NMSS NEWS

A word from the editors, Dana Ma and Jodie Lee.

In January 2023, the National Mathematics Summer School (NMSS) returned to Canberra! It was wonderful to have everyone gather at the newly renovated John XXIII College at ANU for two weeks to experience an in-person NMSS.

Whilst enjoying the nostalgia of being back at ANU, laughing out loud during Norm's number theory lectures instead of "haha" reacting, we welcomed some fresh faces to enjoy the NMSS experience. Further, we saw the return of our amazing EGs, but this time, in person.

Our staff and students represented all corners of the world - including EG lecturers Ty Ghaswala from the University of Waterloo and Asilata Bapat from her ANU office just around the corner (literally) - and represented all levels of experience, from one of our youngest students ever (baby Jarrah Smith) to previous NMSS Director Terry Gagen who paid the school a guest visit.

This year's NMSS newsletter includes a report written by first-time attendee and tutor, Karen Man, some Q&A with two alumni and, as always, a word from our superb director, Norm Do.

We also feature two exciting puzzles, a snail-themed maths problem and some fun snaps from this year's summer school!

TUTOR REPORT

Karen Man is a secondary school maths teacher at Danebank Anglican School for Girls. She writes about her first experience as a NMSS tutor.

After three years of nomadic Summer Schools, the last two being in the virtual world, NMSS had finally returned to Canberra!

The journey to Canberra wasn't without its logistical and COVID challenges. Nevertheless, students and staff members were able to be flexible and adapt to the changing environment and, armed with masks and RATs, most staff and students were able to arrive on time ready to dive deep into exploring what Mathematics has to offer outside of what is learnt in a high school classroom.

Being the first NMSS in Canberra for a few years, it also meant that everything was new to all participants, including those in the Experienced Group (EGs). Students arriving at John XXIII College at ANU were met with not only the academic challenges, but also the physical challenges with some students having to do their own laundry for the first time. Students (and some staff) would accidentally lock themselves out of their bedrooms, only to be saved by Em or Michael, who did an amazing job looking after the welfare of both staff and students. The EGs provided daily "days since EG locked out" reports for the amusement of all.

The recently renovated John XXIII College common spaces provided students and staff with many open spaces where they were able to chat, play games and solve puzzles together. The students also braved the hot afternoon sun to walk to Civic most days to enjoy the city centre. The weekend also gave time for the students to explore some of the significant landmarks in Australia's capital, including Parliament House, the Australian Museum, the Art Gallery and Questacon.

> **"***…the students fully embraced the challenges that the school had to offer.*

Academically, the students fully embraced the challenges that the school had to offer. They wholeheartedly engaged in their lectures on Number Theory, Algorithms, and Projective Geometry. The EGs dabbled in Automata, Braids, and Latin Squares as well as seeing the second part of the Number Theory course for the first time. They were challenged by the problems they faced in tutorials and were often put into confusion by the vague, but hopefully somewhat helpful, comments and suggestions by their tutors. Many appreciated the 1:1 time with their tutors and lecturers in the post-dinner study session while the tutors bustled around the dorm trying to see each of their students before time was up.

Besides the academic program, a highlight was the alumni lectures, the first given by our very own Dr Olivia Smith whose passion for mathematics radiated through the room as she spoke about how mathematics (in particular, NMSS) has shaped her career. We also welcomed Dr Justin Koonin for the second alumni talk, and all the students and staff were enraptured with his stories about his incredibly diverse set of achievements and experiences. We were also honoured to have Distinguished Prof. Susan Scott give this year's Blakers lecture in the iconic Shine Dome.

I would like to commend the EGs who, on top of their own challenging academic curriculum, organised games, competitions, and activities throughout the two weeks for both staff and students. They looked out for the main group students and created and continued long time NMSS traditions to pass on to the next generation of EGs.

In order to bring students and staff members from all over Australia into one place, it takes extensive planning and organising, even without the risks encountered in a world coming out of a pandemic. I can only imagine the constant writing and rewriting of plans and coming up with contingency plans on contingency plans that was being done prior to the start of the School. All credit goes out to the director and the senior staff team whose hard work must be recognised in making this possible.

As a first time NMSS attendee, I had no idea what I was getting myself into. However, in the same way the students have learnt a lot and changed from their experience of NMSS, I know I have too. This NMSS experience could not have been had if not for the 73 students and 19 staff who were part of the 2023 National Mathematics Summer School.

A (large) subset of the NMSS 2023 staff members.

