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## **AMSI Schools Division**

The AMSI Schools team provides professional development sessions and school visits across Australia. Together we look at how to best communicate mathematics to your students and source engaging classroom activities to capture and stimulate creative mathematical minds.

AMSI Schools division delivers a multi-faceted program devoted to encouraging more Australian students to study and enjoy mathematics throughout their school years and into university.

The vast majority of our work with schools is funded by grants from government and industry. Funding partners in the 2013-2104 round of projects were Boeing, The William Buckland Foundation, the DEECD and AMSPP.

## **About Michael O'Connor**

From 1988 until October 2013, Michael taught mathematics and science at a number of secondary colleges in New South Wales and Victoria. Since October Michael has been the Schools Outreach Manager for AMSI. In the last twelve months, he has worked with more than 200 teachers from kindergarten to senior secondary in 24 schools around the country. This work has included modelling classes, observing and providing feedback, unpacking the curriculum, planning and professional development. It has been a very insightful period. This essay is in many respects a reflection on twenty-six years of teaching, learning and hunting for the spark that can strike a light for students and teachers alike.

Charles Lutwidge Dodgson was both an author and a mathematics teacher. He was many other things besides, but for the purpose of this talk it is his writing and his teaching that provide us with the best mirrors with which to seek our elusive Spark.

Queen Victoria was so enthralled by “Alice in Wonderland” that that she demanded that whatever Carroll’s next book should be, she wanted a copy.



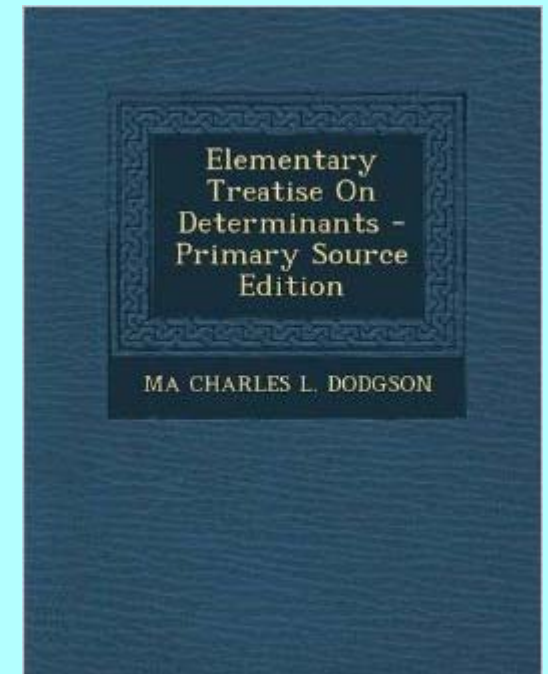
It turned out to be . . .



*An Elementary Treatise on Determinants.*

One can well imagine the great lady invoking her most distinguishable aphorism upon the tome’s arrival.

Reset



## Carroll on the meaning of the Snark

“I’m very much afraid I didn’t mean anything but nonsense!

Still, you know, words mean more than we mean to express when we use them: so a whole book ought to mean a great deal more than the writer meant.

So, whatever good meanings are in the book, I’m very glad to accept as the meaning of the book.”

“we live in a world not of our making that our imaginations help to make”.

Adam Gopnik,  
Introduction to annotated edition, 2006

Martin Gardner:

The Snark is a satirical autobiography

The Bellman - Bell Ringer

Boots - Helmsman

Barrister - Behaviour Management

Broker - assessor

Billiard Marker - "chalkie"

Banker - Numbers man

Beaver - Pace and lacing ideas

Baker - 42 boxes of "baggage"

Butcher - single-mindedness





## **Expert Teachers**

- have high levels of knowledge and understanding of the subjects that they teach,
- can guide learning to desirable surface and deep outcomes,
- can successfully monitor learning and provide feedback that assists students to progress,
- can attend to the more attitudinal attributes of learning (especially developing self-efficacy and mastery motivation), and
- can provide defensible evidence of positive impacts of the teaching on student learning.

Herein lies the differences between the terms ‘expert’ and ‘experienced’.”

