significance for the real world
  - showcase role models who are relatable
- Back to myth-busting …





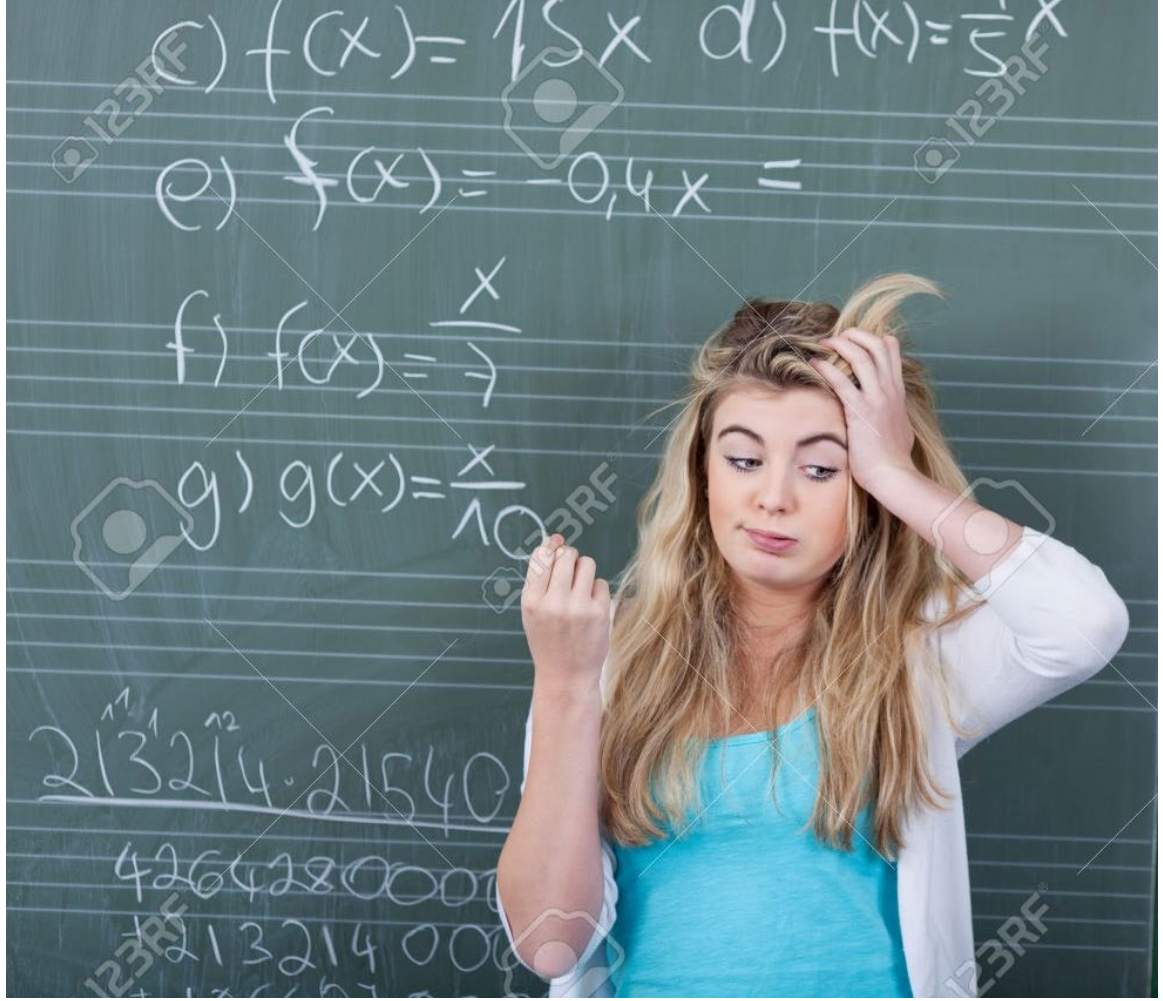






What can you do?

- Find relatable role models to visit school
- contact maths outreach officer at local university
- find math-trained parents
- find alumni to visit school



Literature Review

242 Studies (1990-2007) of 1,286,350 people

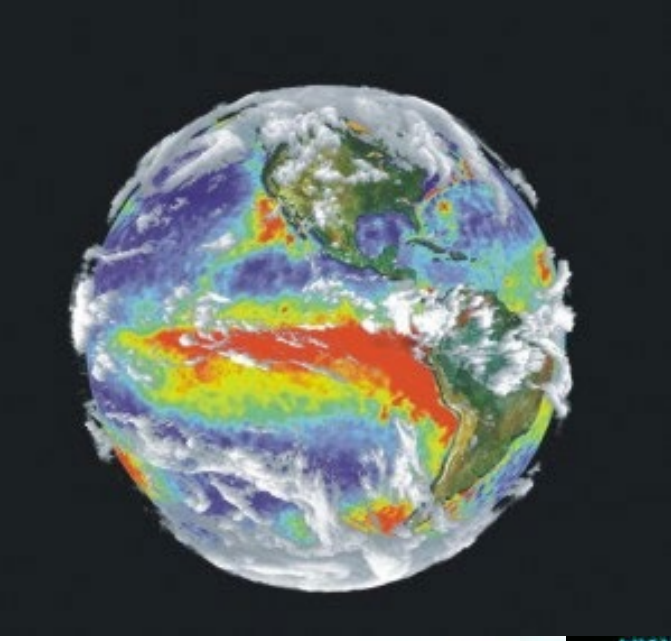
Lindberg, S. M.; Hyde, J. S.; Petersen, J.L.; Linn, M. C. (2010). "New Trends in Gender and Mathematics Performance: A Meta-Analysis". *Psychological Bulletin*. Vol. 136 , no. 6, pp. 1123–1135.

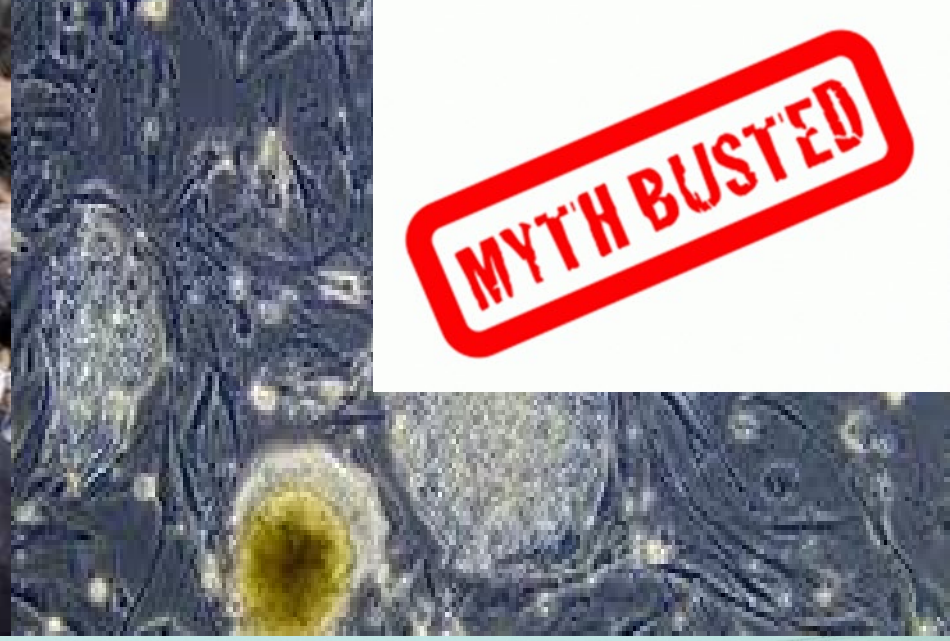
- Share study findings
- AMSI Choose Maths mentors
- growth mindset

Conclusion:

No overall difference in performance in mathematics based on gender

- Reinforce foundational message (hang in there!)
- focus on problem solving and creating “ah-ha” moments, rather than procedural drilling
- creativity, elegance, proof, logic.