ALUMNI Q&A

Justin (centre) with NMSS tutors, Dana, Andy, Karen and Jodie.

What is your day job and what inspired you to pursue your current career path?

I'm now a fund manager. That means that people give us money – mostly it's large superannuation funds, but about a quarter comes through private individuals – and my job is to decide where to invest it to generate the best long-term returns. I also help run the philanthropic programme started by the founder of my company.

It was a bit of an accident really that I ended up doing what I am doing. I had previously had no experience in the financial world, nor any interest really in working in it. I was approached by someone I knew from school days, thought I'd give it a go, and I haven't looked back. That was eight years ago.

> **"** *Keep learning as much as you can, and the world will present you with amazing opportunities...*

How do you apply mathematical concepts in your workplace or everyday life?

Investing for the long-term is fundamentally a game of probabilities. You never know with certainty how things are going to turn out.

Having a mathematically trained mind helps you cut through the noise, so people with these skills tend to be better at investing than those without it. We like to hire people with maths or physics PhDs, even if the work isn't highly technical.

(Side note – there are other areas of the finance world, like high-frequency trading, which **are** more technical. Personally, I don't find these as satisfying, as you are dealing with a bunch of numbers rather than businesses and people, but some people do.)

What is one memorable moment from the National Mathematics Summer School?

Roaming the streets of Canberra at all hours on the last night (oops... I'm probably not meant to say that... I'm sure it's not allowed now!). In truth, I met people at NMSS who are still part of my life twenty-five years later, and that is a remarkable gift.

What do you know now that you wish you knew when you were a NMSS student?

That you don't have to have everything figured out right now. Keep learning as much as you can, and the world will present you with amazing opportunities that you can't even envisage at the moment.

You're involved in an incredibly diverse set of projects, spanning global health and human rights to investment and corporate governance. Do you have any tips for managing your time and energy across so many interests and demands?

Figure out what really needs to be done, and what doesn't. At some point I realised that I could get 80% of the way there with the first 20% of effort (that's called the Pareto Principle).

It means you have to let go of perfectionism, but this approach also lets me keep a lot of balls in the air at the same time.

Also, some jobs are scalable – that is, output is much better than a linear function of input – and some are not. It doesn't matter whether I'm investing $100, $1m or $1b. The process is the same, so we can have quite a large impact with a small time. Other jobs, you put in X hours and you produce Y. If you put in $2X$ hours, you'll produce $2Y$. That's not necessarily bad, but if you want to be able to juggle lots of things, having something in the former bucket is helpful!
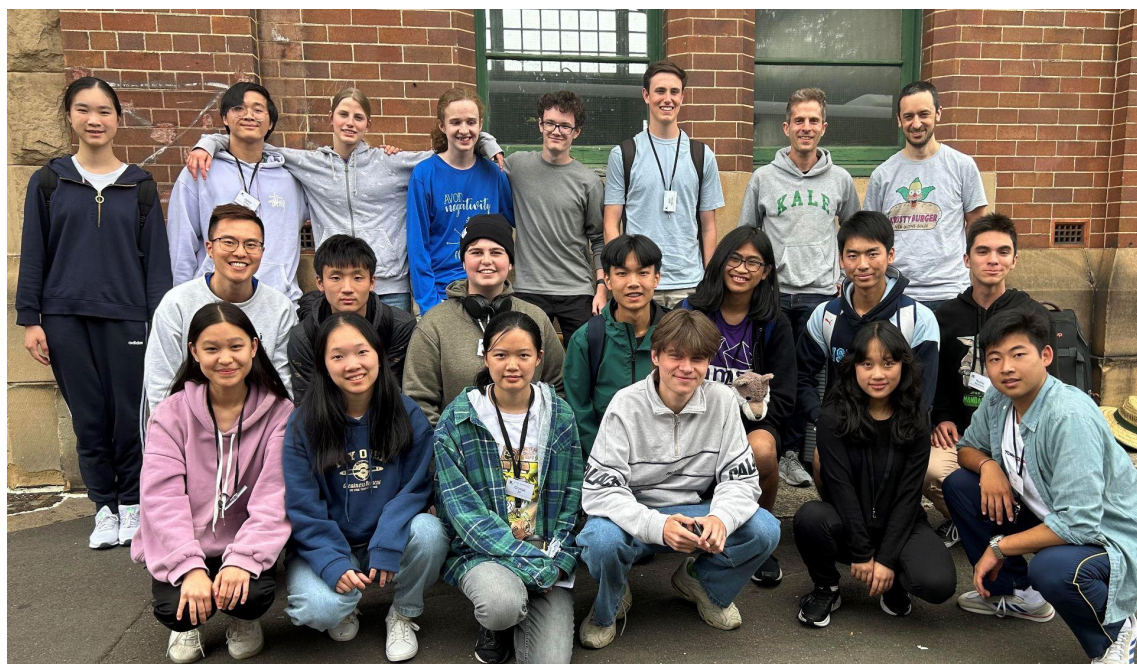
Sydney NMSS students and staff with Justin Koonin (back row, second from right) on the way home from Canberra.