(Hattie 2012).

- Experts excel only in their own domain.
- Experts perceive large and meaningful patterns.
- Experts can work quickly and solve problems with little error.
- Within their domain, experts possess remarkably large short-term memories.
- Experts see and represent problems at a deeper or principled level, whereas novices focus on superficial aspects.
- Experts spend relatively more time analysing problems carefully and qualitatively.
- Experts have strong skills in self-monitoring.”  
(Hattie, Yates, 2013)

“What’s the good of Mercator’s  
North Poles and Equators,  
Tropics, Zones, and Meridian Lines?”

So the Bellman would cry: and the crew  
would reply

“They are merely conventional signs!

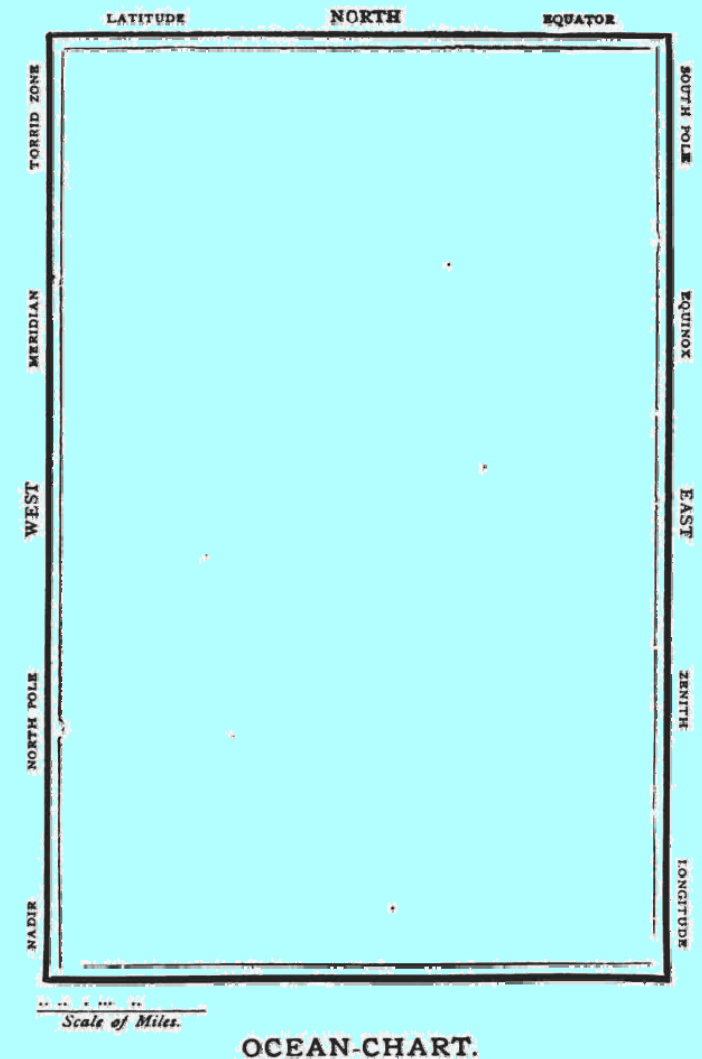
“Other maps are such shapes,  
with their islands and capes!

But we’ve got our brave  
Captain to thank”

(So the crew would protest)

“that he’s bought us the best

— A perfect and absolute blank!”



One explanation for the origin of boojum is that it can be found in “mumbo jumbo”.

It is, unfortunately, many people’s experience that mathematics is just so much mumbo jumbo.

## The Five Unmistakable Marks of a Snark

- their taste, which while at the surface level refers to how the taste when cooked can also be interpreted as their taste in fashion.
- their habit of getting up late
- their slowness in taking a jest
- their fondness for bathing machines and finally
- their ambition

The Modern Teenager!

Hide Caption

“if your students are not successful in mathematics, look not to deficiencies in the student, instead look to how you can change your practice”.

John Mighton (2003)

None of us likes to think of ourselves as “below average”

however the very definition of *average* means that half of the population always will be!