MYTH BUSTED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John E. Freund's
Mathematical Statistics with Applications
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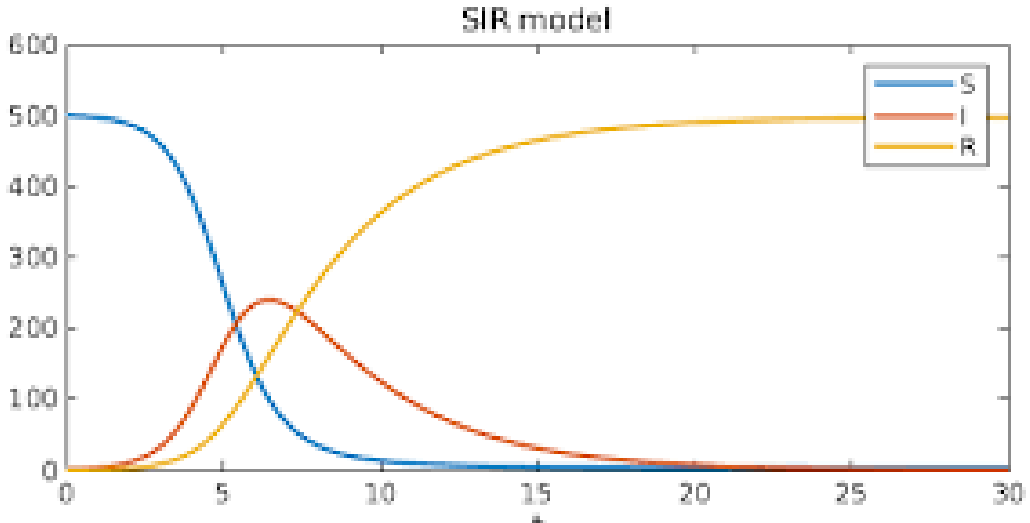
THE ELEMENTS
A HISTORY OF
MATHEMATICS
Algebra I
Algebra I
CALCULUS
Calculus
FOR DUMMIES
MYTH BUSTED

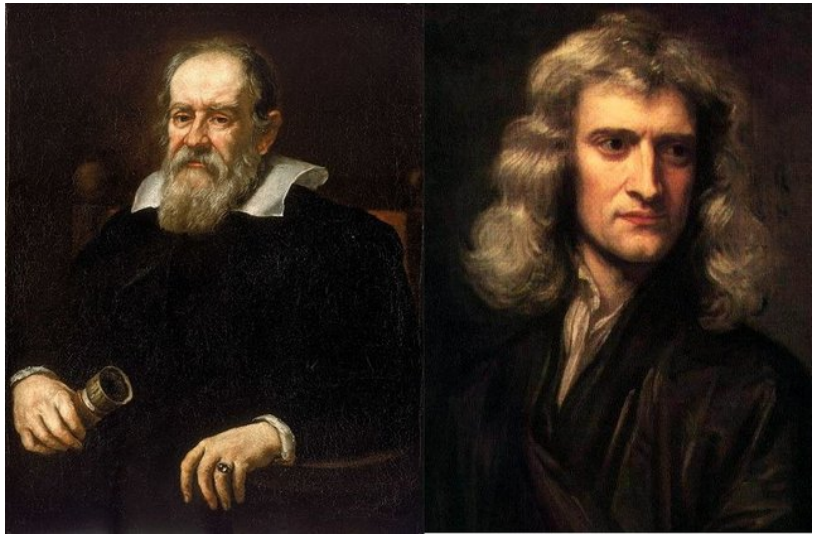
PART 2: Classroom ideas to inspire curiosity

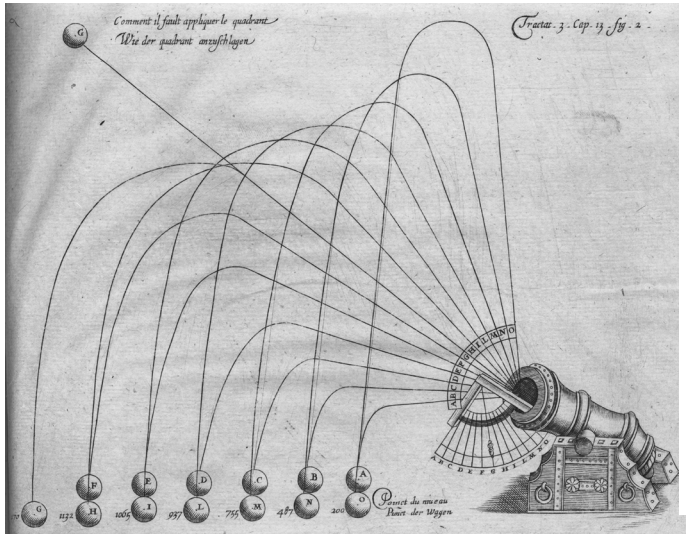
- Where does new maths come from?
- New maths is often created in response to society's current challenges
- Mathematical training has ***always*** been critical to innovative futures

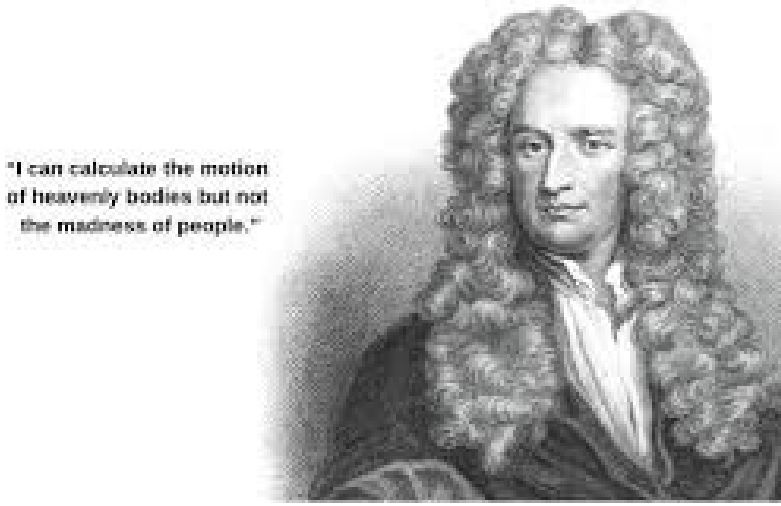


Responsive maths: 17th and 18th Centuries → WWI

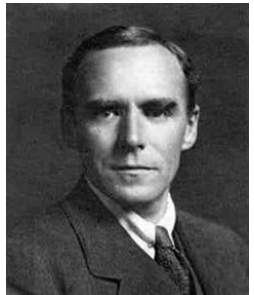
- New methods to respond to urgent pressures in society (= WAR)
- Galileo and Newton studies of projectile motion led to “a general method whereby I can calculate curves and determine maxima, minima, and centers of gravity” (i.e. calculus)