SOMEWHERE OVER THE REAL LINE

Somewhere over the real line
Way up high
There's a number I've heard of
Commonly denoted i

Somewhere over the real line
i's feeling blue
She's so far away from her real friends
Like zero, one and two

Someday she'll wish on $\mathbb{Z}$ five star
Where plus and minus i just are
Like 2 and 3
But 2 and 3 in the complex plane
Lie on a certain narrow lane
That's where you'll find e

Somewhere over the real line
i is feeling sad
Wishing that she had the imaginary part
That the integers had

If happy natural numbers lie along the real line
Why, oh, why can't i?

A NEVER REPEATING PATTERN

If asked to tile a plane, you might think of using tessellating hexagons or triangles, or perhaps the squares on your bathroom floor. Now, what if the pattern could never repeat? Maybe your mind drifts to a jigsaw puzzle, each piece unique but fitting together perfectly.

Some mathematicians are interested in tile shapes that can cover the whole plane without ever creating a repeating design, known as **aperiodic tilings**. In other words, there is no pattern that you can copy and paste to keep the tiling going.
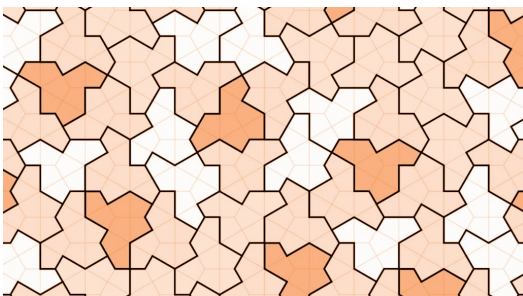
Until recently, aperiodic tilings have always required at least two differently shaped tiles. In a groundbreaking discovery, a retired print technician named David Smith stumbled upon a funny hat shape he believed could be used in an aperiodic tiling (pictured on the left).

Working together with mathematicians Myers, Kaplan and Goodman-Strauss, it was found that Smith had discovered not only one, but an infinite number of single tiles that can generate an aperiodic tiling.

These tiles are called **einstein tiles**, and create a simple but beautiful pattern.

*For more, here is the preprint article.
https://arxiv.org/abs/2303.10798*

A NEW WAY TO CUT A PIZZA

Can you cut a pizza (circle) into 12 congruent pieces, such that half of them have crust (circle boundary), while the other half do not? The pieces must have the same shape and area, but can be mirrors of each other.
Bonus: Can you do it with identical pieces, where pieces are not mirrors of each other?

This problem was supplied by Dima Kamenetsky, NMSS alumnus (2001-2002).

Q&A WITH PROF. NICK WORMALD

The **Thomas Ranken Lyle Medal** is a prestigious award that recognises outstanding achievement by a scientist in Australia for research in mathematics or physics. This year the Medal was awarded to **Distinguished Professor Susan Scott**, whom NMSS 2023 attendees were fortunate enough to have as the Blakers Lecturer, and **Professor Nick Wormald**, a former NMSS student (1971) and staff member (2001-2002). Congratulations to Prof. Scott and Prof. Wormald for their inspiring accomplishment!

Prof. Nick Wormald shares a few memories about his time at NMSS.

Could you say a few words about your areas of interest?
My areas of specialisation are combinatorics and graph theory, and in the last few decades, I have concentrated on random graphs and other combinatorial structures, as well as related questions on the enumeration of such objects.

Random graphs are also called random networks, and some of these are difficult to study due to the unusual ways of specifying their probabilities. This often happens when people attempt to use random graphs to model real-life networks (e.g. social networks).

I've also spent a lot of effort on graphs with simply specified probabilities. For instance, if you take a random graph with a given number of vertices where each vertex has 3 neighbours, each such graph equally likely, what properties is it likely to have? One of my old results states that if the graph is large, it is highly likely to have a single path visiting each vertex exactly once.

Are there any NMSS memories that stand out to you?