Rather than focus on our current ability level it is more advantageous to seek to improve continually whether this be by using “thimbles and care”, “forks and hope”, “railway shares”, “charm” or “soap”.

The AMSI approach to teacher professional development is to meet teachers at their point of need, to offer a variety of materials, resources and support that enables teachers of all experience levels to continue to grow, develop and improve. We strive to help all of the teachers we come into contact with become comfortable in their own skin and thus make the classroom truly their own, where they feel free to roam all areas rather than staying safe at the front and “appear(ing) unaccountably shy.”



# Developing Reflective Practice

- How did that (lesson) go?
- What parts worked (particularly) well?
- What parts did not work well?
  - What can I do next time to correct this?
- Did I interact with each student in the class by
  - Asking questions of individuals
  - Giving each of them an opportunity to contribute to the lesson
  - Guiding them toward deeper understanding and engagement
- How did the students interact with each other?
- How often did I seek feedback from the students and check for understanding
- Was there anything left unanswered that I can follow up on next time?
- Where were there any opportunities for incidental and/or remedial teaching?
- Where did I physically spend my time?
  - What were the reasons for this? How aware was I of this at the time?
  - How did I spend my time in these locations? Was I waiting?
  - Was I observing and monitoring progress and performance.

So what was Dodgson like as a teacher?

We know he could entertain, particularly in his stories. We also know that he was a reasonable mathematician. As to his ability to teach however, the evidence is mixed (Wilson, 2008).

In particular reference to school aged students, apart from a few arithmetic “tricks” that he performed he did not seem to have the spark. Also, he did not persevere in the school environment long enough to develop the skills, the total of his experience coming to less than a year.

(Who are you?)

We need firstly, to develop within ourselves a robust capacity for reflection and metacognition, thinking about what we are thinking and doing.

*engage with (the Snark)... every night after dark ...and use it for striking a light.*

This approach to learning has a long tradition, going back at least to Socrates who believed that the “unexamined life was not worth living

See Dean et al (2012) 2nd edition of Marzano’s (2001)

The language you speak

*I said it in Hebrew – I said it in Dutch –  
I said it in German and Greek:  
But I wholly forgot (and it vexes me much)  
That English is what you speak!*

Are the students are catching what we are pitching?

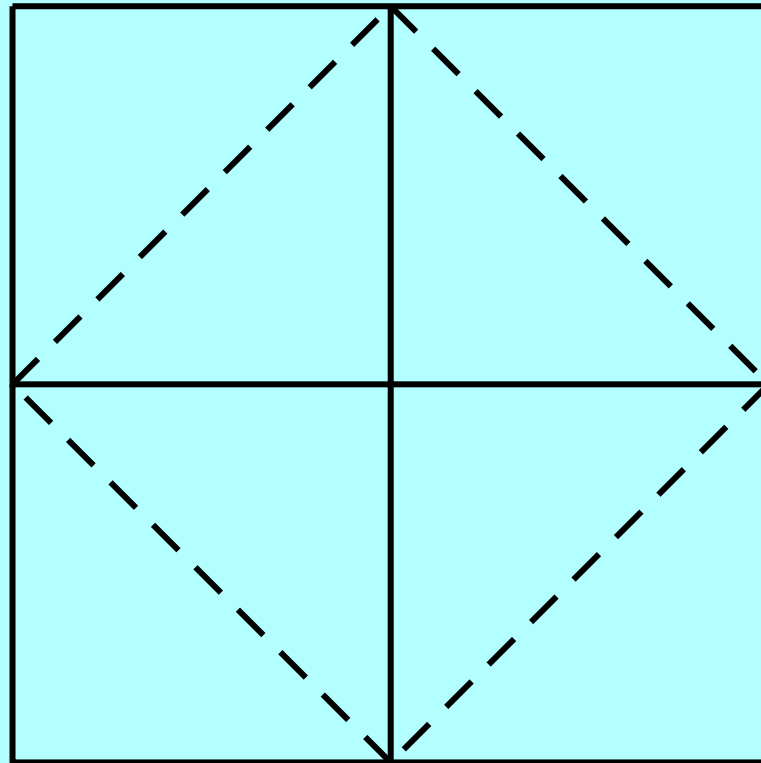
“you don't understand anything until you learn it more than one way”.