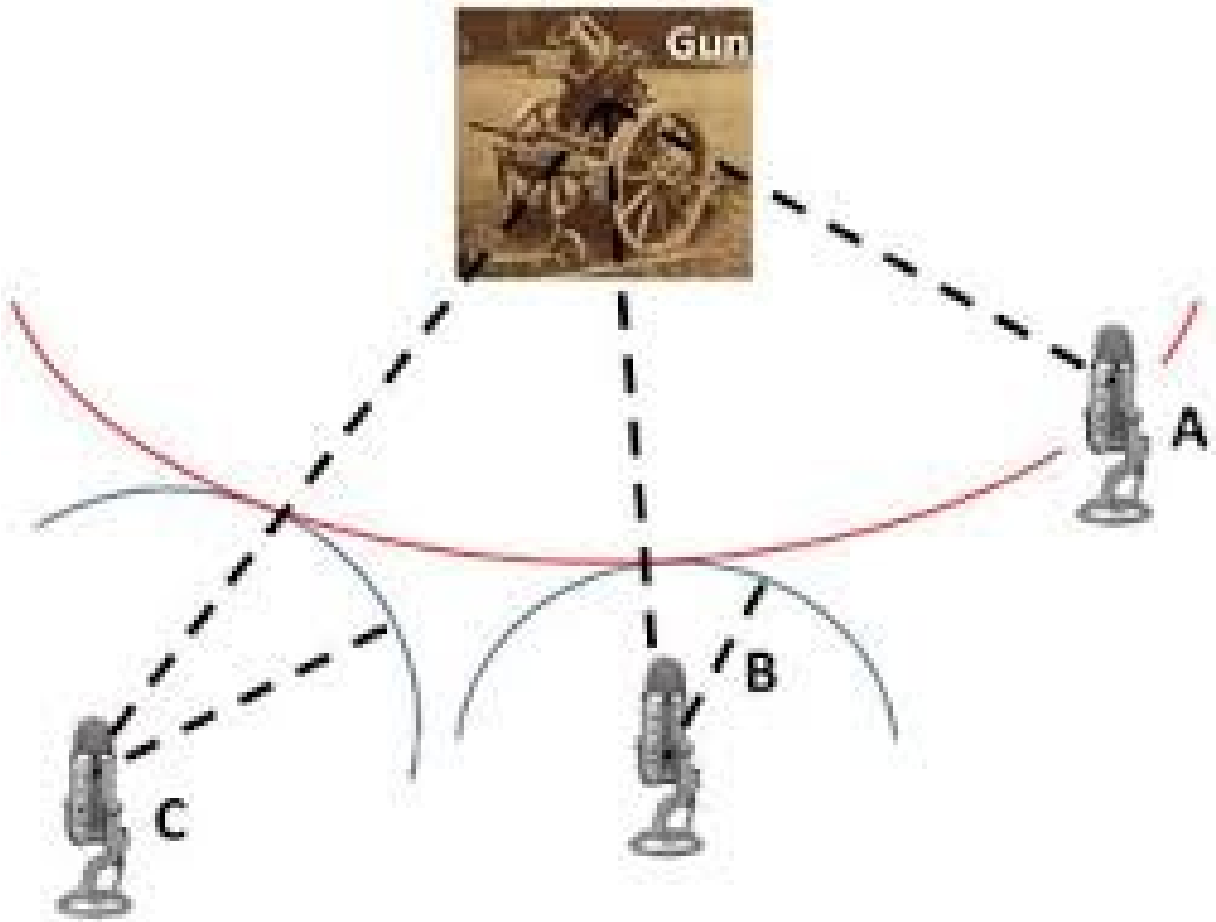




- Geoffrey Taylor (WWI pilot and mathematician) studied parachute dynamics to optimise landing locations

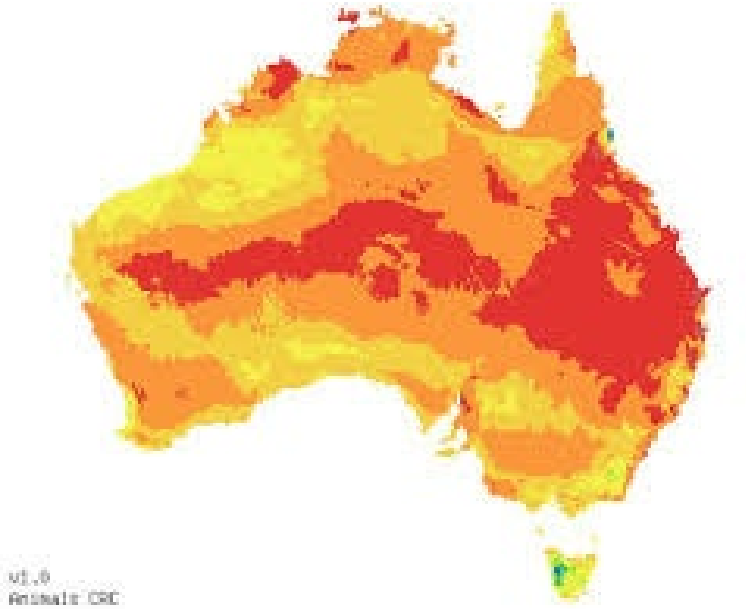


WW1 and sound-ranging …
where are the guns hiding?



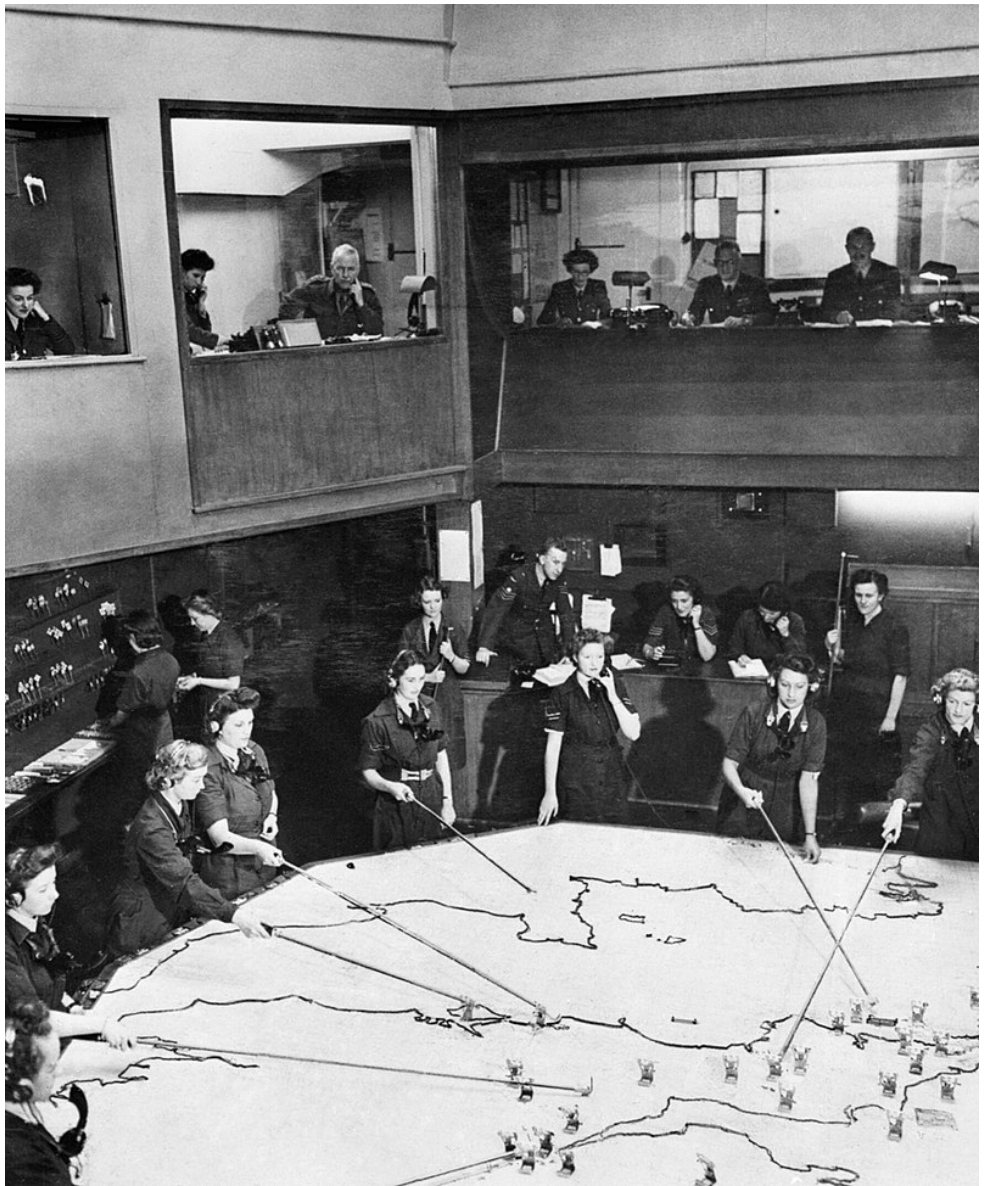
Similar modern inverse problems (non-war)