Larry Blakers was the director and Professor Paige gave the main lecture series on projective geometry - I found it very interesting at the time even though I never returned to the topic.

Another main course was on the programming language APL with lab time on time-shared computer terminals. I could not follow all of the talks given (the one presenting 3rd year university level differential equations might have been a bit too advanced for just about everyone) but the projective geometry was nice and I still remember seeing Pappus' theorem there.

The summer school also marked first meetings with a number of my cohort who became friends for following years. It was only the third NMSS so there were few past students. There were no IGs or EGs or tutors, instead there were two teachers there to help with local organisation and supervision.

The excursion on the weekend included a visit to the top of Mt Kosciuszko - my first time there - and staying overnight at a ski lodge.

What impact did NMSS have on you and your mathematical journey?

In those days, Australia was not entering the International Mathematics Olympiad so there were no training camps or anything similar. NMSS was the first opportunity I had to experience advanced talks of any sort in mathematics. I was already particularly interested in maths, but this cemented the idea.

Also, it was accidentally instrumental in my going to ANU since it was a letter from one of my friends from NMSS who informed me about National Undergraduate Scholarships at ANU. This lead to me studying pure mathematics there and at ANU, I met up with other NMSS students. In my Honours year, my three other classmates had all been with me at NMSS. Back then, there was no internet and phone calls were expensive, so handwritten letters were the primary means of communication. If I had not made it to ANU, it is doubtful that I would have been in touch with such wonderful people.

# *COOKIE CIRCLE CONUNDRUM*

7 people sit in a circle, initially one of them has 7777 cookies and everyone else has none. At any point, a move consists of any person giving 1 cookie to their left and 2 cookies to their right, or taking 1 cookie from their left and 2 cookies from their right. Is it possible for a different person to end up with all 7777 cookies after some number of moves?

This problem was supplied by Jeremy Yip, NMSS alumnus (2015).

SNAILS, SLIME & SEQUENCE TIME

Turbo the snail sits on a point on a circle with circumference 1. Given an infinite sequence of positive real numbers $c_1, c_2, c_3, \ldots$, Turbo successively crawls distances $c_1, c_2, c_3, \ldots$ around the circle, each time choosing to crawl either clockwise or counterclockwise. Turbo leaves a trail of snail slime as it crawls to mark the points on the circle it has crawled across and visited.

For example, if the sequence $c_1, c_2, c_3, \ldots$ is 0.4, 0.6, 0.3, ..., then Turbo may start crawling as follows:
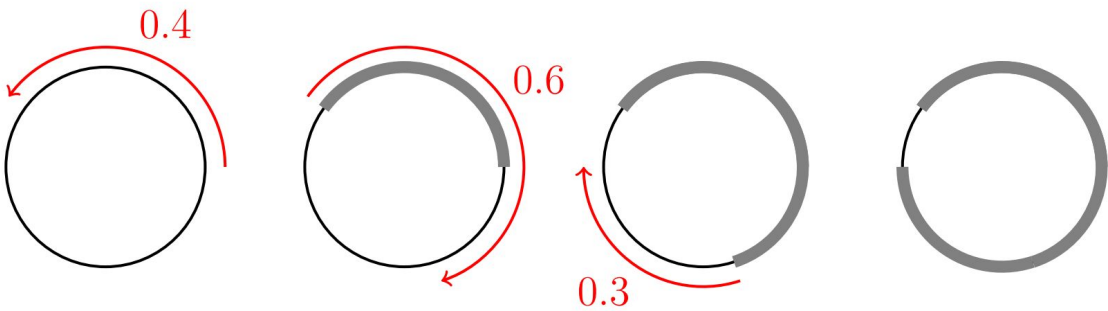
Determine the largest constant $C > 0$ with the following property: for every sequence of positive real numbers $c_1, c_2, c_3, \ldots$ with $c_i < C$ for all i, Turbo can (after studying the sequence) ensure that there is some point on the circle that is not covered with snail slime.