Marvin Minsky

“if a scientist cannot explain to the woman who is scrubbing the laboratory floor what he is doing, he does not know what he is doing.”

Ernest Rutherford

- Sequence 8 Actions
- Present 4 Actions
- Reset
- Hide Segments

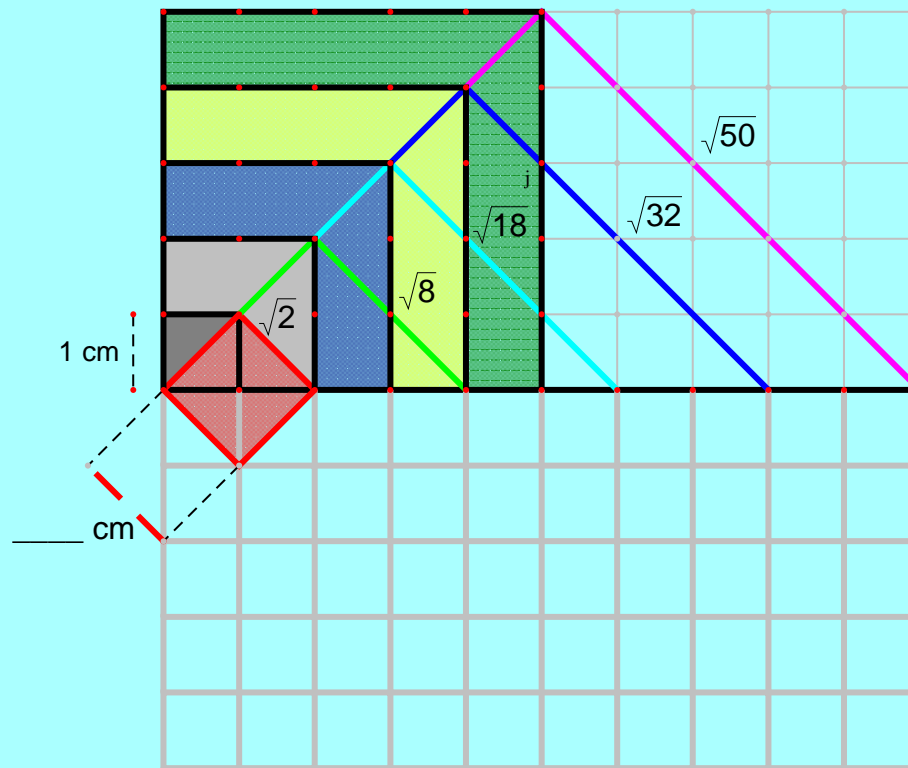


Year 8:  
Investigate  
irrational  
numbers

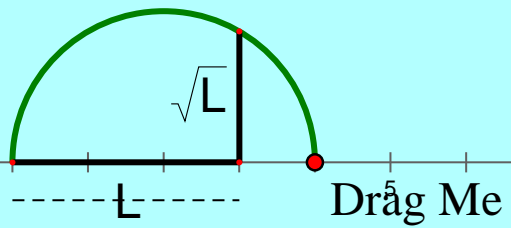
Please take a paper square

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To show that  $\sqrt{2}$  continues on indefinitely as a decimal, draw the parent square with ever larger units: 4 cm, 4 dm, 4 rubber chickens, 4 m, etc.



Geometry with Mathomat and Beyond,  
 Objective Learning Materials  
 Picciotto and O'Connor, 2014