- Where are the ants going?
- Where are the ant nests hiding?



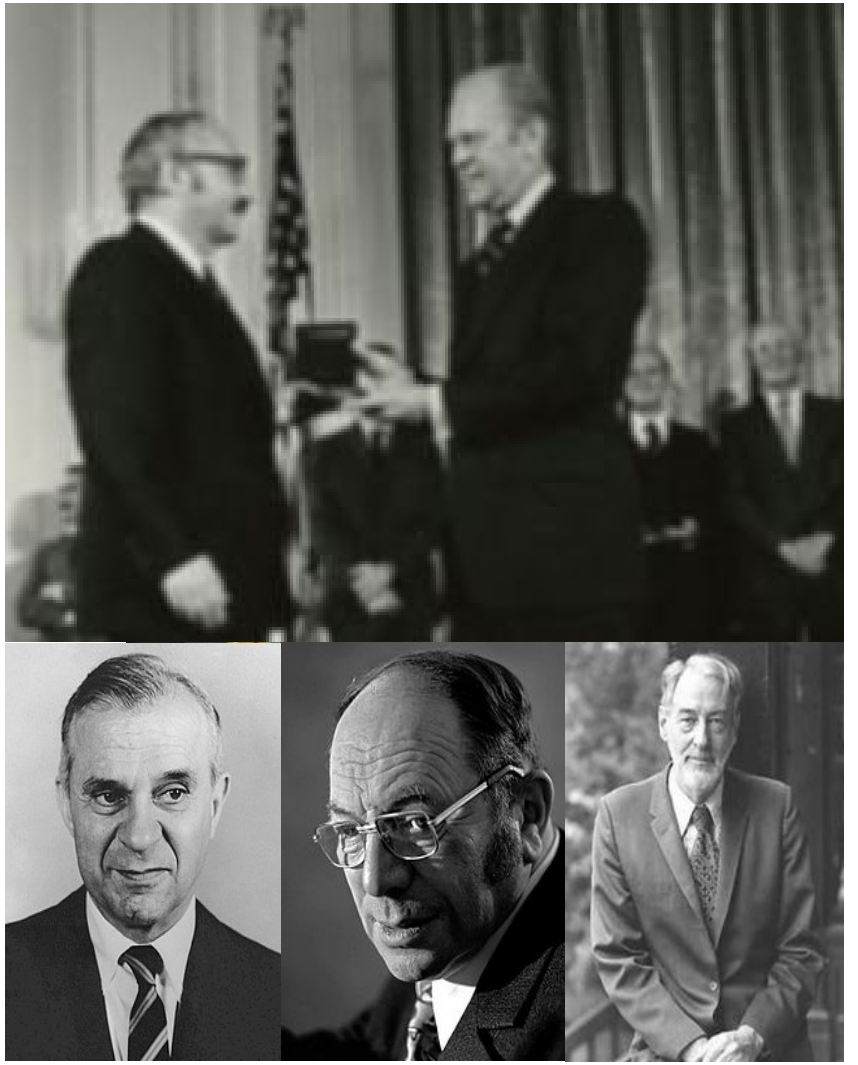
Optimisation – a new branch of maths from WW2

- A whole field of mathematics emerged from war-time decision making
  - Which troops should be sent to which battles?
  - How should weapons be allocated across the army?
  - When should maintenance be done on war planes and ships?
- All of these questions involve making decisions:
  - Maximise or minimise something while satisfying some limits or constraints



Optimisation Example: Stigler's Diet problem (1939)

- How to feed an army of men for minimal cost while meeting essential nutritional requirements?
- Stigler formulated the problem mathematically with
  - 77 variables (available food choices)
  - 9 constraints (nutritional rules)
  - No method to solve it exactly yet
  - Stigler's best guess cost $39.93 per man per year
- After the Simplex Method invented by Dantzig in 1947, it took 2 weeks for 9 people (120 man-days of hand calculations) to *prove* that the optimal solution cost $39.69
- After Dantzig moved from the Pentagon to Rand Corporation in 1953 to work on computer implementation, he solved it in 8 hours



The Stigler Diet … palatability constraint?

- George Stigler won the Nobel Prize in 1983 "for his seminal studies of industrial structures, functioning of markets and causes and effects of public regulation“ – not for his Diet Problem or its unpalatable solution

Stigler's 1939 Diet

Food	Annual Quantities	Annual Cost
Wheat Flour	370 lb.	$13.33
Evaporated Milk	57 cans	$3.84
Cabbage	111 lb.	$4.11
Spinach	23 lb.	$1.85
Dried Navy Beans	285 lb.	$16.80
Total Annual Cost		$39.93

Optimal solution replaced evaporated milk with beef liver

Table of nutrients considered in Stigler's diet

Nutrient	Daily Recommended Intake
Calories	3,000 Calories
Protein	70 grams
Calcium	.8 grams
Iron	12 milligrams
Vitamin A	5,000 IU
Thiamine (Vitamin B_1)	1.8 milligrams
Riboflavin (Vitamin B_2)	2.7 milligrams
Niacin	18 milligrams
Ascorbic Acid (Vitamin C)	75 milligrams

- Is it possible to create an appealing dish out of these five ingredients?
- Stigler: “No one recommends these diets for anyone, let alone everyone”
- Others have said “The solution to the least-cost diet is the equivalent of the human dog biscuit”
- Google Chef Anthony Marco took the challenge

Foie Linéaire à la Stigler - Seared calf liver dredged in flour, atop a navy bean purée with marinated cabbage and a spinach pesto.

Create your own optimized menu!

To create your own optimized menu, select the foods that you would like to consider in your menu and specify the nutritional constraints that you would like to satisfy.

Enter your email address if you want the solver solution log: Email address

Solve Diet Problem

Food Selection

- Mark the checkbox next to each food that you would like to consider in your menu. Note that you are more likely to get a solution if you select more food choices.
- Edit the "Min" and "Max" values if you would like to change the defaults for the number of servings of each food from Min = 0 and Max = 10.