This problem was sourced from the 2023 European Girls Mathematical Olympiad. Congratulations to NMSS 2023 student Eunsu Choi who represented Australia at the EGMO and was awarded a silver medal! NMSS 2023 staff member Dana Ma was also present as Deputy Leader of the Australian EGMO team.
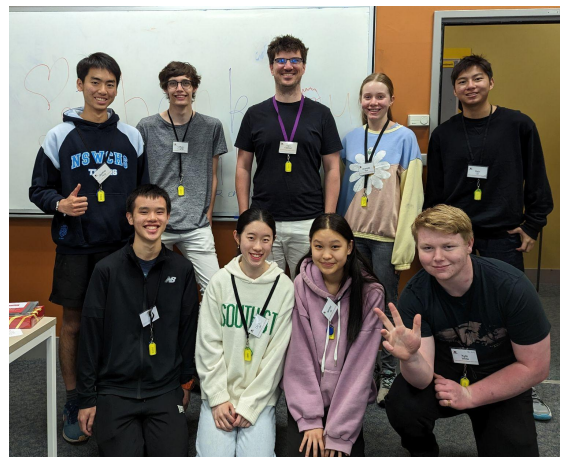
NMSS tutorial groups.

STUDENT REFLECTIONS

By LJ Spriggs
NMSS Student 2023

Throughout my childhood, when someone would ask me what I loved to do - whom I was gonna be when I grew up - I would have always responded: "Science!" Or, astrophysics, more specifically. I read books on science, studied science, and got involved with science programs; it was even at a science program that I first heard of NMSS!

It was a guest mathematics presenter that mentioned it and, at first, I had thought, "Two weeks of intensive math? Over the summer? Instead of science?" The idea was almost comical--it certainly was for my parents who still manage to tease me for attending. However, the prospect of NMSS earwormed its way into my mind and, the more I thought of it, the more appealing it became.
I slowly realised that science - and, especially, astrophysics - is mathematics. All of it. Every theory I had learnt to explain, I would then learn to mathematically represent and every equation I'd memorised, I would then learn to mathematically derive. Math is the "why" of science!

So, with this revelation behind me, I thought I'd give the NMSS application my best shot - I had, by this point, begun reading books on, specifically, mathematics and was thoroughly enjoying them.

I didn't believe there was even a sliver of possibility of my getting accepted into the summer school but I'd been working on leaving no stone unturned, so I didn't let my slim chances stop me.

As you've probably guessed, I was successful in my application and I spent the seemingly endless months (it was only three) until the program began squealing and stimming over this wild and incredible opportunity. I think my parents were just as excited to have me out of the house by the time January rolled around.

At the camp, I was truly thrown into the deep end. The tutors - who I suppose in this analogy would be life jackets - managed to respond with more questions than answers; I was left treading water in an entirely unfamiliar environment and surrounded by the strongest, most elegant swimmers I had ever met. Nevertheless and in spite of my severe imposter syndrome, I listened to Norm's lectures eagerly, taking diligent notes and desperately trying to not lag in my understanding.

He spoke of number theory, referencing so many terms I'd heard only once or twice whilst reading science books. This math was so familiar ("2 + 2 = 4"), yet so alien ("2 + 2 = 1 mod 3"). It challenged everything I thought I knew, every concept I had claimed to understand. I learned that this math - pure math - is the "why" of mathematics!
I was enraptured.

> **"***At NMSS, I learnt so much and yet so little.***

We learned not just of number theory, but of algorithms and projective geometry as well; both of which turned out to be entirely, mind-blowingly different from the visions of programming and shadow art that I had devised for the respective topics.

At NMSS, I learnt so much and yet so little. I feel as though I know so much more but, truly, so much less. A whole world of thought and knowledge has been unlocked.

An overwhelming curiosity about the "why" of mathematics has been unleashed in my mind though I've so frustratingly little time to nurture it. On the first day of camp, if someone would've asked me what I loved to do - whom I was gonna be when I grew up - I would have responded with "Science!". Now, however, if someone were to ask me, I suppose I might tell them that I'm not certain but I'll forever be loving and studying mathematics.

National Mathematics Summer School - Not Just Maths

A video by Rain Lai
NMSS Student 2023

I was extraordinarily lucky to be invited to the National Mathematics Summer School for 2023. It was a lifetime memorable experience. I thought such an amazing program deserves more attention, and for that, with my limited ability, I made a short video to share my experience.

https://www.youtube.com/watch?v=Pxqkg8taGUw&ab_channel=Still_RAINing

By Enda Han
NMSS EG Student 2023

Last year, I wrote a piece in this newsletter reflecting on my experiences as an IG at an online NMSS '22. At the close of the reflection, I wrote the following: "... NMSS 2022 provided a week which, looking back on it, could only be described as nigh on bliss. Thanks for the experience of a lifetime."

With an almost fanatical conviction, I thought that NMSS '22 was as good as it got and so naturally, I jumped at the chance of being an EG at NMSS '23.