Set L =

Drag Length L = 3.00 cm

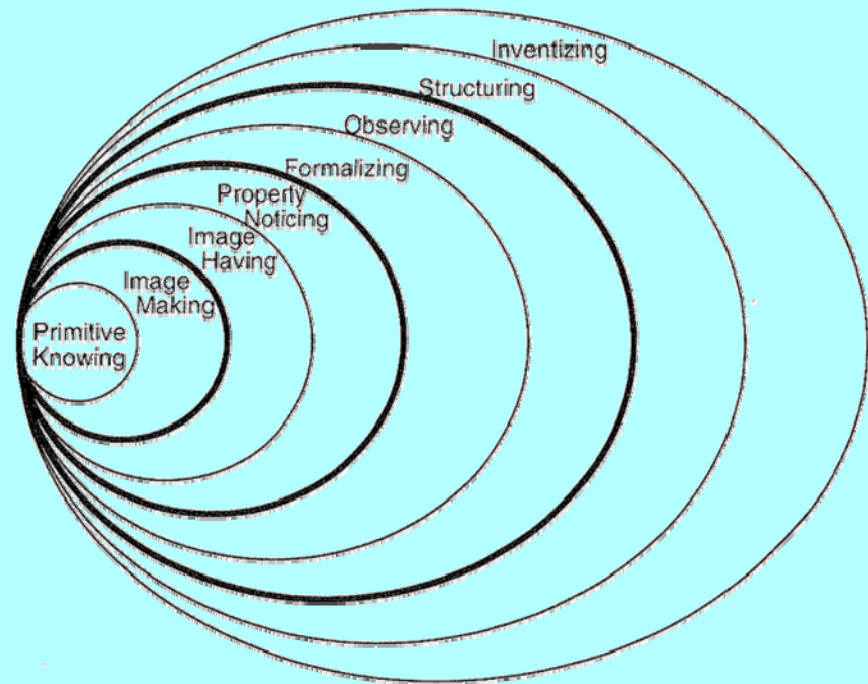
$$\sqrt{L} = \sqrt{3.00 \text{ cm}} = 1.73205 \text{ cm}$$



## Developing Understanding

Understanding of mathematical concepts is not a fixed or static quantity. Like Carroll's response to the meaning of The Snark each concept holds within it much more meaning than we originally perceive or intend.

Pirie and Kieren (1989)

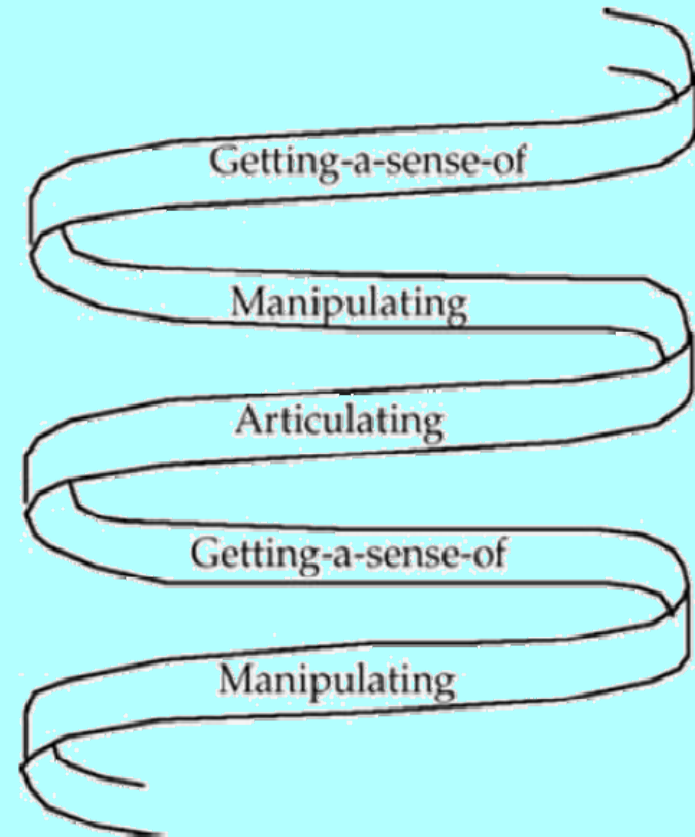


**Manipulating** – either physical or in the imagination

**Getting a sense of** – recognising the “feel” of the idea being studied

**Articulating** – bringing the perceptual sense to a conscious level. This acts to clarify the idea, to give it solid form. This in turn creates a completely new “object” echoing Gopnik’s (Carroll, 2006) assertion that “we live in a world not of our making that our imaginations help to make”.