Uncheck all

Select	Name	Serving	Price/Serving ($)	Min	Max
☑	Frozen Broccoli	10 Oz Pkg	0.16	0	10
☑	Carrots, Raw	1/2 Cup Shredded	0.07	0	10
☑	Celery, Raw	1 Stalk	0.04	0	10
☑	Frozen Corn	1/2 Cup	0.18	0	10
☑	Lettuce, Iceberg,Raw	1 Leaf	0.02	0	10
☑	Peppers, Sweet, Raw	1 Pepper	0.53	0	10
☑	Potatoes, Baked	1/2 Cup	0.06	0	10
☑	Tofu	1/4 block	0.31	0	10

Nutritional Requirements

- Unselect the checkbox next to any nutrients that you do not want to consider.
- Edit the "Min" and "Max" values for the nutrient levels if you would like to change them from their defaults.

Uncheck all

Select	Name	Unit	Min	Max
☑	Calories	cal	2000	2250
☑	Cholesterol	mg	0	300
☑	Total_Fat	g	0	65
☑	Sodium	mg	0	2400
☑	Carbohydrates	g	0	300
☑	Dietary_Fiber	g	25	100
☑	Protein	g	50	100
☑	Vit_A	IU	5000	50000
☑	Vit_C	IU	50	20000
☑	Calcium	mg	800	1600
☑	Iron	mg	10	30

Nutrition information for each food

Name	Calories	Cholesterol	Total_Fat	Sodium	Carbohydrates	Dietary_Fiber	Protein	Vit_A	Vit_C	Calcium	Iron
Frozen Broccoli	73.8	0.0	0.8	68.2	13.6	8.5	8.0	5867.4	160.2	159.0	2.3
Carrots, Raw	23.7	0.0	0.1	19.2	5.6	1.6	0.6	15471.0	5.1	14.9	0.3
Celery, Raw	6.4	0.0	0.1	34.8	1.5	0.7	0.3	53.6	2.8	16.0	0.2
Frozen Corn	72.2	0.0	0.6	2.5	17.1	2.0	2.5	106.6	5.2	3.3	0.3
Lettuce, Iceberg,Raw	2.6	0.0	0.0	1.8	0.4	0.3	0.2	66.0	0.8	3.8	0.1
Peppers, Sweet, Raw	20.0	0.0	0.1	1.5	4.8	1.3	0.7	467.7	66.1	6.7	0.3
Potatoes, Baked	171.5	0.0	0.2	15.2	39.9	3.2	3.7	0.0	15.6	22.7	4.3
Tofu	88.2	0.0	5.5	8.1	2.2	1.4	9.4	98.6	0.1	121.8	6.2
Roasted Chicken	277.4	129.9	10.8	125.6	0.0	0.0	42.2	77.4	0.0	21.9	1.8
Spaghetti W/ Sauce	358.2	0.0	12.3	1237.1	58.3	11.6	8.2	3055.2	27.9	80.2	2.3
Tomato,Red,Ripe,Raw	25.8	0.0	0.4	11.1	5.7	1.4	1.0	766.3	23.5	6.2	0.6
Apple, Raw, w/Skin	81.4	0.0	0.5	0.0	21.0	3.7	0.3	73.1	7.9	9.7	0.2
Banana	104.9	0.0	0.5	1.1	26.7	2.7	1.2	92.3	10.4	6.8	0.4
Grapes	15.1	0.0	0.1	0.5	4.1	0.2	0.2	24.0	1.0	3.4	0.1
Kiwifruit, Raw, Fresh	46.4	0.0	0.3	3.8	11.3	2.6	0.8	133.0	74.5	19.8	0.3
Oranges	61.6	0.0	0.2	0.0	15.4	3.1	1.2	268.6	69.7	52.4	0.1
Bagels	78.0	0.0	0.5	151.4	15.1	0.6	3.0	0.0	0.0	21.0	1.0
Wheat Bread	65.0	0.0	1.0	134.5	12.4	1.3	2.2	0.0	0.0	10.8	0.7
White Bread	65.0	0.0	1.0	132.5	11.8	1.1	2.3	0.0	0.0	26.2	0.8
Oatmeal Cookies	81.0	0.0	3.3	68.9	12.4	0.6	1.1	2.9	0.1	6.7	0.5

Maybe not recommended for humans, but …

- The army diet problem was the precursor of a wide variety of applications
  - cattle and chicken feed
  - fertilizer
  - general (ingredient) mixing problems
- The idea of a minimum cost diet for humans also served as a baseline for governmental funding and school lunch planning
- Whole number decision variable issue remains though
  - cans of evaporated milk (discrete) versus lbs. of liver (continuous)

McDonald's Diet Problem Formulation

Data for the McDonald's Diet Problem

McDonald's Food: the Facts

Menu Item	Price* ($)	Calories	Protein (g)	Fat	Sodium (mg)	Vit. A % U.S. RDA	Vit. C % U.S. RDA	Calcium % U.S. RDA	Iron % U.S. RDA
Hamburger	0.69	260	13	9	530	2	2	15	15
Big Mac	1.99	560	25	30	1010	8	2	25	25
Chicken McNuggets (6pcs)	1.99	250	15	15	670	2	2	2	4
Garden Salad	2.05	35	2	0	20	120	40	4	6
Baked Apple Pie	0.79	260	3	13	200	0	40	2	6

* Prices recorded Jan. 12, 2000 in St. Louis, Missouri

1. What must be decided?

Diet Plan

x1 = # of hamburgers
x2 = # of Big Macs
x3 = # of Chicken McNuggets
x4 = # of Garden Salads
x5 = # of Baked Apple Pies