Expecting the same great academic program just with the added "responsibility" of staff-sanctioned IG abuse, I, along with the other 10 EGs, went into the program with some level of confidence in what to expect from the school. Yet, as the Orwellian saying goes, ignorance is strength, and that initial hubris that we made no mistake in holding over the IGs quickly unravelled as we came to realise just how very different an in-person NMSS was going to be.

After all, it had been 4 years since the last iteration of a NMSS in Canberra and 3 since it was in-person at all and we, as the EGs, were unceremoniously tasked with the reinstitution of a culture that we had never experienced.

So, feigning the confidence and self-assurance that any good EG ought to, we did our level best to plan activities, be disorganised come EG announcements and somehow still find time to stare at the ceiling for at least a few hours a day struggling with maths, or, more accurately, the trauma of learning about braids for the nth time.

Indeed, the 7-hour program of '22 was now very much a 24-hour program. Whether that was slaving away at "secret EG business" at 7 am, stressing about some activity yet to be planned for the coming day at ungodly hours or being woken up by Chris' incessant muttering at the crack of dawn, sleep deprivation was part and parcel of the EG experience. Did I hate it? Absolutely. Would I have it any other way? Absolutely not.

> **"** *Visceral was the realisation that people just like me were not in short supply.*

Last year I was wrong – NMSS '22 was not as good as it got. Maybe it was that I had finally gotten over the delirium of lockdown or that people were no longer trapped behind screens (which supposedly made me significantly taller) or simply that I was an EG this year, but at NMSS '23, whilst the academic excitement was important, the people were what made it truly special. As I hope was the case for many, visceral was the realisation that people just like me were not in short supply.

This January I learnt a lot. I learnt about automata, braids, Latin Squares, and I did a little more number theory. I also learnt that instant noodles at 1am go hard (thanks Eunsu), that Oscar goes to the gym, that 2+2=5 for extremely large values of 2, and that, whilst there were plenty of hiccups along the way and the occasional suboptimal play, two weeks was not nearly long enough.

To Norm, Em, Michael, Ellena, Brendan and all the other staff, lecturers and tutors, I couldn't thank you enough for making NMSS '23 as enjoyable as it was, and I hope we EGs didn't prove completely incompetent.

To my fellow EGs, we survived. And finally, to the IGs, as much as I hate to admit it, you were a great bunch and really what made the summer school such a blast.

Oh, and to those of you who will be lucky enough to be in my position next year, never forget: EG>IG. And so, I close with some degree of, perhaps again misguided, fanatical conviction. Here's to the sleepless stress-filled nights, to the hours spent staring at my ceiling, and to the friends I made. Here's to the two weeks in January that could only be described as nigh on bliss. Here's to NMSS '23.

Thanks for the experience of a lifetime … 2.0.

"EG>IG"
EG tutorial group with EG tutors Ellena and Brendan

A WORD FROM THE DIRECTOR

By Norm Do
NMSS Director

NMSS RETURNS HOME

In January 2023, the National Mathematics Summer School returned to the Australian National University for the first time in four years. The bushfires in 2020 and the pandemic in 2021 and 2022 weren't enough to stop the school from running. However, they did prevent us from sharing meals at John XXIII College, visiting the spectacular Shine Dome, and seeing the sights of Canberra. So it was particularly exciting to be back at our usual home!

When I took on the role of NMSS Director, I knew that my primary goal would be to maintain the culture of the school against the changing winds of maths education and society more broadly. The summer school is truly the most amazing learning and teaching environment that I have been a part of, but also something that I had taken for granted. Recreating this culture from year to year would require a deeper understanding. So I spent some time reflecting on the fundamental principles – the axioms, if you will – of the National Mathematics Summer School.

As I often tell my students, to understand what something is, it helps to also understand what it is not.

- NMSS is not just a holiday program… although I'm sure that some parents/guardians appreciate us taking their offspring into our care for two weeks!

- NMSS is not just an extension of school maths… although a firm foundation of the basics taught at school is desired, and we certainly push students far beyond the curriculum.

- NMSS is not just preparation for university maths… although the experience, and to a lesser extent the content, should help with further studies.

In brief, I have settled on the belief that NMSS provides a genuine experience of mathematical discovery in a nurturing environment. It is the authentic nature of the program that allows students to flourish academically and make strong social connections with like-minded peers.

The two weeks of the summer school may be but a fleeting moment in the arc of a person's life. However, I believe that the experience that we are aiming to cultivate is valuable, and in some cases transformative, for the students and staff involved.