Mason et al (2005) Open University



## The teacher-student relationship

After finding or establishing a common plan or goal though, the barriers come down and an openness to learning replaces it.

This is one reason why many educators advocate the finding of a problem to be solved as a means to assist in learning.

In the work that the AMSI Schools division has done around the country aiding teachers in implementing the new curriculum there has been a *distinct progression* in what teachers have asked for. In the first year or two the emphasis was almost solely on the Content strands. Now we are seeing a desire to unpack proficiencies in increasing detail.

# **The Four Proficiencies** (Doug Clarke on Friday)

(Conceptual) Understanding

(Procedural) Fluency

Problem Solving (Strategic Competence)

(Adaptive) Reasoning

# Polya's Problem Solving Principles (1945)



1. Understand the problem
2. Devise a plan

Partial Strategy Checklist

Guess and check	Look for a pattern
Make a list	Draw a picture
Eliminate possibilities	Solve a simpler problem
Use symmetry	Use a model
Consider special cases	Work backwards
Use direct reasoning	Use a formula
Solve an equation	

3. Carry out the plan
4. Look back

Conrad Wolfram, the co-founder of Mathematica and Wolfram Alpha, has his Stages of Doing Mathematics.

Like Polya, there were four components:

- 1) Define the questions
- 2) Translate into Maths (convert the real world into mathematics)
- 3) Compute Answers
- 4) Interpret Results (convert the mathematical solutions back into real world answers)

The Wolfram Demonstrations Projects is well worth exploring.

<http://demonstrations.wolfram.com/>

# The Subject of the Beaver's Lesson

Hide Caption

Pick a number

Hide Caption

We add Seven,

Hide Caption

Add Ten,

Hide Caption

Multiply out By One Thousand diminished by Eight.

Hide Caption

Divide, as you see, by Nine Hundred and Ninety Two

Hide Caption

Subtract Seventeen

Algebraically

$$\frac{(x + 7 + 10)(1000 - 8)}{992} - 17$$

Reset

## Do not Defend the Indefensible

The Barrister's Dream exemplifies much that tends to disengage and alienate students from the learning process. The Snark speaks for an interminably long period of time. When it comes time for the jury (class) to speak they do so all at once without pause or attention to others. The Snark defends, prosecutes, judges and pronounces sentence on a defendant who is incapable of being defended because it is already dead.

Teachers, schools, even educational consultants can be guilty of defending theories and techniques that the evidence does not support. In order to improve the learning outcomes of students it is sometimes necessary to let go of ideas and practices we have used, and in some cases held dear, for many years.



Einstein is attributed with saying that

"insanity is doing the same thing over and over again but expecting different results."

If we truly want to change the results we are receiving we need to honestly, earnestly and deliberately work on changes to what we practice.

## Learn from others even while you teach



In this Fit, Carroll describes what can happen when only the observable actions of good practice are copied to the exclusion of the reasons why they are done and how.



The Banker observes that the Baker has courage and, so inspired, rushes madly ahead only to meet with a most gruesome fate.

His zeal has the effect of turning him into a negative of what he thought he was accomplishing. The Banker is an example of one who cherry picks parts of the solution, and focusses on this to the exclusion of the rest. It is also suggestive of holding individuals to a standard of expertise that they may not have.



## Developing Deep Understanding

It is important for individual teacher development to create our own notes and to write our own assessment materials rather than just borrowing from other people.

Text books and Black Line Masters are static documents unless or until the teacher using them has a sense of how they were put together, what the links between ideas are and why they are important.

By engaging with the subject matter and turning it over in our minds, looking at it from different perspectives, always being open to discovering new properties we become better equipped to lead our students into that same place of “*aha*” moments and gratification.