2. What measure should we use to compare alternative sets of decisions?

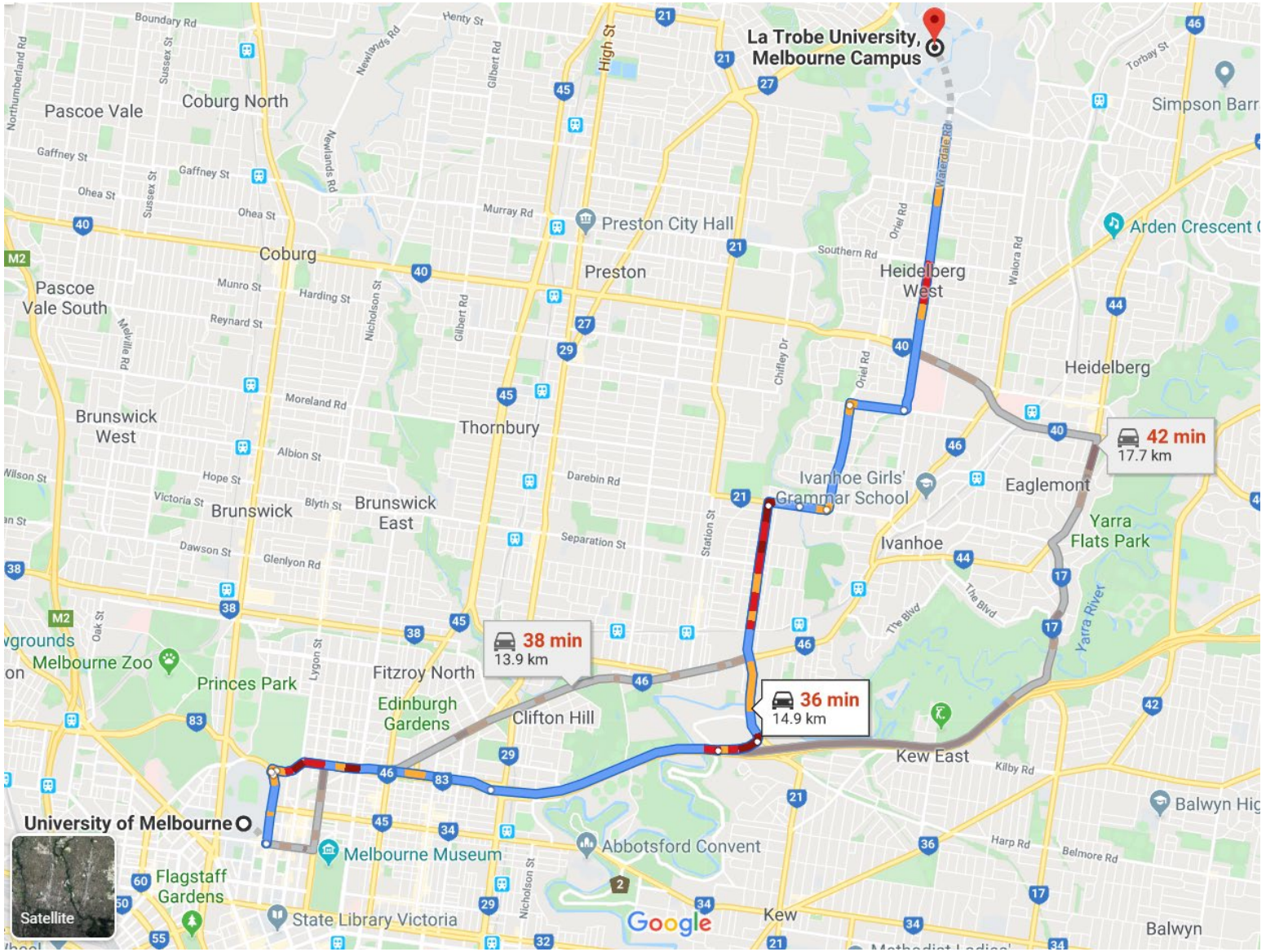
Money Spent on McDonald's Diet

3. What restrictions limit our choices?

Calories obtained ≤ 2000
Protein obtained ≥ 55 gram
Vitamin C obtained ≥ 100% of U.S. RDA
Calcium obtained ≥ 100% of U.S. RDA

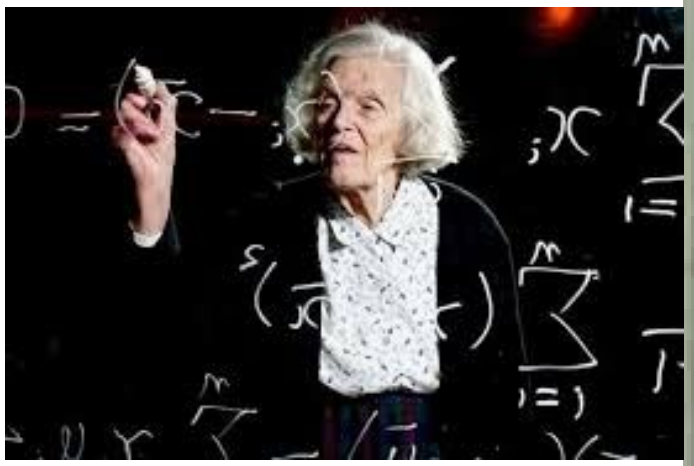
Everyday (non-war) optimisation problems

- Same methods used in Google Maps to plan your trip
- Minimise travel time getting from A to B while avoiding tolls, using roads, avoiding traffic jams, etc.



What if decisions have to be whole numbers?

- Famous “Branch and Bound Algorithm” pioneered by Melbourne woman Alison Harcourt in 1960!
- Victorian Senior Australian of the Year, 2019
- Queen’s Birthday AO honour, 2019



ABC 7:30 TV story

Maths: For women as well

Housework? No! Hobbies? No! but

Computing pioneer gets her PhD

Almost six decades on, the University of Melbourne will recognised at last the unsung achievement of one of its pioneering female graduates. It will award an honorary doctorate to mathematician Alison Harcourt, 88, whose work helped found a field of

See YouTube recording at
https://youtu.be/jdcCtOp80jY?t=326

THE UNIVERSITY OF MELBOURNE

ACEMS Public Lecture

OPTIMAL DECISION MAKING:
A TRIBUTE TO FEMALE INGENUITY

Kate Smith-Miles and Alison Harcourt AO

October 12th, 2021

ACEMS
AUSTRALIAN RESEARCH COUNCIL CENTRE OF EXCELLENCE FOR MATHEMATICAL AND STATISTICAL FRONTIERS

OPTiMA
ARC TRAINING CENTRE IN OPTIMISATION TECHNOLOGIES INTEGRATED METHODOLOGIES AND APPLICATIONS

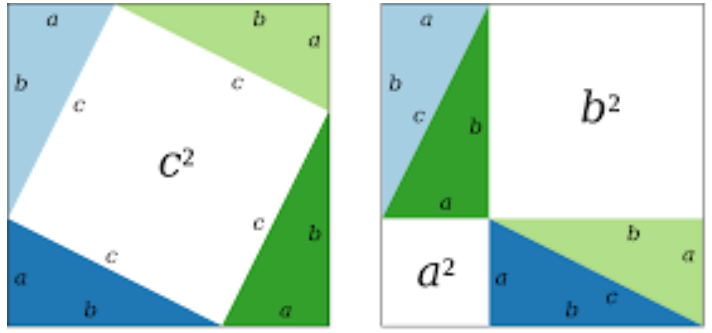
PART 3: A personal reflection on my STEM career (and the inspiring influence of a maths teacher)

Year 12 Graduation Book

AMBITION: “To get 369 in these exams,
to work out *Kate’s Theorem*,
for someone else to use it, and
to find a career and way of life
that I would be happy in.”

Where did this ambition come from?

- Prior to year 12, “mathematician” wasn’t on my radar
  - … Good enough?
  - … Enjoyment? Passion? Curiosity?
  - … Sense of purpose?



$$c^2 = a^2 + b^2$$

- Then an inspiring Year 12 maths teacher changed my view
  - … maths is creative, elegant, beautiful … curiosity sparked!

- She tried to dissuade me from studying maths at university!

“where will that lead you? To become a maths teacher like me? You can aim higher!”

- But I’d made up my mind to learn more maths and see where it took me …

STEM journey begins: Melbourne University

- Bachelor of Arts (lots of maths, and music history and psychology)
- Day 1, Monday 9am, decided to become a maths professor!
- PhD became next goal, transferred into Bachelor of Science
- 3rd year: “these equations can be used to model traffic flow”
- Drawn to practical applications, operations research, mathematical modelling, improving the world, rather than abstract (pure) maths
- Summer vacation research work at CSIRO
- PhD with CSIRO, good exposure to industry work, but decided I still wanted to be a maths professor

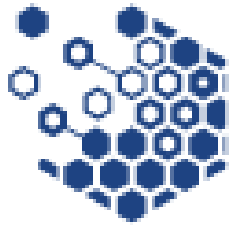
Academic pathway through STEM fields

- Lecturer in Information Technology at age 25 (Monash University)
  - Teaching computer programming and artificial intelligence
- Professor of Information Technology at age 35
- Professor of Engineering at age 36 (Deakin University)
  - Head of the School of Engineering, IT, and maths; research in robotics and AI
  - Teaching maths to future primary school teachers
- Maths underpins all of STEM
  - Easy to collaborate
  - Easy to move into new areas of STEM

Finally, a real Maths Professor!

- 2009: Professor of Applied Mathematics (Monash)
  - Head of the School of Mathematical Sciences
  - Teaching maths to engineering students and maths students
  - Research in mathematical modelling and industrial optimisation
- 2017: Professor of Applied Mathematics (University of Melbourne)
  - Teaching, research, collaboration
- 2019: Associate Dean (Enterprise & Innovation), Faculty of Science
- 2021: Director of OPTIMA

- No “Kate’s Theorem” but lots of new research
  - over 10000 citations
- Enjoy intellectual freedom
- Enjoy impact in society
  - collaborations
  - industry
  - outreach



OPTiMA

ARC TRAINING CENTRE IN OPTIMISATION TECHNOLOGIES INTEGRATED METHODOLOGIES AND APPLICATIONS

The hidden work of mathematicians

- Who works out the traffic light sequences?
- Who works out which trains we need on which lines at which times?
- Who works out when airplanes should take-off and land?
- Who works out what the weather forecast will be?
- Who works out which stocks investment funds should buy?
- Who works out the best premium to charge insurance customers?
- Who works out how much radiation cancer patients need in various parts of a tumour?
- Who works out if a credit card application is fraudulent?
- Who works out which frequency your mobile phone should be assigned so your call doesn’t interfere with others?

What my teachers should have told me …

1. There is a growing skills shortage of mathematically qualified people
2. The world needs mathematical scientists to help
   - Understand our world and beyond
   - Model and improve systems
   - Fill the world with people who can think clearly and rationally!

"Do as much mathematics and statistics as you can in your degrees – these skills will empower your professional life."

Sir Gustav Nossal

Australian of the Year, 2000

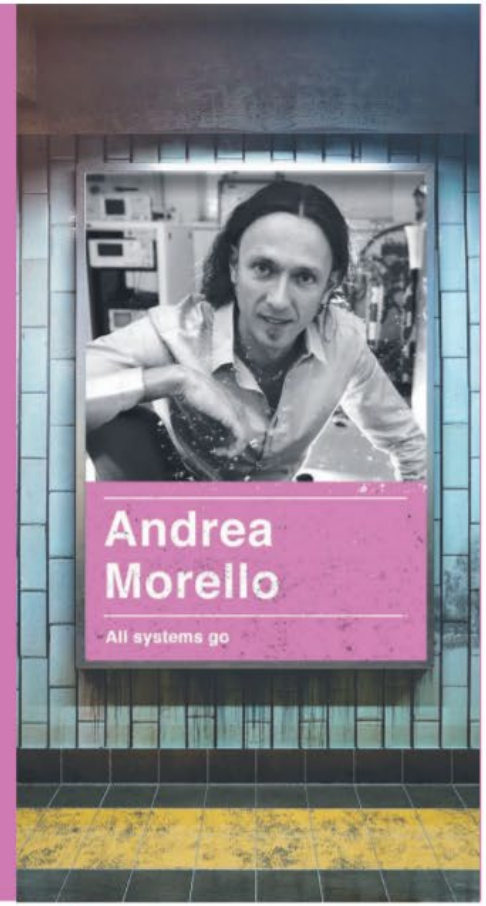
Distinguished Scientist

Other (maths) things I wish I knew when I was 17 …

- Maths is a language (of logic, truth, to describe the world, and improve it)
- Maths is the key to tackling many significant challenges for society
- Maths is creative, elegant, beautiful and satisfying
- There are many ways to be a good mathematician (collaboration not just competitions)
- There are many ways to have an impact in society through maths and STEM
- The maths you have seen at school is foundational and preparation for the good stuff at university!
- Maths is a foundation for many careers (always has been, always will be)
- An inspiring teacher can change your life!

STEM heroes

These Australians have made the best of the educational opportunities in their smart, rich country and emerged as transformers and innovators. Individually, they have uncovered new phenomena and collectively, they represent the discovery and knowledge creation important for Australia to improve its productivity and create the new products, fields and the industries of the future.



Andrea Morello

Associate Professor of Quantum Nanosystems, University of NSW

It has been called "the space race of the 21st century" and Andrea Morello is at its vanguard. Morello studies quantum computing – technology that allows multiple calculations to be made at the same time, making it faster and more powerful than normal computers – and attempts to scale it for commercial use. He and his team have come closer to making quantum computing a reality – which until now has been mostly hypothetical – by installing the technology on silicon smartphone chips, the material of choice for hardware.

When it is fully realised, quantum computing could have a huge impact in industries like pharmaceuticals, finance and security. It harnesses the weird quantum properties of atomic particles that demonstrate "entanglement" – particles acting on each other across vast distances even, theoretically, from opposite sides of the universe. "We have the operation of a quantum computer entirely under control," says Andrea Morello. Quantum computers could perform calculations that stretch the limits of the imagination in terms of power and speed.

Cyrille Boyer
Deputy Director, Australian Centre for NanoMedicine

Associate professor Cyrille Boyer is a chemical engineer who prepares "macromolecules", the largest molecules and essential building blocks for life. Using light, Boyer creates complex new substances that can be used for non-stick coatings, precision drug delivery, and medical diagnosis and imaging. His interest in science began at a young age in rural France with a chemistry set. Now, he has been recognised in Australia with the 2015 Malcolm McIntosh Prize for Physical Scientist

Nalini Joshi
Chair, Applied Mathematics, University of Sydney

Nalini Joshi is an Australian mathematician using mathematical methods to solve challenging scientific problems. She is the first woman to become a professor and Australian Laureate Fellow at the University of Sydney's School of Mathematics and Statistics. Joshi works on the forefront of new knowledge and says we must be fearlessly curious. "I think of it as an incredible treasure hunt. You pick up clues and you put them together," she says. Joshi has said that mathematics is

Mark Cassidy
Director, Centre for Offshore Foundation Systems, University

Professor Mark Cassidy has made a distinguished contribution to the theory and practice of geomechanics. He researches how we can safely extract vast reserves of natural gas in remote and deep oceans and works on some of the largest infrastructure projects in Australia. One challenge was successfully anchoring an offshore system like WA's floating liquid natural-gas platform, which weighs 600,000 tonnes – five times as much as an aircraft carrier – and must be secured

Dayong Jin
Director, Initiative for Biomedical Materials and Devices, University of Technology Sydney

Professor Dayong Jin and his team were recently awarded the Eureka Prize for Excellence in Interdisciplinary Scientific Research for their Super Dots technology – microscopic torches which fight disease by using a tiny beam of light to influence the behaviour of molecules. Jin's work convened experts from a variety of fields, including molecular biology, physics and engineering. As Australia embarks on its transition to a knowledge economy, adventurous collaborators like Jin will be at the forefront of industry-driven collaborative research – and forming strong international partnerships which encourage impact.

Maria Kavallaris
Director
Australian Centre for NanoMedicine
University of NSW

Advances in nanotechnology are changing the future of medicine. Professor Maria Kavallaris is recognised internationally for her innovative work in the field of cancer biology, which helps to reveal how cancers grow, spread and become resistant to therapy. Her research focuses on developing more effective – and less toxic – cancer therapies with nanotechnology, including drugs that can be delivered directly to tumour cells without "hitting" healthy cells. Kavallaris is a research leader at the Children's Cancer Institute in Sydney.

Ryan Lister
Laboratory Head
Epigenetics and Genomics, Harry Perkins Institute of Medical Research

Professor Ryan Lister is laboratory head at the Harry Perkins Institute of Medical Research. He researches epigenomes – the chemical compounds that surround DNA and tell it how to behave. If DNA is a musical instrument, epigenomes are the sheet music that tell it what notes to play. Epigenomes play central roles in the growth of humans, animals and plants. Lister's research sheds light on the essential building blocks of life and may help prevent disease or engineer drought-resistant crops. Lister was awarded the Prime Minister's Prize for Life Science last year.