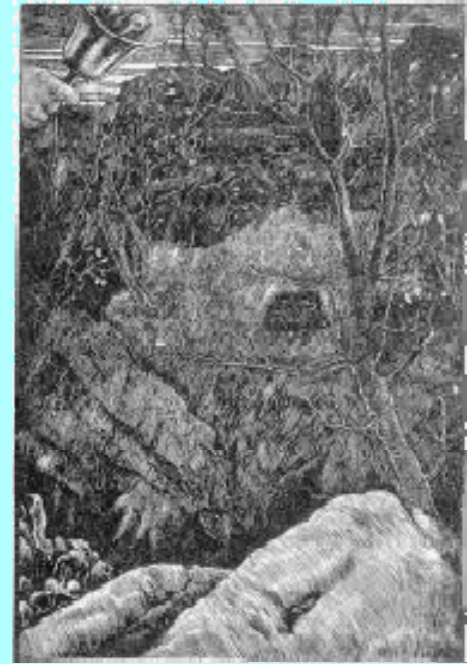
## The Vanishing

This last chapter of Carroll's story ends, sadly, with the Baker vanishing without a trace. Why? And in the allegorical sense of this essay, why do teachers continue to vanish from our classrooms?

At the end the Baker, was separated from the rest of his company.

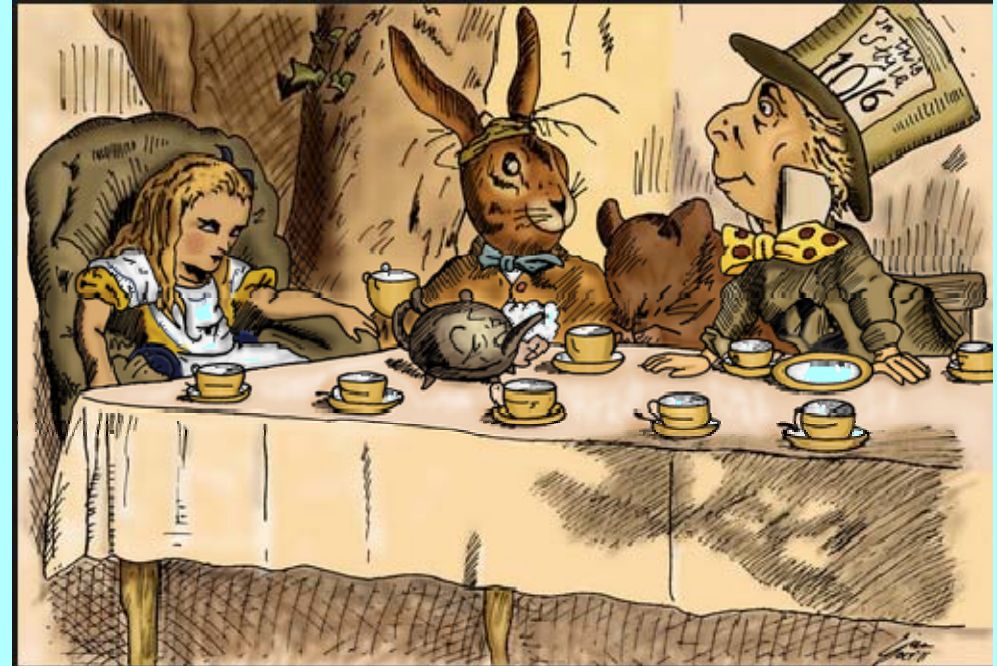
Likewise, teaching, in its day to day form, can separate us from our fellows. Mathematics teaching perhaps even more so than other subject disciplines.

It is necessary to continually counter this and provide support to one another.



## Tea Party

The faculty tea room of many universities is where academics gather to discuss ideas, seek help and collaborate with their peers



Young men should solve theorems and old men should write books.

G. H. Hardy

The internet has allowed for the rise of “citizen science” websites where professional paid scientists enlist the help of laypeople around the world

There are also collaborative efforts in mathematics.

Perhaps the most notable of these is the PolyMath Project.

Australia’s own Fields Medallist Terry Tao

<http://polymathprojects.org/>

Mathematics in the real world is a collaborative exercise, a meeting of minds and ideas where sparks fly and new ideas are born.

This is all too often missing in school classrooms but can be done.

This presentation was brought to you by:

The number 42 and the letters C, L and D

Powered by: Geometers Sketchpad and the Sketchpad Explorer APP for iPad

Backgrounds by: a hyper-intelligent shade of the colour blue

May every one of your days hold just a little bit of Wonderful Nonsense