Peter Quinn
Executive Director, International Centre for Radio Astronomy Research, University of WA

Professor Peter Quinn leads the International Centre for Radio Astronomy Research and its Square Kilometre Array (SKA). This global collaboration, headquartered in WA and South Africa, is the world's largest science project. Sifting through this data to detect faint signals from distant galaxies will be like "finding needles in a cosmic haystack", says Quinn. The infrastructure and human talent required to address the data-storage and analytic challenges prompted by the SKA – construction of which starts in 2018 – will result in future economic spin-offs in this age of big data.

Ian Reid
Professor of Computer Science, University of Adelaide

Professor Ian Reid's research pivots on computer vision. Driverless cars, robotic mining, smart security and even at-home stroke rehabilitation are possible when computers "see". Professor Reid led the Active Vision Laboratory at Oxford where he researched robot vision. His work received attention when he showed that the winning goal of the 1966 soccer World Cup final should not have been awarded. His current work is creating environmental maps, turning cameras into sensors that "understand" a scene. This has applications in areas such as robotics and surveillance.

Kadambot Siddique
Director, Institute of Agriculture, University of WA

Professor Kadambot Siddique, Hackett Chair of Agriculture at the University of WA, has a simple mission – feeding the world. Siddique's research examines how improved crop yields and better management can help Australia prepare for a warmer, drier and more populated future. "Science and technology [are] absolutely essential for humanity and we must use that to our benefit," says Siddique. His research is often concerned with future-proofing our food bowls and agricultural innovation. He is credited with developing the $300-million-per-annum chickpea industry in Australia.

> *We're preparing for the collaborative opportunities we know are out there*
>
> **KATE SMITH-MILES**

Kate Smith-Miles
Professor, School of Mathematical Sciences Monash University

Professor Kate Smith-Miles uses advanced maths to solve real-world problems. As an applied mathematician, she's helped psychologists, physiologists, doctors and even bionic-vision experts. Kate's passion for collaboration led her to establish MAXIMA (Monash Academy for Cross and Interdisciplinary Mathematical Applications). MAXIMA blends teaching, research, consulting and community engagement. "MAXIMA is a one-stop shop where people can go to access mathematical minds," she says.

Svetha Venkatesh
Director, Centre for Pattern Recognition and Data Analytics, Deakin

Svetha Venkatesh is a professor of computer science. Her expertise lies in developing new technology that recognises patterns in big data, which she has commercialised with two start-ups. Venkatesh's work helps doctors to predict suicide risk, reduces neighbourhood crime and even provides therapy for children with autism through the Toby Playpad app. Her work was used to create the technology that powers intelligent video surveillance software. Commercialised

Gordon Wallace
Director, Intelligent Polymer Research Institute, University

"Science is catching up to science fiction," says Professor Gordon Wallace, a renowned expert in the emerging field of biofabrication: printing 3D body parts. The bionic ear and eye have entered the mainstream, and Wallace insists it won't be long before we have made-to-order hands, bones and organs. He is optimistic about the future of biofabrication, but says that traditional boundaries between industries must be broken down if we are to capitalise on this emerging technology. "We may

VOGUE

5 female STEAM trailblazers on following their passions and the secret to their success

MENTORING THE NEXT GENERATION OF MATHEMATICIANS

ARC Australian Laureate Fellow, Professor Kate Smith-Miles from The University of Melbourne, is an applied mathematician. Her Australian Laureate Fellowship is developing mathematical techniques to better understand the strengths and weaknesses of algorithms essential to a wide range of fields such as machine learning, forecasting and software testing. Her methodology is being adopted by groups around the world and is soon to be available on a web resource known as MATILDA (Melbourne Algorithm Test Instance Library with Data Analytics).

In addition to her Laureate project, Professor Smith-Miles was awarded a 2014 *Georgina Sweet Australian Laureate Fellowship*. This additional award enables her to be an ambassador in a science and technology discipline, promoting women in research and mentoring early career researchers, particularly women, to enter and establish careers in research in Australia.

She remembers being inspired in her schooling to see the beauty in mathematics and enjoys sharing her love of the discipline to future students. She believes that female role models can be critical to success and she has tried to inspire girls through frequent public lectures and her YouTube video on Myth-Busting Mathematics.

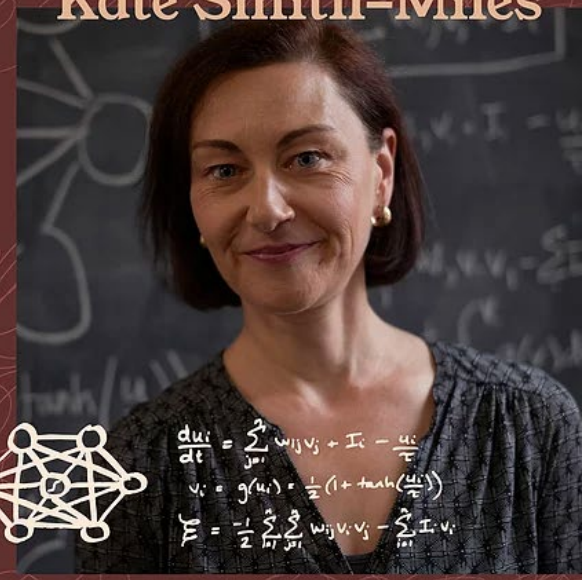
In her role as Chief Investigator at the *ARC Centre of Excellence for Mathematical and Statistical Frontiers* (ACEMS), Professor Smith-Miles mentors many researchers including Dr Sevvandi Kandanaarachchi, a female postdoctoral fellow who is working in a research team using mathematics and statistics to identify anomalous events such as assessing the risk of a bushfire igniting from vegetation on powerlines.

As a supervisor, Professor Smith-Miles says she finds it particularly rewarding to mentor the next generation to become independent researchers who generate their own successes.

Professor Smith-Miles loves teaching and training the next generation. She encourages students and academics to follow their passions first and highlights the importance of keeping everything in balance while striving for the satisfaction that comes from creating a positive impact on the world.

Mathematician Professor Kate Smith-Miles.
Credit: The University of Melbourne.

Kate Smith-Miles



Location: Melbourne
Affiliation: University of Melbourne
Research: applied mathematics

Maths is a language to describe our world. When you know how to speak that language you can use it to describe the world as it is now, and as it could be, and figure out how to improve things.

Imposter syndrome is a very real feeling for many mathematicians, and especially women I believe, since the field of mathematics can be quite hierarchical. We tend to idolise the genius stereotype and feel that we are not the real-deal by comparison. In maths you may feel that you are not successful for a long time. It's a career that needs great patience, but the rewards are usually worth the wait.

This talk is dedicated to the inspiration of Ms Elizabeth Kerr (1953-2003)

AMBITION:

"To get 369 in these exams, to work out *Kate's Theorem*, for someone else to use it, and to find a career and way of life that I would be happy in."

Key take home messages:

1. *"The Criticality of Mathematics Training in Creating Innovative Futures"* is both
   - for our society (technological solutions)
   - for our people (personal growth = brain training, empowerment, sense of purpose, job satisfaction, etc.)
2. As educators, you are critical to this innovative future!

Thank you!

Wishing you all a wonderful conference!

Questions?

e-mail: smith-miles@unimelb.edu.au

https://katesmithmiles.wixsite.com/home

THE UNIVERSITY OF MELBOURNE